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Preface

I am glad that today we announce to all the participants the opening of the International Symposium of Innovative Management, Information and Production and just started this new area of innovative research studies on the disciplinary fields crossing management, information and production not only relating to private and public corporations but also national and world economics. The aims of the symposium are to enhance international academic exchanges on related topics and to provide a chance for communications among researchers.

Today, our research studies are very much related to social and humanity sciences even though we are concerned with engineering. The production cannot be discussed from the perspective of production engineering but also should be decided from the scope of management, marketing, economy, etc.. Many research topics are bidirectional. This new conference perspective should influence production engineering from the perspective of the management and information as same as management and information should not be self-contained and self-absorbed science. All the fields are interrelated. Therefore, we have to work on interdisciplinary fields proposed in this IMIP symposium.

At the end I express our sincere appreciation to Professor Bing Xu who has prepared the conference. Also we should send many appraisals to Professor Berlin Wu, National Chengchi University, Professor Hung T Nguyen, New Mexico State University, Professor Vladik Kreinovich, University of Texa at El Paso, Professor Kun-huang Huarng, Feng Chia University, Renshou Zhang, *Zhejiang Gongshang university,* and other committee members who initiated the start of the conference.

I hope this small step will be the start of our wide strides of big progresses by this international conference.

General chair of IMIP 2010

Junzo Watada

Junzo Watada, *Waseda University*, *Japan*

9 October 2010，At Hangzhou

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Keynote Speech A

Managing Uncertainty Using Belief Functions: State of the Art

October 9, 09:30—10:10

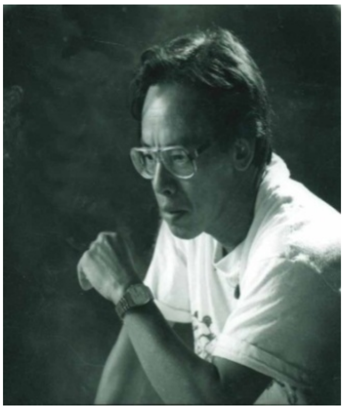
Dr. Thierry Denoeux

Graduated in 1985 as an engineer from the Ecole Nationale des Ponts et Chaussees in Paris, and received a doctorate from the same institution in 1989. Currently, he is Full Professor with the Department of Information Processing Engineering at the Universite de Technologie de Compiegne, France. His research interests concern belief functions theory, fuzzy data analysis and, more generally, the management of imprecision and uncertainty in data analysis, pattern recognition and information fusion. He is the Editor-in-Chief of the ***International Journal of Approximate Reasoning***, and a member of the editorial board of Fuzzy Sets and Systems.

Keynote Speech B

Some Practical Issues in Risk Analysis for Management

October 9, 10:10—10:50



Dr. Hung T. Nguyen

Received his Ph.D. in Mathematics at the University of Sciences and Technologies of Lille (France) in 1975. After spending several years at the University of California, Berkeley, and the University of Massachusetts, Amherst, he joined the faculty at New Mexico State University (USA) where he is currently professor of mathematical Sciences. His current research interests include econometrics, statistical and fuzzy decision-making.

Keynote Speech C

Building Nations Future in Times of Recession :
Financing Production Frontier, Agriculture & Employment

October 10, 09:00—09:40

Dr. Agarwal Aman

Has been felicitated by being Enthroned to a Ch air position of the St. Emillion Brotherhood (from 8th Century AD) by the Heritage City o f Bo rdeau, France (o n 28 th June 200 7). A special Honour and Privilege gi ven t o W orld fi gures in Business, Arts and Science. He has also been fe licitated b y a nomination for the Honorary Doctorate of Finance by University of Cergy-PontoiseThema, France (in 2007) a nd the Hono rary Professorship as Professo r of Uzbekistan by Tashk ent State Univ ersity of Economics, Uzb ekistan (in 2002), a 76 years old prestigious university in Uzbekistan (estd. 193 1), in recognition of his contribution to academics and literature. He has studied at some of the most illustrious Institutions like Delh i University, In dian In stitute of Finan ce, Lo ndon Sc hool of Econo mics and Columbia University. He has also pursued a specialized program in Finance on Options, Futures and Other Derivatives from London School of Economics. He has also pursued the joint Japan/World Bank initiated Senior Execut ive program in Economic Policy Management from Columbia Un iversity at School of In ternational & Publ ic Affairs and has had a sho rt stint at The World Bank in Washington DC, USA. He is cu rrently heading as Pro fessor of Fi nance and Vice-Chairman at Ind ian In stitute of Finance (India).

CONTENTS

Part A: Innovation Management in Information

Part B: Innovation Management in Production

STRATEGY BUILDING FOR FOREIGN EXCHANGE EXPOSURE

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ABSTRACT. *In the presence of deviations from parity conditions, the influence of foreign exchange rate variability beyond the range of financial companies only, and is now represents to be an important source of risk for non-financial corporations. As the major developed country with high effect on international trading, this research takes Japan for example and examines how foreign currency movements affect Japanese manufacturing companies. From firm and industry perspectives respectively, we find 16% of 65 sample companies and three out of six sub sector of manufacturing industries experienced an economically significant effect from exposure to the U.S. Dollar, the Chinese Yuan, or the European Euro from January 2002 to December 2007. Based on the findings, we propose a hedging method using real options analysis and a binomial decision tree model as a strategy to mitigate the impact of this exchange rate exposure. The results of numerical example illustrates that options theory can provide useful financial hedges for the management of economic exposure by removing the adjustment costs or providing faster adjustment procedures, which can be used to manage economic exposure and thus to reduce risk.*

Keywords: Exposure; Foreign Currency; Real Options Analysis Corporation

1. Introduction. Among many of the factors that affect the uncertainty of investments, the exchange rate variability has become an important source of risk in a business for companies. Due to the parity conditions nowadays such as purchasing power parity and the international fisher effect, not only financial companies, but also non-financial corporations are confronted with risks from the impact of unexpected exchange rate variability on the value of the firm, particularly for companies with foreign currency-based activities, such as imports and exports. As a result, the risk management of currency exposure has been taken into consideration of a non-financial company to address both short-term and long-term exposures and encompass financial as well as operational hedges. Especially for multinational corporations, operational hedges that can be viewed as real options are used to manage the risk of foreign exchange rate variability.

Exchange rate exposure is an essential issue in financial management. Changes in exchange rates will influence the cash flow and ultimately the value of the firm. Chamberlain et al. (1997), He and Ng (1998) found that exchange rate exposure has a significant influence on the stock performance of banks and multinational corporations (MNCs). However, non-financial firms also face risk with economic exposure. Jorion (1990) found that the percentage of foreign sales effect exchange rate risk on the stock price of nonfinancial firms, while Dukas et al. (1996) declared that firm size and Williamson

(2001) showed market share played the major role in affecting nonfinancial corporations. Even though they do not face transaction exposure risk, they encounter economic exposure indirectly. This occurs because exchange rate fluctuations can cause price shifts in foreign currency.

In the absence of adjustment costs and lags, a risk-neutral firm prefers exchange rate uncertainty to fixed exchange rates, because they can benefit from the exchange rate variability by adjusting input and output decisions. However, in the real world, switching takes time and involves costs, but firms can still benefit as long as the adjustment lags and costs are not prohibitively high. It is important in risk measurement to distinguish between general and downside risk aversion (the desire to reduce a firm's default risk or costs of financial distress or to protect investors against exchange rate-related losses).

Two main research questions are examined in this paper. First, this paper examines whether there is any relationship between the stock returns of Japanese manufacturing firms and fluctuations in the currency values of Japan's major trading partners, and whether or not these exchange risk exposure patterns are both firm-level and industry-specific. This paper uses firm-level monthly data to investigate the foreign exchange exposure of Japanese non-financial manufacturing corporations listed on the Tokyo Stock Exchange for the continuous period from January 2002 through December 2007. It is of interest to consider the exchange rate exposure of Japanese corporations, since Japan is an open and highly developed country and Japanese firms have a high foreign debt ratio.

Second, the significant finding of exchange rate exposure in three subsectors of the manufacturing sector gives management a picture of how to reduce the risk of exchange rate fluctuations. Madura (2000) mentions that inflation rate, interest rate, earnings level, government control, and market expectation are five primary factors that influence the level of an exchange rate. In foreign exchange risk management, it is in fact difficult to forecast results accurately, due to many unquantifiable influencing factors. Depending on the analysis of risks that firms face from foreign currency exposure, a corresponding hedging policy is proposed by introducing a real options method and a binomial decision tree model, as most firms can change between their home currency and foreign currency after a certain adjustment period or by incurring adjustment costs. The result indicates that options theory can provide useful financial hedges for managing economic exposure by removing the adjustment costs, which can be used by manufacturing industries to manage their economic exposure and thus reduce risk.

The remainder of this paper contains the following: Section 2 provides a background of currency exposure; Section 3 analyzes the influence of exposure in Japanese industries, with some industries being naturally heavily affected, while others experience little influence; Section 4 discusses strategic decision-making in light of real options analysis for managing currency risk exposure. Finally, conclusions are drawn in Section 5.

2. Literature Review.

2.1. Empirical Evidence. Economic exposure is defined as the influence of exchange rate fluctuations on the present value of expected business cash flow. Economic exposure is much more important for shareholder value in the long term compared with transaction exposure and/or translation exposure. Shapiro (1975) concluded on his research that the main determinants of exchange rate risk are the proportion of foreign sales, the substitutability of production factors, and the level of intensity of competition. corporations with a high proportion of foreign sales, or with direct foreign investment, will experience significant exposure to exchange rate fluctuations. Adler and Dumas (1984) illustrate that exposure to exchange rate risk is similar to that of market risk measured in the traditional sense. Therefore, the average exposure to exchange risk can be obtained by regressing the stock returns on the changes of exchange rates.

Until now, many researchers have done a large number of empirical studies analyze the foreign exchange rate exposure of nonfinancial corporations. Bartram and Karolyi (2006) found that the foreign exchange rate exposure of nonfinancial firms is systematically related to firm characteristics, regional factors and industry characteristics. Jorion (1991) found a significant impact of foreign exchange rate risk on stock prices for only 5.2% of the analyzed 287 U.S. multinationals at the 5% level. While Choi and Prasad (1995) showed that 14.9% of the individual firms in the United States and 10% of the industry portfolios show a significant foreign exchange rate exposure at the 10% level. He and Ng (1998) found that from 1979 to 1983, 25% of 171 Japanese MNCs' stock returns were impacted by significant foreign exposure. Bodnar and Gentry (1993) examined industry-level exposures for Canada, Japan, and the U.S. They found that 20% to 35% of industries in Canada, Japan, and the U.S. displayed significant exchange rate exposure. Booth and Rotenberg (1990), Chan (2002) also found significant exposure to exchange rates in both companies and industries.

2.2. Foreign Exchange Exposure Measurement. In determining the extent of exposure, much of the research on exchange rate exposure employs variations of a model in which an individual stock return is regressed on a foreign exchange rate variable, see for example, the work of Dumas (1978), Hodder (1982) and Adler and Dumas (1984). In each case, the coefficient of the foreign exchange variable is interpreted as the firm's exchange rate exposure. Kent and Shapiro (1984) used a cash study method to assess the impact of foreign exchange risk, and their study uses the present value of cash flow as the primary determinant of the firm's value, in order to gauge exposure. The formula is written as follows:

$$\mathrm{CF_t} = \alpha + \beta \mathrm{FX_t} + \varepsilon_\mathrm{t} \qquad (1)$$

where $\mathrm{CF_t}$ is the cash flow of the company at time t, $\mathrm{FX_t}$ the percentage of exchange rate movement within period t, and ε_t the error.

Adler and Dumas (1984) defined exchange rate exposure as the effect of exchange rate fluctuations on the value of an asset. The exposure is calculated by regressing stock returns with respect to exchange rate changes. The regression formula is expressed as follows:

$$\mathrm{R_{it}} = \beta_{\mathrm{i0}} + \beta_{\mathrm{ix}} \mathrm{FX_t} + \varepsilon_{\mathrm{it}} \qquad (2)$$

where $\mathrm{R_{it}}$ is the stock return of firm i at time t, $\mathrm{FX_t}$ the percentage change in an exchange rate variable at time t, and β_{ix} the measure of exposure of firm i.

Bodnar and Wong (2003) reformulated the model by including a stock market portfolio in the regression model, and estimate R_{it} as:

$$R_{it} = \alpha_{i0} + \beta_{im} R_{mt} + \beta_{ix} FX_t + \varepsilon_{it}, \tag{3}$$

where R_{it} is the stock return of firm i at time t, FX_t the percentage change in an exchange rate variable at time t, and R_{mt} the return on domestic market portfolio at time t.

3. Exposure Measurement in Japanese Manufacturing Industries. Methodology: With regard to the first research question as mentioned in Section 1, the following model is developed to identify whether manufacturing industries in Japan have significant exposure. The Japanese Yen (JPY) exchange rates against the U.S. Dollar (USD), Chinese Yuan (CNY) and European Euro (EUR) are identified as the independent variables, and the stock return of the firm is identified as the dependent variable**.**Mathematically, the above issue can be expressed in the following model:

$$R_{it} = \beta_{i0} + \beta_{USD} \Delta FX_{USD} + \beta_{EURO} \Delta FX_{EURO} + \beta_{CNY} \Delta FX_{CNY} + \varepsilon_{it} \tag{4}$$

where Rit is the stock return for firm i at time t, FXUSD, FXEURand FXCNY are the percentage changes in the USD, CNY and EUR exchange rate at time $t-1$, respectively. β_{USD}, β_{EURO}, β_{CNY} are the estimates of USD, EUR and CNY exposure, respectively, and ε_{it} is the standard error. The regression model will produce some value for β_{i0}, β_{USD}, β_{EURO} and β_{CNY}. The regression coefficient β_{i0} will illustrate the extent to which the exchange rate movements affect a firm's value.

However, because of an omitted variable problem, the estimates of the exposure coefficients could be biased. For example, there may be factors that simultaneously affect stock returns and exchange rates but have nothing to do with exposure. Suppose there is a reduction in interest rates, which simultaneously stimulates the economy and lowers the exchange rate. Since stock returns rose due to the stimulation from lower interest rates, and simultaneously exchange rates fell, it may appear that there is a direct relationship between stock returns and exchange rates--when in fact there is not.

In order to solve the problem, following the work of Adler and Dumas (1984), the above issue can be expressed mathematically by the following model:

$$R_{it} = \beta_{i0} + \beta_{USD} \Delta FX_{USD} + \beta_{EURO} \Delta FX_{EURO} + \beta_{CNY} \Delta FX_{CNY} + \beta_{mt} R_{mt} + \varepsilon_{it} \tag{5}$$

where R_{mt} is the market return, and all the other terms are as before.

However, the market portfolio is simply an aggregation of the individual stocks, and if the individual stocks are exposed, then the market is exposed. Therefore, R_{mt} is the exposure of stock *i* over and above that of the market portfolio. However, if the stock has the same exposure as the market portfolio, then the equation above would result in the conclusion that the exposure of stock *i* is zero, but since the market return contains a currency exposure component, this would be incorrect.

To solve the problem, we used the Nikkei 225 composite index in this research, for market returns from monthly stock price changes. A composite index consists of many constituents averaged to form a product representative of an overall market or sector, and thus provides a useful statistical measure of the overall market or sector performance over time. For example, the Nikkei 225 index is a market capitalization-weighted grouping of 250 stocks listed on the Tokyo Stock Exchange and represents 36 industry groupings. Indices are useful tools for measuring and tracking changes in price levels for an entire stock market or sector. Therefore, they provide a useful benchmark against which to measure an investor's portfolio. The goal of a well-diversified portfolio is usually to outperform a selected major composite index that is used as a benchmark.

Research Variables**:** This research employs five variables, namely, a dependent variable and four independent variables. The dependent variable is the average returns of company stocks, and the independent variables are (1) change in the JPY–USD exchange rate, (2) change in the JPY-CNY exchange rate, (3) change in the JPY-EUR exchange rate and (4) market returns.

The stock returns used in this research are obtained from the difference between today's stock price (closing price) and yesterday's. The stock returns are obtained in the following formula:

$$R_{it} = \frac{P_{it} - P_{it-1}}{P_{it-1}} \tag{6}$$

where:

Rit = stock returns of company i for period t,

Pit = stock closing prices of company i for period t, and

Pit-1 = stock closing prices of company i for period t – 1.

The average stock returns of the manufacturing industry are obtained from averaging individual stock returns, which can be obtained by formula (6) above; otherwise, it can also be obtained directly from the following formula:

$$\overline{R_{it}} = \frac{\sum_{1}^{N} R_{it}}{N} \tag{7}$$

where:

$\overline{R_{it}}$ = average stock returns of the manufacturing industry for period t,

Rit= individual stock return of manufacturing firm for period t,

N = the number of manufacturing sample firms.

The JPY – USD, JPY—CNY, JPY – EUR exchange rates were obtained from Bank of Indonesia’s data monthly. The changes in these exchange rates are calculated using the formula below:

$$\Delta FX_{st} = \frac{FX_{st} - FX_{st-1}}{FX_{st-1}} \tag{8}$$

where:

ΔFXst = change in JPY-USD, JPY-CNY, JPY-EUR exchange rates, respectively for period t,

FXst = JPY-USD, JPY-CNY, JPY-EUR exchange rates, respectively, for period t,

FXst-1= JPY-USD, JPY-CNY, JPY-EUR exchange rates, respectively, for period t-1,

Market returns are obtained from the changes in the monthly stock price composite index. They are computed by the formula below:

$$R_{Mt} = \frac{Nikkei225_t - Nikkei225_{t-1}}{Nikkei225_{t-1}} \tag{9}$$

where:

R_{Mt} = market returns for period t

Nikkei225t= stock price composite index for period t

Nikkei225t-1 = stock price composite index for period t – 1

TABLE 1. Influence of exchange rate exposure in Japanese industries

Industry	Constant	Exchange rate exposure coefficient			R-Sqr
		USD	EUR	CNY	
Pharmaceutical	-0.002	-0.428**	0.595**	-0.305	0.425
Metal & Non-metal	0.008	-0.175	-0.172	0.092	0.766
Electronic	0.001	0.802**	-0.519	0.264	0.770
Food & beverage	0.003	-0.041	0.147	0.431**	0.382
Machinery	0.015	0.023	-0.320	-0.021	0.731
Textile	0.006	-0.065	-0.318	0.079	0.611

Note: Exchange rate exposure coefficients that are significant at 5% level.

(1) Data Description: In this paper, the nominal exchange rate is measured by the Japanese yen/U.S. dollar, Japanese yen/Chinese Yuan, Japanese yen/European dollar exchange rates (see Figure 1). The data comes from Statistics Bureau of Japan. It is of interest to consider the exchange rate exposure of Japanese manufacturing corporations, since Japan has an open economy, and Japanese firms have a high foreign debt ratio ((exports+imports)/GDP ratio).

The sample firms are limited to manufacturing companies listed on The Nikkei Stock Average (Nikkei 225). The sample consists of 64 companies, with complete information on the stock prices and financial statements providing data on the variables we use, for the entire period from 2002:01 to 2007:12.

A monthly return horizon is used in this paper, following the prevalent argument in the literature that the use of weekly or daily data may understate the true extent of exposure. As Bartov and Bodnar (1994) argue, because of the complexity of modeling the effect of exchange rate on firm’s future cash flow, stock prices do not respond immediately to changes in exchange rates. Chow et al. (1997) argue that a longer return horizon, such as a month or more, can make the exposure of firms becomes more detectable.

Following the models developed to answer the research hypothesis, the data used in this study are gathered from a range of sources.

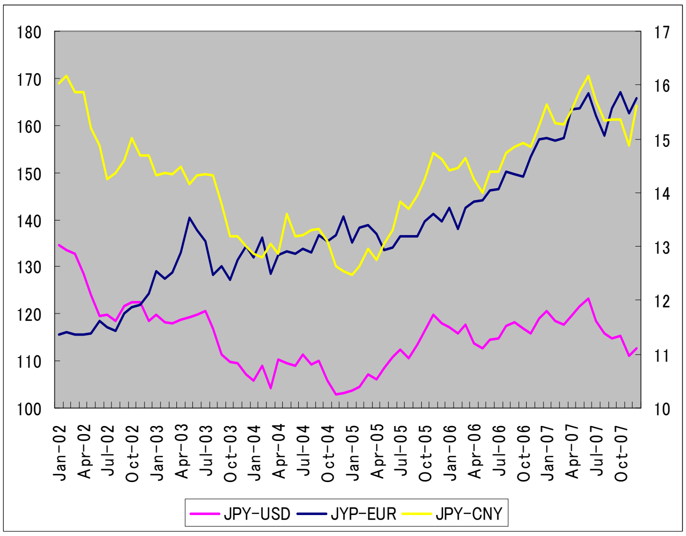

FIGURE 1. Real exchange rate of JPY against USD, EUR and CNY

(2) Empirical Testing and Analysis: As explained in the methodology section, the extent to which JPY fluctuations impact manufacturing industries is investigated by measuring the impact of the three currencies of Japan's major trading partners, namely the USD, EUR, and CNY. The real exchange rate of JPY against USD, EUR and CNY is shown in Figure 1. And the results produced by this model are reported in Table 1.

From Table 1, because the p-value of the exchange rate is lower than the level of significance ($\alpha = 0.05$), it can be concluded that there is significant exchange rate exposure in the food & beverage, pharmaceutical and electronic industries within the period. The coefficients of exchange rate variables are positive for food & beverage and electronic industries. This shows that, ceteris paribus, the correlation with the dependent variable is reciprocal, indicating that for every 1% increase in the value of CNY, there will be increases of 0.431% and 0.802% in share price appreciation for the food & beverage and electronic industries, respectively. The pharmaceutical industry has USD and EUR exposure, but the coefficient of the JPY/USD exchange rate variable is negative. The correlation with the dependent variable is reciprocal, indicating that, ceteris paribus, for every 1% increase in the value of the USD, a 0.428% decrease in stock return occurs for the pharmaceutical industry. The coefficient of the JPY/EUR exchange rate variable is positive, showing that the correlation with the dependent variable is reciprocal, meaning that, ceteris paribus, for every 1% increase in the value of the USD, a 0.595% increase in share price occurs in the pharmaceutical industry.

Generally, all models have relatively high R^2 values of around 40–80%. This means that the models can explain 40–80% of the variations in the share price performance of Japanese manufacturing companies, with the rest explained by other factors affecting share prices, but not captured by the model. The models also show that there are variations in exposure among the samples. Regarding the high percentage of the companies exposed to the USD, EUR, or CNY, the results show that the samples are jointly exposed as a group (exposure at the industry level) to those three currencies.

Based on the research at the firm level, see Table 2, about 5% of the 65 manufacturing firms experienced economically significant effects from exposure to the USD (all 3 firms had significant positive exposure coefficients), 6% to the CNY (all 4 firms had significant positive exposure coefficient) and 5% to the EUR (all 3 firms had significant positive exposure coefficients). Since the extent of exchange rate exposure is relatively low, this points to the fact that firms, especially multinational firms, are likely to have access to both

TABLE 2. Summary of the impact of currency exposure in Japanese industries

Industry	of firms	Summary of Statistics					
		USD exposure		CNY exposure		EUR exposure	
		N(+)*	N(-)*	N(+)*	N(-)*	N(+)*	N(-)*
Food & Beverage	12	0	0	2	0	0	0
Textile & apparel	7	0	0	0	0	2	0
Pharmaceutical	7	0	0	1	0	1	0
Electronic	12	2	0	0	0	0	0
Machinery	13	0	0	0	0	0	0
Metal & Non-metal	14	1	0	1	0	0	0
Total	65	3	0	4	0	3	0

Note: N(+)* reports the number of firms with positive coefficients that are significant at the 5% level. N(-)* indicates the number of firms with negative coefficients that are significant at the 5% level.

financial and operational hedging strategies. The positive coefficients suggest that appreciation of the USD, CNY and EUR against the JPY has a positive impact on Japanese

Stock returns, in other words, the share price valuations of Japanese manufacturing are positively affected by the appreciation of these currencies.

The outputs show that some samples are exposed to a time-lagged exchange rate of certain currencies by using a time-lagged rate, the low utilization of hedging techniques in many firms also contributes to the firms' sensitivity to exchange rate fluctuations.

3. Strategy Building for JPY/CNY Currency Exchange.

3.1. F inancial Hedging. Different companies have different approaches to managing foreign exchange risk, though they usually take one-sided hedges, such as options, swaps, forward contracts, etc, to avoid adverse effects, in the face of macroeconomic shocks to their industry, trade volumes, geographical markets and market power. To avoid downside risk and practice good risk management, companies should measure their foreign exposure, identify all the components of their business that are exposed to foreign exchange risk, and then calculate what will happen if the currency to which they have significant exposure appreciates or depreciates by a certain amount against their own currency.

Jorion (1991) defined exchange rate exposure as the sensitivity of the value of the firm to exchange rate randomness. The finding of significant exchange rate exposure in three sub-sectors of the manufacturing sector gives management a picture of how to reduce the risk of exchange rate fluctuations. For example, implementing more efficient use of imported raw material, applying proper hedging techniques, and expanding the market to foreign markets are some strategies that firms can use to reduce and more effectively manage their risk.

In this research, we suppose that firms consider the timing of payables and receivables in order to implement the most suitable foreign exchange rate risk management. As Snijders (1989) addressed, the greater the firm's ability to react, the shorter is its adjustment lag, translating into lower adjustment costs. We also suppose that a company with adjustable cash flows has the choice of whether to purchase inputs and pay in the home currency (HC) or to pay in foreign currency (FC), or even the ability to switch between HC and FC under certain conditions (1997). In the above situation, with sufficiently low adjustment costs and lags, managers can exploit the variability of the company's real profit and thus apply the corresponding policy to its investment and business activities. However, the elements that can result in the fluctuation of exchange rates are complicated and difficult to forecast.

3.2. General Methodology.

3.2.1. Real Options Analysis. A real option refers to a real investment, in which the owner of the option has the right, but not the obligation, to acquire the present value of expected cash flows by making an investment when the opportunity is available.

Real options analysis is an application of a discrete-time financial option valuation model that attempts to quantify the values of options. In another words, it applies the techniques of option valuation to capital budgeting exercises in which a project is coupled with a put or call option. For example, the firm may have the option to abandon a project during its life. Ignoring the cash flow associated with the project, which is the value of real options (as in standard discounted cash flow techniques) can lead to incorrect investment evaluation decisions. Under the assumption of investment reversibility, the net present value (NPV) rule implicitly assumes that "either the investment is reversible" or "if the investment is irreversible, it is a now or never proposition" ,Dixit and Pindyck (1994).

Nowadays, real options analysis has been widely used by companies considering investment decisions. Traditionally, the Discounted Cash Flow (DCF) method is probably the most widespread and commonly established method to quantify the value of an investment within a corporation. On a high level, option valuation models can be divided into continuous and discrete-time models.

A continuous model assumes an infinite number of steps between now and the future, and that the variations in the underlying asset follow a specified statistical distribution. The Black-Scholes option formula is the classical continuous model, which uses the variables defined in the following way following Bodie and Merton (2000):

$$C=N(d_1)S-N(d_2)Ee^{-rT} \tag{10}$$

$$d_1=\frac{\mathrm{In}(S/E)+\frac{(r+\sigma^2)}{2}}{\sigma\sqrt{T}} \tag{11}$$

$$d_2=d_1-\sigma\sqrt{T} \tag{12}$$

where E = expenditure required to acquire the project's assets; r = risk-free rate of return; T = length of time the decision may be deferred. Amram and Kulatilaka (1996) offer the following interpretation for the groups of terms on the right-hand side of equation 1: $N(d_1)S$ represents the expected value of the current underlying asset, if the current value is greater than the investment cost at expiration. $N(d_2)S$ represents the risk-neutral probability that the current value of the underlying asset will be greater than the cost of investment at expiration. Finally, Ee-rT represents the present value of the cost of investment.

3.3.2. Binomial Options Pricing Model. A binomial pricing model uses a "discrete-time framework" to trace the evolution of the option, under the condition that the prices of a stock can either appreciate or depreciate over the period.

Each node in the lattice represents a possible price of the underlying, at a particular point in time. This price evolution forms the basis for the option valuation.

The valuation process is iterative, starting at each final node, and then working backwards through the tree to the first node (valuation date), where the calculated result is the value of the option.

Option valuation using this method is, as described, a three-step process:

(1) price tree generation;

(2) calculation of option value at each final node;

(3) Progressive calculation of option value at each earlier node; the value at the first node is the value of the option.

A pricing tree diagram is formulated by working forward from the valuation date to expiration. At each step, it is assumed that the underlying instrument will move up or down by a specific factor (u or d) per step of the tree (where, by definition, $u \geq 1$ and $0 < d \leq 1$). Therefore, if S is the current price, then in the next period the price will either be

$$S_{\mathrm{up}} = S \cdot u \quad \text{or} \tag{13}$$

$$S_{down} = S \cdot d\ . \tag{14}$$

The up and down factors are calculated using the underlying volatility σ and the time duration t in years of a step (using the day count convention of the underlying instrument). From the condition that the variance of the log of the price is σ^2t, we have

$$u = \exp(\sigma\sqrt{t})$$

$$d = \exp(-\sigma\sqrt{t}) = 1/u\ ,$$

Where σ is the underlying volatility, and t is the time duration in years of a step.

The above can be obtained from the original Cox, Ross, & Rubinstein (CRR) method (1979). The binomial tree model has underlying relations with the classic Black-Scholes (B-S) models, which is the core of real option analysis.

3.4. Effect of JPY/CNY Exchange Rate Variability. According to a recent report from the Japanese finance ministry, in 2006, China replaced the U.S. as Japan's largest trading partner. Japan's trade with China was valued at 25.4276 trillion Yen, while its trade with the U.S. was valued at 25.1608 trillion Yen. China is also the largest importer of goods from Japan. In 2002, China was responsible for 38% of Japan's economic growth, but in 2006, this rate reached 68%. China's fast economic growth is the main reason for Japan's export surplus with China. The value of the China-Japan trade is shown in Figure 2.

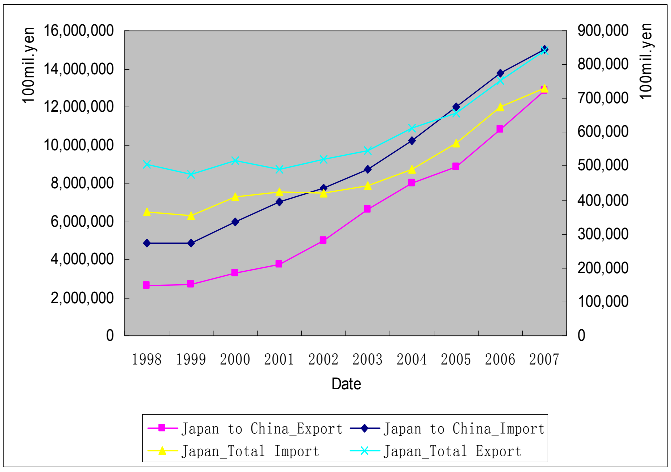

FIGURE 2. Trade between Japan and China

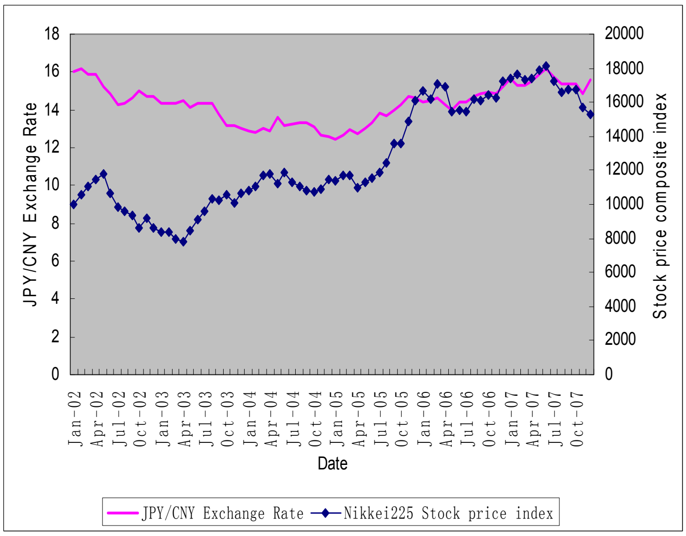

FIGURE 3. Exchange rate variability of JPY / CNY and Nikkei225 stock price composite index

Since July 21, 2005, Chinese Yuan policy reform has ushered in a new exchange rate system in China. Subsequently, the appreciation of the CNY has also promoted an increase in Japanese exports to China. The international situation has changed fundamentally, impacting imports and exports as well, as China is one of the biggest production countries in the world. Based on the analysis of the currency exposure of Japanese manufacturing industries, it is meaningful to use the CNY as an example to analyze the hedging practices of Japanese companies; the exchange rate variability of JPY/CNY and the Nikkei225 stock price composite index is shown in Figure 3.

Changes in the Nikkei 225 composite index are used in this research to get market returns, which are obtained from changes in the monthly stock price composite index. The market value of a firm is the present value of its expected future cash flows. The impact of exchange rate variability on a firm's operation is as follows:

(1) Exchange rate fluctuations are relevant to a company: for example, price fluctuations

between JPY and CNY may have a real impact on the trade between Japanese and Chinese firms. In another words, the payment terms, as determined by the contract, will actually see an increase or decrease in real payment as exchange rates fluctuate.

(2) A company should reduce its exposure based on the extent to which exchange rate changes will affect the firm's performance. For example, a firm's total cash flow in terms of the Home Currency in a given period is affected by depreciation (appreciation) of a Foreign Currency; suppose this effect is negative.

As described above, people often forecast the direction of currency changes in order to reduce risk and derive more benefit. However, accuracy in forecasting is based on the timeliness of the data and the conditions under which the forecast is made. For example, a forecast made on January 1, 2007 for a real exchange rate on January 1, 2010 is less precise and more uncertain than on January 1, 2009. The reason is that updated information will become available in the interim, such as additional real exchange rate observations.

In the absence of adjustment costs and lags, a risk-neutral firm prefers exchange rate uncertainty to fixed exchange rates, because it can benefit from exchange rate variability by adjusting input and output decisions. However, in the real world, switching takes time and involves costs, but firms can still benefit as long as adjustment lags and costs are not prohibitively high. It is important in risk management to distinguish between general and downside risk aversion (risk aversion in order to reduce the firm's default risk or costs of financial distress, or to protect investors against exchange rate related losses).

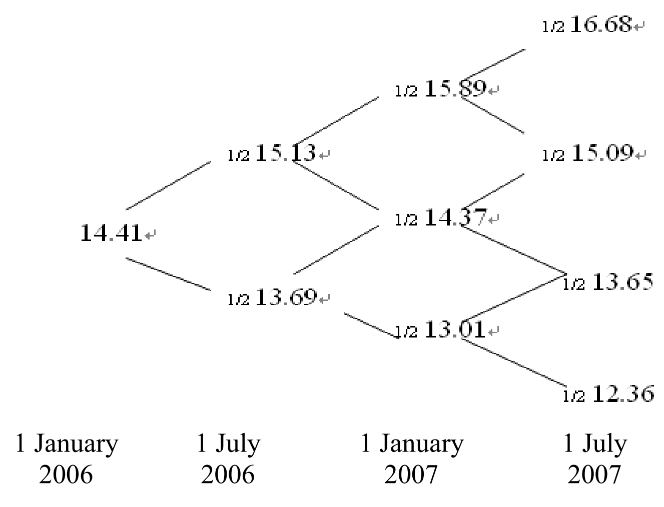

FIGURE 4. Exchange rate path--PY to CNY

3.5. Nu merical Calculation. Exposure to exchange rate risk is a complex problem that requires further discussion. However, a simple numerical example is illustrated here - a project between Chinese and Japanese companies, with a payment scheme as follows:

(1) The project is divided into half-year phases, and after each phase, the Japanese company will pay for the following phase. The currency used for payment can be either JPY or CNY.

(2) The firm should reduce its exposure as it determines the extent to which exchange rate changes affect the firm's performance.

The associated data is as follows:

(1) Payments made on January 1, 2006, July 1, 2006, January 1, 2007, and July 1, 2007 are set to be one million Yen if JPY is the chosen currency, or 69,400 Yuan if CNY is the chosen currency, based on the exchange rate of 14.41 on January 1, 2006.

(2) For simplicity, the real exchange rate is assumed to be 14.41 on 1 January and follow a basic 5% change. The probabilities of appreciation and depreciation are set to be equal, both with a 50% probability.

TABLE 3. Cost minimizing decision at each real exchange rate

Real exchange rate	Currency used	The money will be paid (Unit: thousand JPY)	Paid by switching to alternative strategy (Unit: thousand JPY)
Decisions with greater benefit - Next 1 July			
16.68	CNY	1157.6	**1100**
15.09	CNY	**1047.2**	1100
13.65	CNY	**947.3**	1100
12.36	CNY	**857.8**	1100
16.68	JPY	**1000**	1257.6
15.09	JPY	**1000**	1147.2
13.65	JPY	**1000**	1047.3
12.36	JPY	1000	**957.8**
Decisions with greater expected benefit - Next 1 January			
15.89	CNY	2176.4	**2100**
14.37	CNY	**1994.6**	2100
13.01	CNY	**1805.5**	2078.9
15.89	JPY	**2000**	2276.4
14.37	JPY	**2000**	2094.6
13.01	JPY	1978.9	**1905.5**
Decisions with greater expected benefit on 1 July			
15.13	CNY	3597.8	**3100**
13.69	CNY	**2850.2**	3052.8
15.13	JPY	**3000**	3697.8
13.69	JPY	2952.8	**2950.2**
Decisions with greater expected benefit on 1 January			
14.41	CNY	**3975.1**	4075.1
14.41	JPY	**3975.1**	4075.1

Note: The decisions which should be chosen to maximize benefits are in bold text

(3) The cost of adjustment from one currency to the other is 100,000 Yen. The binominal process of the real exchange rate variability is shown in Figure 4.

The probability distribution of the input costs, and hence the risk implications of cost minimization, can be obtained by eight possible future exchange rate paths, as shown in Figure 2, and thus determine a cost-minimizing decision in each case, as shown in Table 3.

In the simple binominal tree, there are eight different possible paths of exchange rate fluctuation with the possibility of both appreciation and depreciation. If payment is in JPY, when the JPY depreciates against the CNY, a Japanese company's actual payment is less if the CNY is used, and vice versa. Therefore, in order to decrease the risk the company will face due to fluctuations in exchange rates, and to be more competitive, the method of binominal options analysis and real options analysis should be taken into consideration.

TABLE 4. Decision of Japanese company in the change paths

The change path of exchange rate	For Japanese Company	
	Use JPY currency (thousand Yen)	If greater benefit, change to CNY (thousand Yen)
14.41—15.13—15.89—16.68	4000	Change is not more beneficial
14.41—15.13—15.89—15.09	4000	
14.41—15.13—14.37—15.09	4000	
14.41—15.13—14.37—13.65	4000	
14.41—13.69—14.37—15.09	4000	4094.6
14.41—13.69—14.37—13.65	4000	3994.7 (change in 1 July)
14.41—13.69—13.01—13.65	4000	3900.3 (change in 1 July)
14.41—13.69—13.01—12.36	4000	3810.8 (change in 1 July)

From Table 4, we can learn the following:

Firms with relatively low adjustment costs benefit from real exchange rate uncertainty. Table 4 shows that the expected input costs for a firm that switches optimally are 3.9947 million Yen regardless of its initial strategy, and follows the path of 14.41—13.69—14.37—13.65, whereas a firm that starts with Japanese Yen inputs and sticks to that currency regardless, pays a pre-determined 4.0 million Yen. Adjustment costs should be assessed relative to the degree of uncertainty. With different periodical changes in the real exchange rate, the optimal method (to switch or not) will vary. Risk-reduction can be given explicit priority. Exchange rate-induced losses may be lowered by investing mainly in a smooth transition from the FC to the HC strategy.

However, this is only a simple model, as the actual exchange rate variability will be different, and when the ratio of appreciation and depreciation is different, the results will be different. However, the variability of exchange rates is essential to the development of the international market environment, and the binominal method is a useful tool.

4. Conclusions. When the Bretton Woods system of fixed exchange rate unraveled during the 1970s, foreign exchange rate exposure expand to be an important source of risk not only for financial corporations, but also for non-financial corporations. For example, in year 2001, Toyota reported a 2.5 billion Yen operating loss in Europe because of the change of current Euro against Yen. These spectacular losses of non-financial corporations showed us the importance of managing economic exposure, which is to exploit the variability of exchange rates in order to increase a firm's market value, while ensuring that the downside risk of exchange rates remains sufficiently small. In this research, we took Japan manufacturing industries for example and two main research questions are examined in this paper.

First, this paper examines whether there is a relationship between Japanese manufacturing firm's stock returns and fluctuations in the currency values of the Japan's three major trading partners. We find that about 16% of these firms experienced an economically significant positive effect with exposure to the U.S. Dollar, Chinese Yuan and European Euro (among them, 5% of these firms have significant exposure to the U.S Dollar, 5% to the Chinese Yuan and 6% to the Euro). At the industry level, three sub sectors within Japan's manufacturing industry (pharmaceuticals, electronic, foods and beverage industries) had significant currency exposure from January 2002 to December 2007. The pharmaceutical industry was exposed to the USD and EUR, and the impact of the fluctuations was negative. As the JPY depreciated against the USD or EUR, the manufacturing firms' value would decline. The electronics industry, and food and beverage industry were significantly influenced by USD and CNY, respectively. However, the impact of these fluctuations was positive. The coefficients of exposure also vary for each currency and manufacturing industry. These coefficients of exposure for the USD range from -0.428 to 0.802, for the EUR from -0.519 to 0.595, and for the CNY from -0.305 to 0.431. The results also show that the samples are jointly exposed as a group (exposure on the industry level) to those three currencies.

Even though at the firm level, firms face risk with significant positive exposure, at the industry level, the pharmaceutical industry is negatively exposed to the USD and EUR. As Choi and Prasad (1995) and Dominguez and Tsar (2001) pointed out, firms within an industry group are not necessarily homogeneous in their operational characteristics or in their financial strategies, and movement in exchange rates may lead to offsetting effects within an industry. The result may be partly because firms within the same industry group may possess both positive and negative exchange risk exposure, so aggregating across such firms may result in finding an insignificant exposure coefficient for the industry group.

Second, a hedging policy is proposed by investing in lower adjustment costs or faster adjustment procedures. In practice, real exchange rates take a long time to revert to their Law of One Price levels. Therefore, a firm involved in an import/export business can employ a strategy of switching between a home currency and a foreign currency, and be more effective at hedging than a firm that has only access to one strategy. It was shown that by investing in lower adjustment costs or faster adjustment procedures, the firm can attain its dual objective of raising expected cash flows and limiting the downside risk of exchange rate changes. In particular, if the exchange rate uncertainty is high, the firm should consider measures that facilitate future adjustments in its cost and revenue structures.

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DOES THE DIGITAL NATIVES TECHNOLOGIES REALLY HELP? A FUZZY STATISTICAL ANALYSIS AND EVALUATION ON STUDENTS' LEARNING ACHIEVEMENT

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ABSTRACT. *In this paper we investigate the effect of using the digital natives technologies in elementary school's students' learning achievement. The factors we consider including time, content of activity, time of learning, technique of searching, and safety of internet. We use the fuzzy statistics with soft method to analyze the fuzzy data. The results show that：School children spent an average of 3.23 days a week on internet, 2.14 hours each time, 32.84 minutes were for looking up school work related information, the most frequent activity is playing "online games". There is great satisfied to learn "Social Studies and Science and Technology" we recommend that both teachers and parents need to pay more attention to school children how they use internet, their study regarding information on internet and to provide them with appropriate skills on navigating around internet and education on learning information.*

Keywords: Digital Natives; Fuzzy Statistical Analysis; Internet Technologies

1. Introduction. In the age of the knowledge-economy, the measurement of the value of intellectual achievement is increasingly receiving more and more attention. However, the evaluation of students' achievement is complex, it involves many factors, such as peoples' utility (human subjective recognition) and the students' development etc. that are very difficult to calculate by traditional methods. In this paper we propose an integrated fuzzy evaluation procedure to evaluate the students' achievement. The primary main methods used are fuzzy statistical analysis, fuzzy-weighting and fuzzy ranking. This integrated procedure is aimed at yielding appropriate and reasonable rank and value of intellectual capital. We also give empirical examples to illustrate the techniques and how to evaluate it.

Internet, instant messaging in a time of highly advance technologies, some call it the

N-Generation, D-Generation, S-Generation or "Digital Natives". Digital Natives are referring to the "mother tongue" used by this new generation is a product of new thinking and data process derived from using computer and internet. Digital Natives use extensive digital media that allows fast, multiple, illustrative, random access to storage module, this makes the leaning method used by Digital Natives different from the teaching methods used by teachers (Pernsky, 2007; Mayer and Moreno, 1998; Clark and Mayer, 2003).

Online-based learning patterns have modified the traditional roles of learner and teacher as learner's learning method is changed because of information technology, online-based system should place more emphasis on teaching quality and learning effectiveness of online learning environment, Roblyer and Knezek (2003).

Implementing computer hardware is only the beginning, the key is the ability to apply, actual effectiveness of computer relies on the application of online resources, school children of digital natives have become accustom to using extensive information materials; however, are these school children spending too much time on internet and what sort of activities they often engage online? What type of internet ethical issues they have to face? There are fewer documentations targeting how school children use internet after school, therefore this research will specifically study this topic and the findings could be used as reference materials by education institutions.

According to the 2010 "Taiwan Broadband Network Usage Study" conducted by Taiwan Network Information Center, as of February 12, 2010, there is about 16.22 million internet users in Taiwan, a total of 16,217,009 people had used internet, TWNIC (2010). Internet has become part of people's daily activities, through the various functions of internet, learning new knowledge, recreation, reading information or shopping have been made possible. Internet changes how people interact with each other, especially transforming the way people communicate. The growth of internet and networking technologies introduces the development of email, instant messaging and video messaging that lead to new learning pattern or life style.

In this research, we incorporates the concept of fuzzy statistic to explore and analyze how school children use internet with an aim to promote the planning of computer information education courses at schools. Major objectives of this research are as follows:

(1) Analysis on the frequency, time school children use internet for school works.
(2) Analysis on the activities school children often engage online.
(3) Explore the Satisfaction of students for learning information to be used for information education course planning.

2. Fuzzy Evaluation on the Students' Achievement.

2.1. System Investigation. Based on the main objectives of this research, analysis was performed on frequency, time of using internet for school works among school children. Figure 1 illustrate our research map.

We had observed the fact that many school children often spent time on using internet after school, since many researches had pointed out that internet has significant effect on life, school works and cognitive skills as the result of school children using internet. In addition to formal computer course at school, most school children use internet at home, adults from a number of families would limit the use of internet by their children while some families would not interfere the use of internet devices by their children.

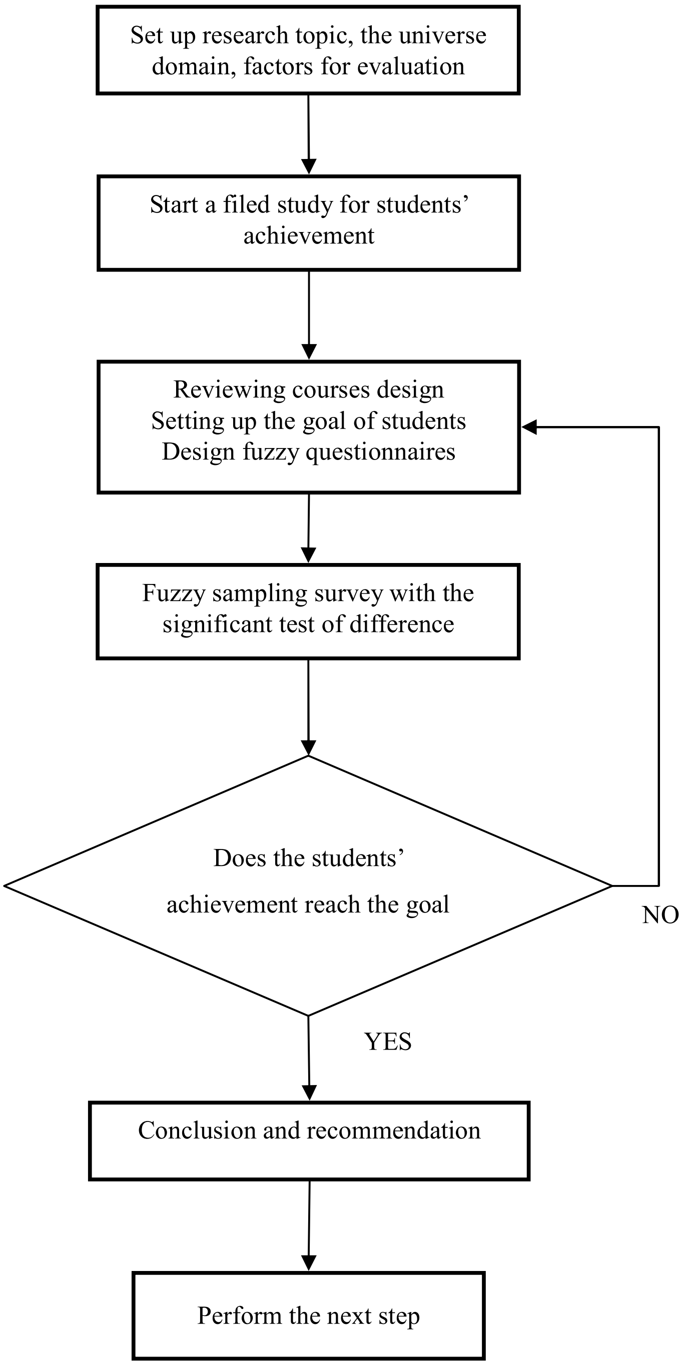

FIGURE 1. A flow chart of research

Figure 2 demonstrates the relations about the courses design and student achievement.

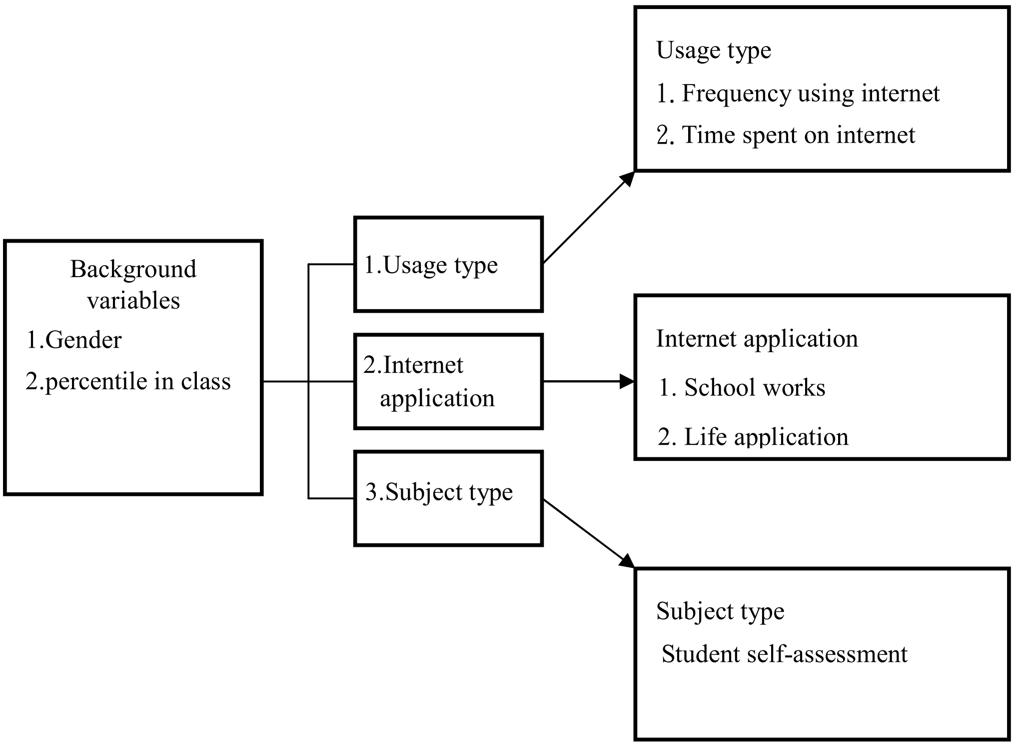

FIGURE 2. Detailed students achievement design and evaluation

2.2. Application with Fuzzy Set Theory. Human beings have a nonlinear but emotional thinking process, traditional questionnaire would be difficult to have people elaborate on their thoughts at a deeper level. For example, research questionnaire often like to include "like" in the question. Liking something is an internal feeling, other than everyone has a different level of feeling, sometimes a pendulum effect could occur resulting in different answers, how much could someone elaborate on the extent of liking something? What would be the percentage that such feeling occupy a person's mind?

Social science aims to study the internal motivation or feeling of human behaviors, traditional quantifiable statistics almost require the subject to express a single motivation or feeling and attempt to apply definitive quantified statistics to display abnormal behaviors of human beings and analyze psychological measurements from a probability perspective, mathematical pattern actually simplified complex issue, nevertheless the complicated subjective point of view and thinking were usually overlook, Wu (2005), Nguyen and Wu (2006).

Motivations that propel human behaviors often change with time, environment, age or stage of life, moreover sometimes human thinking or decision process is filled with great leaps, uncertainty or fuzzy, nonlinear and incoherent as they might be determined by the judgment and dynamic thinking towards certain subject at the moment.

In 1965, Zadeh first introduced the concept of fuzzy set, using fuzzy logic as basis, made a breakthrough from the traditional mathematic binary logic to a dichotomy method distinguishing right and wrong, this argument is based on the fuzzy measurement and classification principle of human brain activity in a dynamic environment thus giving a more moderate solution to a fuzzy phenomenon of multiple-levels, this argument was explained in great details in the research of Lowen (1990), Ruspini (1991), Dubois and Prade (1991).

Zedah (1999) went even further to recommend the use of perception measure and soft computing system as fuzzy function for measurement. Simplified dichotomy method is really unable to accurately describe the multiple nature of human behavior, therefore we consider using fuzzy classification in table analysis to resolve the problem of excessive simplification. Concepts such as fuzzy average, fuzzy median and fuzzy mode in basic descriptive statistics are incorporated to present the research findings of human behavioral statistics, Wu (2000).

Membership grade function is the most basic concept in fuzzy theory, it is derived from the characteristic function of traditional set and it is used for expressing an element's membership grade in a fuzzy set, its range is between 0 and 1. It is not only able to describe the characteristics of fuzzy set, it is also able to quantify fuzzy set while using accurate mathematic method to analyze and process information of fuzzy nature. Membership grade function could be classified as discretization and continuous. Discretization type membership grade function directly assign membership grade to each element in a limited fuzzy set and present the result in a vector format. Continuous type membership grade function could use several frequently used functions to describe a fuzzy set, please refer to Zimmermann (1991) for the various types of membership grade functions.

Membership grade functions can not escape individual subjective consciousness, therefore there is no common theory or formula, confirmation is usually achieved through experience or statistics Wu (2005). For example, activities online to school children, might be favored by them, however there would be difference in the extent of how much they like it. Research subjects like online games the most, time was also spent on chatting or making friend through network system, email is another favorite function of internet. With the design of fuzzy statistic questionnaire, research subjects were allowed to express the extent of how much they like certain activity and assign a percentage of such enjoyment in their mind, this could be presented in percentage or total sum value. In other words, the concept of membership grade was used, a total value of fuzzy statistic equal to 1 was obtained. Thanks to questionnaire based on fuzzy theory, this research was able to accurately reflect the true feeling of individual answering the questionnaire, allowing research subjects to fully express what feel inside, therefore the data received in the questionnaire were able to represent the meaning and value of this research.

3. Fuzzy Statistics. Traditional statistics deals single answer or certain range of the answer through sampling survey, and unable to sufficiently reflect the complex thought of an individual. If people can use the membership function to express the degree of their feelings based on their own choices, the answer presented will be closer to real human thinking. Therefore, to collect the information based on the fuzzy mode should be the first step to take. Since a lot of times, the information itself embedded with uncertainty and ambiguity. It is nature for us to propose the fuzzy statistics, such as fuzzy mode and fuzzy median, to fit the modern requirement. In this and next section we demonstrate the definitions for fuzzy mode and fuzzy median generalized from the traditional statistics. The discrete case is simpler than the continuous one's.

Definition 3.1. Fuzzy sample mean (data with multiple values).

Let U be the universal set (a discussion domain), $L=\{L_1,L_2,\cdots,L_k\}$ be a set of k-linguistic variables on U, and $\{Fx_i=\frac{m_{i1}}{L_1}+\frac{m_{i2}}{L_2}+...+\frac{m_{ik}}{L_k}, i=1,2,...,n\}$ be a sequence of random fuzzy sample on U, $m_{ij}(\sum_{j=1}^{k} m_{ij}=1)$ is the memberships with respect to L_j.Then, the Fuzzy sample mean is defined as

$$F\overline{x}=\frac{\frac{1}{n}\sum_{i=1}^{n} m_{i1}}{L_1}+\frac{\frac{1}{n}\sum_{i=1}^{n} m_{i2}}{L_{i2}}+...+\frac{\frac{1}{n}\sum_{i=1}^{n} m_{ik}}{L_k} \tag{1}$$

Example 3.1. Let the x_1=[2,3], x_2= [3,4], x_3= [4,6], x_4= [5,8], x_5=[3,7] be the beginning salary for 5 new master graduated students. Then fuzzy sample mean for the beginning salary of the graduated students will be

$$F\overline{x}=[\frac{2+3+4+5+3}{5},\frac{3+4+6+8+7}{5}]=[3.4, 5.6] \tag{2}$$

Definition 3.2. Fuzzy sample mode (data with multiple values).

Let U be the universal set (a discussion domain), $L=\{L_1,L_2,\cdots,L_k\}$ a set of k-linguistic variables on U, and $\{FS_i, i=1,2\cdots,n\}$ a sequence of random fuzzy sample on U. For each sample FS_i, assign a linguistic variable L_j a normalized membership $m_{ij}(\sum_{j=1}^{k} m_{ij}=1)$, let $S_j=\sum_{i=1}^{n} m_{ij}$, $j=1,2,\cdots,k$. Then, the maximum value of S_j (with respect to L_j) is called the fuzzy mode (FM) of this sample. That is $FM=\{L_j \mid S_j=\max_{1\le i\le k} S_i\}$.

Note: A significant level α for fuzzy mode can be defined as follows: Let U be the universal set (a discussion domain), $L=\{L_1,L_2,\cdots,L_k\}$ a set of k-linguistic variables on U, and $\{FS_i, i=1,2\cdots,n\}$ a sequence of random fuzzy sample on U. For each sample FS_i, assign a linguistic variable L_j a normalized membership $m_{ij}(\sum_{j=1}^{k} m_{ij}=1)$, let $S_j=\sum_{i=1}^{n} I_{ij}$, $j=1,2,\cdots,k$ $\quad I_{ij}=1\ if\ m_{ij}\ge\alpha,\ I_{ij}=0\ if\ m_{ij}<\alpha$, α is the significant level. Then, the maximum value of S_j (with respect to L_j) is called the fuzzy mode (FM) of this sample. That is $FM=\{L_j \mid S_j=\max_{1\le i\le k} S_i\}$. If there are more than two sets of L_j that reach the conditions, we say that the fuzzy sample has multiple common agreement.

Definition 3.3. Fuzzy sample mode (data with interval values).

Let U be the universal set (a discussion domain), $L=\{L_1,L_2,\cdots,L_k\}$ a set of k-linguistic variables on U, and $\{FS_i=[a_i,b_i], a_i,b_i\in R, i=1,2,\cdots,n\}$ be a sequence of random fuzzy sample on U . For each sample FS_i , if there is an interval [c, d] which is covered by certain samples, we call these samples as a cluster. Let MS be the set of clusters which contains the maximum number of sample, then the fuzzy mode FM is defined as

$$FM = [a,b] = \{\cap [a_i, b_i] | [a_i, b_i] \subset MS\} \quad (3)$$

If $[a,b]$ does not exist (i.e. $[a,b]$ is an empty set), we say this fuzzy sample does not have fuzzy mode.

Example 3.2. Suppose eight voters are asked to choose a chairman from four candidates. Table 1 is the result from the votes with two different types of voting: traditional response versus fuzzy response.

TABLE 1. Response comparison for the eight voters

Candidate	Traditional response				Fuzzy response			
Voter	A	B	C	D	A	B	C	D
1		∨				0.7	0.3	
2	∨				0.5		0.4	0.1
3				∨			0.3	0.7
4			∨		0.4		0.6	
5		∨				0.6	0.4	
6				∨	0.4		0.4	0.6
7		∨				0.8	0.2	
8			∨				0.8	0.2
Total	1	3	2	2	1.3	2.1	3.5	1.6

From the traditional voting, we can find that three are three person vote for B. Hence the mode of the vote is B. However, from the fuzzy voting, B only gets a total membership of 2.1, while C gets 3.4. Based on traditional voting, B is elected the chairperson, while based on the fuzzy voting or membership voting, C is the chairperson. The voters' preference isreflected more accurately in fuzzy voting, C deserves to be the chairperson more than B does.

Fuzzy χ^2-test of homogeneity (with discrete data).

Consider a K-cell multinomial vector n={$n_1, n_2, ..., n_k$} with $\sum_i n_i = n$. The Pearson chi-squared test ($\chi^2 = \sum_i \sum_j \frac{n_{ij} - e_{ij}}{e_{ij}}$) is a well known statistical test for investigating the significance of the differences between observed data arranged in K classes and the theoretically expected frequencies in the K classes. It is clear that the large discrepancies between the observed data and expected cell counts will result in larger values of χ^2

However, a somewhat ambiguous question is whether (quantitative) discrete data can be considered categorical and use the traditional χ^2-test. For example, suppose a child is asked the following question: "how much do you love your sister?" If the responses is a fuzzy number (say, 70% of the time), it is certainly inappropriate to use the traditional

χ^2-test for the analysis. We will present a χ^2-test for fuzzy data as follows:

Procedures for Testing hypothesis of homogeneity for discrete fuzzy samples.

(1) Sample：Let Ω be a domain，$\{L_j, j=1,...,k\}$ be ordered linguistic variables on Ω，and $\{a_1, a_2, \cdots, a_m\}$ and $\{b_1, b_2, \cdots, b_n\}$ are random fuzzy sample from population A, B with standerized membership function mA_{ij}, mB_{ij}.

(2) Hypothesis: Two populations A, B have the same distribution ratio. i.e

$$H_0 : F\mu_A =_F F\mu_B$$

Where

$$F\mu_A = \frac{\frac{1}{m}MA_1}{L_1} + \frac{\frac{1}{m}MA_2}{L_2} + ... + \frac{\frac{1}{m}MA_k}{L_k}$$

$$F\mu_B = \frac{\frac{1}{n}MB_1}{L_1} + \frac{\frac{1}{n}MB_2}{L_2} + ... + \frac{\frac{1}{n}MB_k}{L_k}$$

$$MA_j = \sum_{i=1}^{m} mA_{ij}, MB_j = \sum_{i=1}^{n} mB_{ij}.$$

(3) Statistics：$\chi^2 = \sum_{i \in A,B} \sum_{j=1}^{c} \frac{([Mi_j] - e_{ij})^2}{e_{ij}}$. (In order to perform the Chi-square test for fuzzy data, we transfer the decimal fractions of Mi_j in each cell of fuzzy category into the integer Mi_j by counting 0.5 or higher fractions as 1 and discard the rest.)

(4) Decision rule：under significance level α, if $\chi^2 > \chi^2_\alpha(k-1)$,then we reject H_0.

Procedures for Testing hypothesis of homogeneity for interval fuzzy samples.

(1) Sample：Let Ω be a discussion domain, $\{L_j, j=1,...,k\}$ be ordered linguistic variables on the total range of Ω，and $\{a_i = [a_{li}, a_{ui}], i=1,...,m\}$ } and $\{b_i = [b_{li}, b_{ui}], i=1,...,n\}$ and are random fuzzy sample from population A, B with standardized membership function mA_{ij}, mB_{ij}.

(2) Hypothesis: Two populations A, B have the same distribution ratio. i.e

$$H_0 : F\mu_A =_F F\mu_B$$

Where

$$F\mu_A = \frac{\frac{1}{m}MA_1}{L_1} + \frac{\frac{1}{m}MA_2}{L_2} + ... + \frac{\frac{1}{m}MA_k}{L_k}, \quad F\mu_B = \frac{\frac{1}{n}MB_1}{L_1} + \frac{\frac{1}{n}MB_2}{L_2} + ... + \frac{\frac{1}{n}MB_k}{L_k}$$

$$MA_j = \sum_{i=1}^{m} mA_{ij}, MB_j = \sum_{i=1}^{n} mB_{ij}.$$

(3) Statistics：$\chi^2 = \sum_{i \in A,B} \sum_{j=1}^{c} \frac{([Mi_j] - e_{ij})^2}{e_{ij}}$. (In order to perform the Chi-square test for fuzzy data, we transfer the decimal fractions of Mi_j in each cell of fuzzy category into the integer Mi_j by counting 0.5 or higher fractions as 1 and discard the rest.)

(4) Decision rule：under significance level α, if $\chi^2 > \chi^2_\alpha(k-1)$,then we reject H_0.

Example 3.3. DDP party wants to know the degree of support from an election. Suppose they are interested in how the sex will make a difference about the voting. They conduct a sampling survey and ask the people with two methods for reply: traditional reply and fuzzy reply. The result is as follows:

TABLE 2. Replies for peoples on the degree of party support

	Support of Parties			χ^2-test of homogeneity	Support of parties			χ^2-test of homogeneity
Category	DDP	KMT	others	χ^2=8.27 $> 5.99 = \chi^2_{0.05}(2)$	DDP	KMT	others	$\chi^2 = 3.78 < 5.99 = \chi^2_{0.05}(2)$
Male	220	280	100		216.2	268.5	114.3	
Female	170	150	80		158.1	154.7	87.2	

Null Hypothesis: H_0 : there is no difference of the degree of support for parties. H_1: there is no difference of the degree of support for parties. Under the significance level α =0.05, we can find that there exists difference Statistical testing conclusion: for traditional reply, we will reject the null hypothesis. While for the fuzzy reply, will accept the null hypothesis.

Example 3.4. In order to set up a sales strategy, the R&D of a supermarket manger want to know the living expense(monthly) between community X and community Y. They randomly choose 50 samples from X and Y. during the answering process, people are asked to write their living expense by interval instead of real number. For instance, they can write the living expense as: 1500~2500 with membership 0.7, 2500~4000 with membership 0.3. Then they sum up the memberships and get the following Table 3.

TABLE 3. Monthly living expense for community X and Y

	0~1500	1500~2500	2500~4000	4000~6000	6000+
X	2.8	10.3	19.7	14.2	5.0
Y	7.1	21.6	20.9	6.8	2.6

Null Hypothesis H_0 : The distribution (ratio) for living expense between is no difference. H_1 : community *X* has a higher living expense than *Y.*

Computing the statisitcs χ^2 , we find χ^2 =8.43> $\chi^2_{0.05}(4)$ =7.78. Hence under the significant level α =0.1. We reject H_0 : The distribution (ratio) for living expense between is no difference. Examining again the data, we may say that the community *X* has a higher living expense than community *Y*.

4. Empirical Studies and Findings. Methods that evaluate social behaviors include interview, observation, paper test, this research had adopted paper test, research subjects were given various questions for answering in order to obtain the data needed in this research. 6 questions were in the questionnaire, they were all to be completed by fuzzy answers, research subjects were 6th grade school children from certain elementary school in Houlong town of Miaoli county, instructions were given by the researcher before questionnaire were handed out. 55 sets of questionnaire were handed out, 55 sets were returned, valid questionnaires were 55. Return rate was 100%. Analysis on the descriptive statistics of sample structure is as in Table 4.

TABLE 4. Descriptive statistics of samples

Background variables		Frequency	Percentage
Gender	Girl	24	43.6
	Boy	31	56.4
Average percentile in class of current semester	1~5	9	16.4
	6~10	12	21.8
	11~15	10	18.2
	16~20	13	23.6
	21~25	7	12.7
	26~	4	7.3
whether Parent interfere activities online	yes	40	72.7
	no	15	27.3
Whether parents use internet	yes	43	78.2
	no	12	21.8

Out of the 55 research subjects, boys were the majority accounting for 56.4%; average percentile in class was 16-20 accounting for 23.6%; research subjects with parents interfering activities online was actually 72.7%; and parents that also use internet was 78.2%.

4.1. Usage Condition. The condition of how school children use internet after school was analyzed from the time spent online and frequency, the results are as follow:

Frequency analysis on school children using internet in a week. Statistical findings were as shown in Table 5.Average number of days school children use internet in a week is 3.23 days, if gender was taken into consideration, boys were 3.84 days, girls were 2.63 days.

Analysis on the time spent by school children on internet after school. Statistical findings showed the average time spent by all school children on internet after school was 2.14 hours, if gender was taken into consideration, boys were 2.26 hours, girls were 2.02 hours.

TABLE 5. Frequency analysis on school children using internet in a week

Unit: Days

	Fuzzy average	Fuzzy median	Fuzzy mode
All childrens（N=55）	3.23	1.75-3.50	1-2
Boys（N=31）	3.84	2.00-4.00	
Girls（N=24）	2.63	1.50-3.00	

TABLE 6. Analysis on the time spent by school children on internet after school

Unit: Hour

	Fuzzy average	Fuzzy median	Fuzzy mode
All childrens（N=55）	2.14	1.00-3.00	1-2
Boys（N=31）	2.26	1.00-3.00	
Girls（N=24）	2.02	1.00-3.00	

4.2. Internet Applications. Applications of internet used by school children after schools were examined in terms of school related works, life application, the findings were as follows:

Analysis on the time spent by school children on internet for school related works. Statistical finding were as shown in Table 7. Average time spent by school children on internet for school related works after school was 32.84 minutes, if gender was taken into consideration, boys were 28.39 minutes, girls were 37.29 minutes.

4.3. Subject Type. Regarding course of learning area on the self-assessment for school children, Table 10 is the result from school children make use of fuzzy response for learning area. Most of the distributions lie in satisfaction, “Social Studies and Science and Technology”. “English” was the least.

TABLE 7. Analysis on the time spent by school children on internet for school related works

Unit: Minutes

	Fuzzy average	Fuzzy median	Fuzzy mode
All childrens（N=55）	32.84	1.00-3.00	20-30
Boys（N=31）	28.39	20.00-30.00	
Girls（N=24）	37.29	20.00-50.00	

TABLE 8. Analysis on the activities school children often engage online

	Fuzzy average	Fuzzy median	Fuzzy mode
1.Send/receive e-mail	0.13	0.10	0.05
2.Play online games	0.38	0.35	0.40
3.Chat,making friends	0.21	0.19	0.30
4.Look up information online	0.17	0.13	0.15
5.Looking up for homework	0.11	0.09	0.10

Activities school children often engage online. Statistical findings are as shown in Table 8. “Play online games” had the highest fuzzy average, the lowest was “Looking up for homework”.

TABLE 9. Analysis on the significance of Grades regarding the activities school children engage online

Test of homogeneity	grades	1	2	3	4	5	
H_0: Whether grades would make any difference on the activities school children engage online	1~5	10.56	38.33	28.33	13.89	8.89	$\chi^2=38.69 > 28.41=\chi^2_{0.1}(20)$ Reject H_0
	6~10	14.17	33.25	25.08	16.25	11.25	
	11~15	11.00	44.50	17.00	19.90	7.60	
	16~20	11.38	46.69	19.77	12.69	9.46	
	21~25	13.86	35.29	8.86	22.29	18.14	
	26~	24.75	30.25	14.75	16.50	14.00	

TABLE 10. Analysis on the satisfaction of learning area for school children

Learning Area	Very satisfied	Satisfied	Dissatisfied	Very dissatisfied
Mandarin	18.37	43.29	28.11	10.23
Mathematics	10.89	37.13	40.22	11.76
Social Studies	38.46	37.22	15.78	8.54
Science and Technology	44.21	31.23	19.19	5.37
English	3.29	12.48	32.12	52.11

5. Conclusion. This research is to examine how school children of digital native generation use internet technology after school. Based on the findings, We discovered that average number of days school children spent on internet in a week is 3.23 days, 2.14 hours per day. As for frequency and amount of time, most numbers for boys were greater than those of girls. Time used for looking for home work information was 32.84 minutes, girls spent more time in this area than boys did. “Play online games” was the most frequent activities school children engaged online, on the other hand “looking up for home work” was the least. grades of school children played significant part in online activities.

Internet technology is a daily tool for those in the digital native generation, they use it in daily life, for recreation, looking up information and school works. However, it still takes appropriate to education guide elementary school children in using internet technology and learning information. For example, it was learned that school children spent as long as 2.14 hours on internet after school but only about half hour was used for studying, the rest of time was spend on playing online games. Therefore, teachers and parents should pay more attention to school children in order to better understand how them spend children time on online and the type of activities.

Result shows that fuzzy statistics with soft computing are more realistic and reasonable in the students’ achievement. Finally certain comments are suggested for the further studies.We propose the following suggestions: (1). strengthen fundamental education on internet technology for school children, teaching them to make better use of the convenience and technology brought by internet; (2). provide needed educational information to parents to assist them children for after school online activities; (3). place emphasis E-Learning of Mandarin and Mathematics and English.

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APPLICATION OF THE MONETARY POTENTIAL THEORY IN OPTION PRICING PROBLEMS

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ABSTRACT. *Using the theory of monetary potentials can be solved different American and European (call and put) options pricing problems. Especially, the American put premium Z can be expressed as single money potential with density* θ *and distributed on the American put option optimal exercise boundary* Γ*, i.e. as a money influence function of money source with intensity* θ *and continuously acting along* Γ*. From the financial point of view, these algorithms and solutions are more natural and intuitive. From this expression we can see that when the better the put situation in the stock market, then the higher the price of American put premium, in this case a buyer of American put option will get more payoff than a buyer of European put option with same conditions. The longer the exercise period, than any buyer of American put option has more selection, than the expansive the American put premium. When the price of American put premium is highest if the buyer of American put option exercises in this time then he can get the maximum payoff.*

Keywords: Option Pricing; Black-Scholes Model; Money Potential; Premium

1. Introduction. In 1973, professor Fischer Black of the University of Chicago and professor Myron Scholes of the Massachusetts Institute of Technology in “Journal of Political Economy” published an article entitled “The Pricing of Options and Corporate Liabilities” (Black and Scholes, 1973), laid the theoretical basis of option pricing, creating a new investment area of finance. They shared the 1997 Nobel Prize in Economics. They wrote: "If options are correctly priced in the market, it should not be possible to make sure profits by creating portfolios of long and short positions in options and their underlying stocks."

Black-Scholes equation (BS equation or BS model) is a second order stochastic parabolic partial differential equation, the trading conditions of options can be considered as the initial conditions or boundary conditions of this equation (Black and Scholes, 1973; Jiang, 2008 and Sun, 2008). By means of some mathematical transformations, this BS equation can be converted into a partial differential equation of heat conduction. In particular, the pricing problem of the American put premium forms a free boundary problem of this heat conduction equation, which kind of problem, the author of this paper had discussed 45 years ago (Wang, 1965 and 1980).

With China's financial reform in depth, in this century, Chinese scholars have strengthened the study on the theory of option pricing. Jiang Li Shang and his students are the most prominent, and they are also made a number of China’s financial (derivative) application of BS equation. (Jiang et al., 2008).

The author of this paper initiated the monetary potential theory in 2006, and succeeded in characterization of e-finance activities and transient characteristics of clicks. Determining the basic properties of various monetary potentials, especially after the introduction of direct value concept for single money potential and dual money potential, using their "jump " formula were solved many monetary circulation problems with different initial conditions and boundary conditions for the heat conduction equation (according to their financial significance, also known as the money circulation equation). (Wang, 1980, 2006; Wang et al., 2009).

Using the monetary potential theory can be calculated the European option and American option pricing and other options. From the financial point of view, these algorithms and solutions are more natural and intuitive, while for American put premium can be further found some important characteristics of financial nature: when the better the put situation in the stock market, then the higher the price of American put premium, in this case a buyer of American put option will get more payoff than a buyer of European put option with same conditions. The longer the exercise period, than any buyer of American put option has more selection, than the expansive the American put premium. When the price of American put premium is highest if the buyer of American put option exercises in this time then he can get the maximum payoff.

2. The Basic Concepts of Options. Options are the most basic of financial derivatives. Their price ultimately depends on the price of another underlying asset. Option is a selection right, the option holder offers his price to buy or sell the underlying asset in the appointed time, but assuming the no obligation to buy or sell. Call and put option are two common options. Option contract entered on the date of signing, option expiry date is the due date stipulated in the contract. According to different exercise freedom in the life of the option, can be distinguished the American option (can be exercised in any day before the contract expiry date) and the European option (exercised only in the contract expiry date).

European options firstly introduced by the London Futures Exchange; American options firstly introduced by the Chicago Board of Trade; China's capital market is only 20 years old, not yet launched options trading.

3. BS Equation (Model) and Its Simplified. Without loss of generality, we discuss a kind of (American or European) option, and take a stock (share`) as the underlying asset. In the stock market to do some assumptions (such as the no-arbitrage and risk neutral, and shares without dividends, etc.), the option (price) satisfies the following second order stochastic parabolic partial differential equation (Black and Scholes, 1973)

$$\partial F / \partial t + \frac{1}{2}\sigma^2 S^2 \frac{\partial^2 F}{\partial S^2} + rS\frac{\partial F}{\partial S} - rF = 0 \tag{1}$$

among them

$F(S,t)$: the price of an option;

$S = S(t)$: the underlying stock's price;

t : the time (signing date $t = 0$, expiry date $t = T$);

σ : the underlying stock price volatility; it is a constant;

r : the (risk-free) interest rate; it is a constant.

Equation (1) is called the BS equation (or model) in the plane (S,t) (in the coordinate system (S,t)), which can be transformed into a heat conduction equation.

To make replacement of variables in (1) and (1) will be simplified. To make dependent variable replacement firstly in (1).

Let $H(S,t) = F(S,t)\exp(-rt)$

The equation (1) will be changed to:

$$(\partial H/\partial t)\exp(rt) + rH\exp(rt) + \frac{1}{2}\sigma^2 S^2 \frac{\partial^2 H}{\partial S^2}\exp(rt) + rS\frac{\partial H}{\partial S}\exp(rt) - rH\exp(rt) = 0$$

Or

$$\partial H/\partial t + \frac{1}{2}\sigma^2 S^2 \frac{\partial^2 H}{\partial S^2} + rS\frac{\partial H}{\partial S} = 0;$$

Do replace the stock price variable

$$y = \ln S, \quad H(S,t) = H(e^y,t) = K(y,t);$$

equation (1) is into

$$\partial K(y,t)/\partial t + \frac{1}{2}\sigma^2 \frac{\partial^2 K(y,t)}{\partial y^2} + r\frac{\partial K(y,t)}{\partial y} = 0.$$

For eliminating the first order partial differential of $K(y,t)$ to y, do replacement contacting the stock price and the time independent variables.

$$w = y + \mathrm{r}t, K(y,t) = K(w - rt,t) = J(w,t).$$

Variation of the above equation is

$$\partial J(w,t)/\partial t + \frac{1}{2}\sigma^2 \frac{\partial^2 J(w,t)}{\partial w^2} = 0;$$

To make the above equation into an equation with unit coefficients, the final set is

$$x = \frac{\sqrt{2}}{\sigma}w, J(w,t) = J(\frac{\sigma}{\sqrt{2}}x,t) = M(x,t)$$

The mentioned above equation is into an equation with unit coefficients:

$$M(x,t)_{xx} + M(x,t)_t = \frac{\partial^2 M(x,t)}{\partial x^2} + \frac{\partial M(x,t)}{\partial t} = 0.$$

This is a (in the coordinate system (x,t)) reverse heat conduction equation with unit coefficients.

Finally, do the time change $T - t = \tau$, $M(x,t) = M(x,T-\tau) = Z(x,\tau)$,

The above cited equation is transformed (in the plane (x,τ), in the coordinate system (x,τ)) into a positive heat conduction equation with unit coefficients. This is the (simplified) BS equation (model):

$$Z(x,\tau)_{xx} - Z(x,\tau)_\tau = \frac{\partial^2 Z(x,\tau)}{\partial x^2} - \frac{\partial Z(x,\tau)}{\partial \tau} = 0. \qquad (2)$$

This is the BS equation in the plane (x,τ).

4. Initial Condition and Boundary Condition in (European or American) Option Pricing Problems.

4.1. Initial Condition in European and American Option Pricing Problems.

(1) The exercise conditions for European option and American option in the coordinate system (S,t) can be expressed in terms of the boundary conditions of equation (1).

In the plane (S,t), when $t=T$:

European call option (call right) exercise conditions are

$$F(S,T)=\max(0,S(T)-L) \tag{3}$$

where L is the agreed price (strike price) of exercise in the option contract.

If at $t=T$ the $S(T)$ is bigger (higher) than L, the option holder exercises his option and buys the share (underlying asset) with agreed price L, he gets payoff $S(T)-L$, then $F(S,T)=S(T)-L$;

If at $t=T$ the $S(T)$ is smaller (lower) than L, the option holder does not exercise his option and does not buy the share (underlying asset), he does not get any payoff, then $F(S,T)=0$;

European put option (put right) exercise conditions are

$$F(S,T)=\max(0,L-S(T)) \tag{4}$$

Where L is the agreed price (strike price) of exercise in the option contract.

If at $t=T$ the L is bigger (higher) than $S(T)$, the option holder exercises his option and sells his share (underlying asset) with agreed price L, he gets payoff $L-S(T)$, then $F(S,T)=L-S(T)$;

If at $t=T$ the L is smaller (lower) than $S(T)$, the option holder does not exercise his option and does not sell his share (underlying asset), he does not get any payoff, then $F(S,T)=0$;

The exercise conditions of American option are the same as shown above, but option holder can exercise option in any day before the termination. In what day is the best, to be detailed in following discussion?

(2) The exercise conditions for European option and American option in the coordinate system (S,t) can be expressed in terms of the initial conditions of equation (2) in the coordinate system (x,τ).

Utilizing the above mentioned variable transformations, the relationship between $F(s,t)$ and $Z(x,\tau)$ can be identified.

Because $H(S,t)=F(S,t)\exp(-rt)$, $H(S,t)=H(e^y,t)=K(y,t)$,

$$K(y,t)=K(w-rt,t)=J(w,t),\ J(w,t)=J(\frac{\sigma}{\sqrt{2}}x,t)=M(x,t),$$

therefore

$$F(S,t)=e^{rt}K(y,t)=e^{rt}J(w,t)=e^{rt}M(x,t)=e^{rt}Z(x,\tau)=e^{r(T-\tau)}Z(x,\tau).$$

In the above transformations, we obviously see that

$$S=e^y=e^{w-rt}=e^{\frac{\sigma}{\sqrt{2}}x-rt}\ ,\ \ x=\frac{\sqrt{2}}{\sigma}[\ln S+rt].$$

Thus, (3) is:

$$Z(x,0)=e^{-rT}F(S,T)=e^{-rT}\max(0,S-L)=e^{-rT}\max(0,(e^{\frac{\sigma}{\sqrt{2}}x-rT}-L))=f(L,x,T)\,. \quad (5)$$

(4) is converted to

$$Z(x,0)=e^{-rT}\max(0,(L-e^{\frac{\sigma}{\sqrt{2}}x-rT})=g(L,x,T)\,. \quad (6)$$

(5) and (6) can be regarded as the initial conditions of the equation (2) in the coordinate system (x,τ).

(3) For the European (call or put) option pricing problem, it need to solve the equation (1)with the initial conditions (3) (or (4)) (or to solve the equation (2) with the initial conditions (5) (or (6)).

As is well known on the American call option, to early exercise this kind of option before the expiry day is meaningless (Jiang, 2008). So, on the American call option, the same should solve the equation (1) with the condition (3) (or the equation (2) with the condition (5)).

As is well known too, the European (call or put) option pricing problem and the American call option pricing problem (problem (2, 5) or (2, 6)) can be all solved by means of the plane money potential. (Wang et al., 2009).

4.2. Boundary Conditions for American Put Option Pricing Problem. When discussing the American put option, the due date, and the exercise data has great significance. Clearly, only the put option buyer gets more payoffs that will exercise option before the expiry data. According to market principles of no arbitrage can be proved the existence of the American put option optimal exercise boundary Γ (its curve equation is $S=k(t),0\le t\le T$): it also known as a free boundary. Along this boundary (in the appropriate time and price determined by this boundary) to exercise option, option buyer can get greater benefits than to exercise option in the expiry date. Moreover, the partial derivative of option to the stock price along this boundary takes value of -1 (Wilmott et al., 1995; Zhu, 2006).

This is, the American put option pricing is concerned, except the equation (1) and initial condition (4), the solution should yet meet the (moving) boundary conditions (in the plane (S,t))

$$[F(S,t)\big|S=k(t)]=L-k(t) \quad (7)$$

$$[\partial F(S,t)/\partial S\big|S=k(t)]=-1 \quad (8)$$

The solution of the problem ((1),(4), (7),(8)) are the option price function $F(S,t)$ and the optimal exercise boundary function $k(t)$,which is called the optimal exercise price .

In the plane (S,t) constructing the fundamental solution of the BS equation (1) and decomposing the problem ((1),(4),(7),(8)) to two parts and using a nonlinear integral equation, this problem can be solved, but the final solution takes only a non analytical form (Jiang,2008).

In the plane (x,τ), because $x=\frac{\sqrt{2}}{\sigma}[\ln S+rt]$, therefore, the optimal American put option exercise boundary Γ can be expressed as $x=X(\tau)$,and

$$X(\tau) = \frac{\sqrt{2}}{\sigma}[\ln k(T-\tau) + r(T-\tau)] \tag{*}$$

$$k(t) = \exp[\frac{\sigma}{\sqrt{2}} X(\tau) - rt] \tag{**}$$

From these forms we can see that when $k(t)$ is known then $X(\tau)$ is known also and vice versa.

When to write the condition (7) in the plane (x,τ), we should pay attention to $F(S,t) = e^{r(T-\tau)} Z(x,\tau)$,therefore

$$[Z(x,\tau)|x = X(\tau)] = [e^{r(\tau-T)} F(S,t)|S = k(t)] = e^{r(\tau-T)}[L - k(T-\tau)] = A(\tau) . \tag{9}$$

When write the condition (8) in the plane (x,τ), we should note

$$\partial F / \partial S = [e^{r(T-\tau)}]\partial Z / \partial x[\partial x / \partial S] = [e^{r(T-\tau)}]\partial Z / \partial x[\frac{\sqrt{2}}{\sigma S}]$$

therefore, on Γ

$$\partial Z / \partial x = [e^{r(\tau-T)}]\partial F / \partial S[\frac{\sigma S}{\sqrt{2}}] = [e^{r(\tau-T)}]\frac{-\sigma S}{\sqrt{2}}. = \frac{-\sigma}{\sqrt{2}} e^{\frac{\sigma}{\sqrt{2}}x} = D(x,\tau)$$

Condition (8) can be written as:

$$[\partial Z / \partial x|x = X(\tau)] = [D(x,\tau)|x = X(\tau)] = B(\tau) . \tag{10}$$

4.3. American Put Option Pricing Problem Formulation (in the Plane (x,τ)). In the plane (x,τ) the American put option pricing problem (2,6,9,10) needs to find the option price and the optimal exercise boundary. This American put option pricing problem is one with dual boundary conditions ((9) and (10)) and single initial condition (6). The unknown boundary and the duality of the boundary conditions is the problem solving difficulty.

We will use the monetary potential theory to solve this problem (2,6,9,10). Founding $Z(x,\tau)$ and $X(\tau)$, according to the relationship between variables, we can find finally $F(S,t)$ and $k(t)$ to satisfy equation (1) and initial condition (4) and boundary conditions (7) and (8).

5. American Put Premium Pricing Problem (in the plane (x,τ)). The solving path of the American put option problem ((2), (6), (9), (10)) in the plane (x,τ) is: in view of the linear nature of equation (2), based on the principle of superposition, firstly using European put option problem solving method (Jiang,2008,Wang et al. 2009), the condition (6) will be transformed into an " zero initial value " condition, at this time, an American put option " auxiliary solution $Y(x,\tau)$ " satisfied equation (2) and the initial condition (6) will be found . The " auxiliary solution $Y(x,\tau)$ " meets

$$Y(x,\tau)_{xx} - Y(x,\tau)_{\tau} = 0$$

and initial condition (6): $Y(x,0) = g(L,x,T)$.

Then, finding the appropriate boundary conditions (9) and (10) change (note the new boundary conditions as conditions (A) and (B)), the American put option problem with "non- zero initial value" is changed into a new American put option problem with the "zero initial value".

This "zero initial value" American put option problem, also known as the American put option problem by paying the premium issue, paying the premium is due to possibility to early exercise option (earlier than maturity); this problem is referred as the American put premium (by payment of the premium) problem. We will write down this "zero initial value" problem of American put premium.

merican put premium

$$W(x,\tau) = Z(x,\tau) - Y(x,\tau)$$

meets the heat conduction equation with unit coefficients

$$W(x,\tau)_{xx} - W(x,\tau)_{\tau} = 0, \quad 0 \le \tau \le T, X(\tau) \le x < \infty \quad , \tag{11}$$

and boundary conditions

$$\begin{cases} \mathrm{W}(X(\tau),\tau) = \varphi(\tau) = A(\tau) - Y(X(\tau),\tau), 0 \le \tau \le T, (A) \\ \mathrm{W}_x(X(\tau),\tau) = \psi(\tau) = B(\tau) - Y_x(X(\tau),\tau), 0 \le \tau \le T, (B) \end{cases}, \tag{12}$$

and zero initial condition

$$W(x,0) = 0, X(0) \le x < \infty . \tag{13}$$

The new boundary conditions $\varphi(\tau)$ and $\psi(\tau)$ in (12) are obtained on base of the original boundary conditions (9) and (10) and the corresponding values on the boundary Γ of the auxiliary solution $Y(x,\tau)$. (And, $\varphi(0) = 0$, it said that the initial condition (13) and the first boundary condition in (12) are coordinated.).

6. To Solve the American Put Premium Pricing Problem Using the Monetary Potential Theory. According to the monetary potential theory Wang (2006) (please see the appendix), the solution of the problem (11,12,13) can be written as a single money potential distributed on Γ:

$$W(x,\tau) = V_{\Gamma}(\theta) = \int_0^{\tau} \theta(\eta) G(x,\tau; X(\eta),\eta) d\eta \tag{14}$$

here

$$G(x,\tau;\xi,\eta) = \frac{1}{2\sqrt{\pi(\tau-\eta)}} \exp[-\frac{(x-\xi)^2}{4(\tau-\eta)}] \tag{15}$$

is the money influence function (i.e., the fundamental solution of the heat conduction equation (2) (or 11) with unit coefficients). θ is the density of single money potential $V_{\Gamma}(\theta)$ (14). From the monetary potential theory we know that the single money potential $V_{\Gamma}(\theta)$ meets the equation (11) and the "zero initial value" condition (13) (Wang, 1965; 1980).

According to the "jump" formula for the direct value of partial derivatives of single money potential to space variable, to satisfy the second condition (B) in condition (12), on the Γ for the density θ of the single money potential there should be validated a linear Volterra integral equation of second type:

$$\psi(\tau) = \theta(\tau)/2 + \int_0^{\tau} \theta(\eta) K(X(\tau),\tau; X(\eta),\eta) d\eta \tag{16}$$

among

$$\int_0^\tau \theta(\eta)K(X(\tau),\tau;X(\eta),\eta)d\eta = \int_0^\tau \theta(\eta)[\partial G(X(\tau),\tau;X(\eta),\eta)/\partial\xi]d\eta$$

is the direct value on Γ of the partial derivative to space variable of the single money potential $V_\Gamma(\theta)$. (Wang, 1965; 1980; 2006) Integral equation (16) is

$$\theta(\tau) = 2B(\tau) - \int_0^\tau \frac{\theta(\eta)(X(\tau)-X(\eta))}{2\sqrt{\pi(\tau-\eta)^3}} \exp[-\frac{(X(\tau)-X(\eta))^2}{4(\tau-\eta)}]d\eta - 2Y_x(X(\tau),\tau) \qquad (17)$$

As $X(\tau)$ is known, this is a linear integral equation for $\theta(\tau)$.

To satisfy the first condition (A) in conditions (12), there is written an equation under this condition:

$$\mathrm{W}(X(\tau),\tau) = \varphi(\tau) = V_\Gamma(\theta) \mid x = X(\tau) \qquad (18)$$

Integral equation (18) is

$$A(\tau) = Y(X(\tau),\tau) + \int_0^\tau \frac{\theta(\eta)}{2\sqrt{\pi(\tau-\eta)}} \exp[-\frac{(X(\tau)-X(\eta))^2}{4(\tau-\eta)}]d\eta \qquad (19)$$

As $\theta(\tau)$ is known, this is a nonlinear integral equation for $X(\tau)$.

Equation (17) and equation (19) compose a simultaneous nonlinear integral equation system of two unknown functions $X(\tau)$ and $\theta(\tau)$. Solved $X(\tau)$ and $\theta(\tau)$ by this equation system and, then substituted into (14), we get solution $W(x,\tau)$ of American put premium problem with "zero initial value"; re-considering superposition of European put option auxiliary solution $Y(x,\tau)$, we ultimately get the solution $Z(x,\tau) = W(x,\tau) + Y(x,\tau)$ of American put option problem (2,6,9,10).

As the highly nonlinear nature, it is difficult to obtain the explicit analytical solution of (17) and (19).

However, there is extensive literature to research their approximate solution and the nature of optimal exercise boundary.

However, by means of expressions (17) and (19), we can get a number of qualitative information and then strengthen some knowledge of financial nature about the American put premium.

Using the tools provided in the monetary potential theory, we can also discuss other types of option pricing problems.

7. Some Financial Nature of American Put Premium. The (20) shows that in the plane $(x.\tau)$ the American put premium $W(x,\tau)$ can be expressed as a single money potential distributed on the optimal exercise boundary Γ with the density θ, i.e. as a money influence function of a money source with intensity θ and continuously acting along Γ.

$$W(x,\tau) = \int_0^\tau \frac{\theta(\eta)}{2\sqrt{\pi(\tau-\eta)}} \exp[-\frac{(x-X(\eta))^2}{4(\tau-\eta)}]d\eta \qquad (20)$$

At this time, θ is known as the American put premium density. The relationship between the American put premium and its density is shown by (20). Clearly, American put premium prices can be estimated with the maximum value of its density in the period of option exercise.

As is well known, the stock price and time plane (x,τ)(or(S,t)) is divided by the optimal exercise boundary Γ into two parts Σ_1 and Σ_2, in the Σ_1, the option buyer shall continue to hold option contract and in Σ_2 the option holder shall terminate the option contract. To continue to hold and the termination of possession are two different (economic) behaviors, which is separated (divided) by the boundary line Γ. Other words, the option buyer does not act continuously through this line Γ, while, on Γ buyer's behavior reveals a "jump".

Similarly, as is well known (20) is the single money potential distributed on Γ with density θ, its partial derivatives to the space (stock price) variable also has in the cross Γ a "jump", that is, the difference of the limit values of this derivative on both sides of Γ is precisely equal to the density θ of this single money potential.

As a result, the change of American put premium $W(x,\tau)$ on the stock market (that is, its partial derivatives to the price) is continuous in the both sides of optimal exercise boundary Γ and on Γ there is shown a "jump." The value of this "jump" is just the density θ of this American put premium. This "jump" is precisely corresponding with the "jump" of the option buyer's behavior.

(20) also shows that when bearish stock market is better, and put situation is more clear, namely, the smaller is x in (20) (and therefore also smaller is S), then obviously, the greater is the corresponding value W. That is to say: when the stock market is better put, the American put premium price will more expensive. Therefore, the purchase of American put option than to buy European put option with the same conditions can gain more income, so the purchase of American put option should be paying more premium.

By (20) is also not difficult to see, for the same x, the bigger is T, then the higher is the corresponding value $W(x,T)$. That is, the longer the period of option exercise, option buyers have more choices to get more revenue, therefore, to meet more buyers premium.

The American put premium $W(x,\tau)$ satisfies equation (2). According to the maximum principle for heat conduction equation, the maximum of $W(x,\tau)$ is reached on the Γ.

Let $W(x_0,\tau_0)=\max W(x,\tau)$, then $x_0 = X(\tau_0),(x_0,\tau_0)\in\Gamma$.
Obviously, in the time τ_0 and in the share price

$$S = S_0 = \exp(\frac{\sigma}{\sqrt{2}}x_0) - r(T-\tau_0) \quad \text{(corresponding to } x_0\text{)}$$

will be the highest American put premium price. If the American put option buyer exercises option at this time, he will receive the maximum benefit (payoff).

8. Similarity between the Money Circulation Problem and the Option Pricing Problem. Stock (or other underlying assets) trading is as money putting and withdrawing. From stock market trading are derived options, from money putting and withdrawing is derived money circulation.

Stock price does not take negative, do not take negative also money values, the stock market, like the money market, all are discussed with non negative time value: that, the money circulation problem and the option pricing problem have the same time domain of definition.

Microscopic randomness of stock trading as microscopic randomness in money putting and withdrawing, then in the macro aspect they can be characterized and studied by means of the same methods and by means of second-order stochastic parabolic partial differential equations.

The option pricing has initial value problem (such as the European option pricing problem), money circulation has the issue also; the option pricing has boundary value problem (such as the American option pricing problem), the money circulation has boundary value problem too.

The different economic and financial policies will affect the circulation of money; similarly, the different economic and financial policies will also affect option pricing. Option pricing and money circulation, in essence, are the financial activities and financial processes, the essence of consistency determines the consistency of their study methods. The monetary potential theory is a powerful tool to study the money circulation, naturally the option pricing also.

Many natural phenomena or processes have both "now", another "past" and "future" and their "now", "past" and "future" can be observed and measured simultaneously. The process of their change and evolution over time has rules to follow. Water flow process and some of the meteorological processes are such. These phenomena or processes, mathematically, often described and analyzed by hyperbolic partial differential equations.

For some natural phenomenon or process, for some financial activities, cannot simultaneously observe their "now", "past" and "future." For these phenomena or processes or activities, in finding their change and evolution over time and according to their "last" record and "now" situation may infer their "future", these phenomena or processes, mathematically, often studied with the use of parabolic partial differential equations: you can use the parabolic partial differential equations, from the "past" and "now" of some process conclude its "future," predict its "future."

Option pricing, in a sense, is a stock market prediction and forecasting.

The phenomenon or process or activity described by parabolic partial differential equations are an irreversible process in time order, it is impossible to repeat and reproduce this process. Molecular motion caused by heat conduction, thermal diffusion and thermal convection are such processes. Electronic money movement, particularly movement of bank notes, stock trading process, and option price change process, are very much like the thermal motion of molecules. They have the same random micro; their macro can be used in parabolic partial differential equations.

Financial activities in human society is exactly such irreversible process, that is impossible to make money once again flows and option pricing through various states in their development process in completely opposite chronological order.

In a parabolic partial differential equation, time variable and space variables are asymmetric, roughly speaking, the one time derivative to time variable of financial activities (currency in circulation, option pricing and other financial process) is equivalent to two times derivative to space variables. Thus, in these activities, the time variable is more “valued” variable. In fact, in economic and financial activities, we often feel that time is more important than space, "time is life", "time is money," "time is efficiency" have been become the motto of economic and financial activities. (When in the stocks market to buy shares, futures, options and other financial products, the key is to seize the opportunity to sign orders and contract, but not in that place, in that the securities or futures companies).

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Appendix.

Brief introduction of the monetary potential theory (Wang, 2006).

If at a moment t and in a place x is put (or withdrawn) money, then we say that at this moment t and in this place x there is a money source. The money amount put (or withdrawn) by some money source in a unit of time and in a unit of area around this source is called the intensity of this source.

Suppose that in the place x there is a put source of money, which continuously acts in the time interval $0 \le t \le T$. If in a unit of time this source continuously puts money $f(t)$, then we say that in this place there is a continuously acting money source with the intensity $f(t)$.

The money influence function for continuous from the moment $t = 0$ to the moment

$$\int_0^t f(\tau)G(x,t,0,\tau)d\tau = V[\mu] = V(x,t)$$

t acting of this money put source is here

$$G(x,\tau;\xi,\eta) = \frac{1}{2\sqrt{\pi(\tau-\eta)}}\exp[-\frac{(x-\xi)^2}{4(\tau-\eta)}]$$

is the money influence function (i.e., the fundamental solution of the heat conduction equation (2) with unit coefficients)

This integral $V[\mu]$ is called the single money potential, $\mu = f(t)$ is its density.

It is easy to test that when

$0 < t \le T, x \ne 0$

This single money potential satisfies the heat conduction equation with unit coefficients.

$V_{t=0} = [V_x]_{t=0} = 0$

Obviously, We can define the direct value on the line $x = 0$ of single potential derivative to x and introduce its jump formula.

Jump formula for the derivative to x of the single money potential

$$\overset{+}{\underset{-}{}} V_{x\lim}(0, t0) = \frac{-\mu(t0)}{+\quad 2}, t0 > 0$$

here,（＋）means that （x, t）tends to（0，t_0）on the strait line ($x = 0$) from its right side；（－）means that （x, t）tends to（0，t_0）on the strait line from its left side.

STOCHASTIC FRONTIER ANALYSIS WITH FAT-TAILED ERROR MODELS APPLIED TO WHO HEALTH DATA

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ABSTRACT. *The stochastic frontier analysis (Aigner, Lovell and Schmidt, 1977; Meeusen and van den Broeck, 1977) has been widely used to estimate technical efficiency of firms. The basic idea lies in the introduction of a composed error term consisting of a noise V and an inefficiency term U. From there, technical efficiency of each firm is estimated by utilizing distributional assumptions on the two error components. In the literature, V is usually assumed to be normally distributed and the distribution of U can be exponential, truncated normal or Gamma. In this study, we will consider Cauchy-Half Cauchy model which is more realistic than the existing models in accounting for heavy-tailed data and accommodating outliers under both cross-sectional and panel data. We apply the models to two data sets: U.S. electric utility industry data and WHO health data for illustration.*

Keywords: Technical Efficiency; Stochastic Frontier Analysis; Estimation; Fat-tailed Models; Maximum Likelihood Method; Cross-sectional Data; Panel Data

1. Introduction. Stochastic frontier analysis originated with two papers of Meeusen and van den Broeck (1977) and Aigner et al. (1977). One of the most important purposes of stochastic frontier analysis is to measure efficiency of a firm. In the context of stochastic frontier analysis, technical efficiency can be measured as the ratio of the realized output to the potential output. The basic idea lies in the introduction of a composed error E = V - U term consisting of a noise V and an inefficiency term U, which capture the effects of statistical noise and the effects of technical inefficiency, respectively. Then in order to estimate technical efficiencies of firms, distributional assumptions are assigned to both V and U. Utilizing the distributional assumptions, one can estimate all parameters of the model by the Maximum Likelihood method. Then central measures such as the mean or the mode of the conditional distribution U|E can be used to obtain estimates of the technical efficiency of each producer in the sample, Jondrow et al. (1982). This approach can be used under both cross-sectional and panel data.

It is well known that in economics and finance, the data usually evidence "fat tail" and in this case the Normal distribution is not a good model to use. In this paper, we consider the Cauchy-Half Cauchy model that allow for the possibility of heavy tail data. This model will be considered under both cross-sectional and panel data. In both cases, U and V are assumed to be independent.

The remainder of this paper is organized as follows: Section 2 provides a brief description of the model and the estimation procedure. Section 3 considers the Cauchy-Half Cauchy model under cross-sectional data. Section 4 is devoted to the Cauchy-Half Cauchy model under panel data. In Section 3 and Section 4, applications to the U.S. electric utility data and the WHO health data are provided for illustrations. Finally, Section 5 concludes the paper.

2. Modeling and Estimation Procedure. We begin by assuming that we have a balanced panel data set with observations on I producers, indexed by i = 1,…, I, through T time periods, indexed by t = 1,…, T. The case where T = 1 implies the model under cross-sectional data. A Cobb-Douglas production frontier with time-invariant technical efficiency (see Kumbhakar and Lovell (2000) for details) is written as:

$$\ln y_{it} = \beta_0 + \sum_{n=1}^{N} \beta_n \ln x_{nit} + V_{it} - U_i$$

To build a stochastic production frontier, we incorporate producer-specific random shocks on each producer. The stochastic production frontier is written as:

$$y_{it} = f(x_{it};\beta)\cdot \exp(V_{it})\cdot TE_i \tag{1}$$

Where βs are parameters in the production function and [f(xit; β).exp(Vit)] is the stochastic production frontier, Vit; i = 1,…, I; t = 1,…, T reflects random noise and TEi is the time-invariant output-oriented technical efficiency of producer i; i = 1,…, I. From (1), we have:

$$TE_i = \frac{y_{it}}{f(x_{it};\beta)\cdot \exp(V_{it})} \tag{2}$$

which defines the technical efficiency as the ratio of the observed output to the maximum possible output f(xit; β).exp(Vit) under the condition of the random shocks exp(Vit).

Next, assuming that f(xit; β) takes the log linear Cobb-Douglas form, we write:

$$TE_i = \exp\{-U_{it}\} \tag{3}$$

where Ui is the technical inefficiency error component. Since we require that TEi ≤ 1, Ui ≥ 0. Then the stochastic production frontier becomes:

$$\ln y_{it} = \beta_0 + \sum_{n=1}^{N} \beta_n \ln x_{nit} + V_{it} - U_i \tag{4}$$

Let Eit = Vit-Ui, then this model is usually referred to as a “composed error” model since the error term has two components.

From equation (4), note that Vit and Ui are two components of the composed error term Eit and there is no way to distinguish the two. A solution to this problem under the context of cross-sectional data was proposed by Jondrow et al. (1982) where distributional assumptions are imposed on both error components and then the conditional U|E could give us the information on the technical efficiency of each firm. Under the context of panel data, the conditional distribution of Ui|Eit;t=1,…,T can be derived and since Eit;t=1,…,T contains information on Ui, the conditioning will extract this information. Then an estimate of the technical efficiency of producer i is obtained by TE1i = exp{-E(Ui|Eit;t=1,…,T)}; or TE2i = E(exp{-Ui|Eit;t=1,…,T), which can be obtained by substituting the estimates of all parameters into the expression of E[-Ui|Eit;t=1,…,T] or E[exp{-Ui|Eit;t=1,…,T]. The parameters in the model are estimated using the Maximum Likelihood method.

3. MLE under Cross-Sectional Data. In this section, we assume that Vi is distributed as The expressions for E(Ui|Ei) and E(exp{-Ui|Ei}), i = 1,…, I for this case are:

$$M_i = (\sigma_v^2 - \sigma_u^2 + \varepsilon_i^2)^2 + 4\varepsilon_i^2\sigma_u^2$$

$$M_i' = 6[\varepsilon_i^4 + (\sigma_u^2 - \sigma_v^2)^2 + 2\varepsilon_i^2(\sigma_v^2 + \sigma_u^2)]$$

$$K_i = M_i * [\varepsilon_i \ln\frac{\sigma_u^2}{\sigma_v^2 + \varepsilon_i^2} + \frac{\pi(\sigma_v + \sigma_u)[(\sigma_v - \sigma_u)^2 + \varepsilon_i^2]}{2\sigma_v\sigma_u} + \frac{\sigma_v^2 - \sigma_u^2 - \varepsilon_i^2}{\sigma_u}\tan^{-1}(\frac{\varepsilon_i}{\sigma_v})]^{-1}$$

$$E_i = [\varepsilon_i^2(-6 + \sigma_u^2) - 3\varepsilon_i^2(-2 + \sigma_u^2) + 3(-2 + \sigma_u^2)(\sigma_u^2 - \sigma_v^2)] * M_i'^{-1}$$

$$F_i = [2\varepsilon_i\sigma_u^2(-6 + \sigma_u^2) - 3\varepsilon_i^2(-2 + \sigma_u^2) + 3(-2 + \sigma_u^2)(\sigma_u^2 - \sigma_v^2)] * M_i'^{-1}$$

$$G_i = [-\varepsilon_i^4 - 6\varepsilon_i(-2 + \sigma_u^2) + \varepsilon_i^2(6 - 3\sigma_u^2 - 2\sigma_v^2) + (\sigma_u^2 - \sigma_v^2)(-6 + \sigma_v^2)] * M_i'^{-1}$$

$$H_i = -[-3\varepsilon_i^4 + 2\varepsilon_i^2(-6 + \sigma_u^2) + 2\varepsilon_i(-6 + \sigma_u^2)\sigma_v^2 + 3(\sigma_u^2 - \sigma_v^2)(-2 + \sigma_v^2) + 3\varepsilon_i^2(\sigma_u^2 - 2(3 + \sigma_v^2))] * M_i'^{-1}$$

By substituting the estimates of all parameters into E[Ui|Ei] and E[exp{-Ui|Ei}], we have $2i$ for the technical efficiency of firm i, i = 1,…, I.

Application to the U.S electric utility data set: As an illustration, we will apply the model to a real data set of the U.S. electric utility industry. It contains 123 observations on

$$\ln(\cos t / P_f) = \beta_0 + \beta_1 \ln Q + \beta_2(\ln Q)^2 + \beta_3 \ln(P_l / P_f) + \beta_4 \ln(P_k / P_f) + E$$

Cost, Output (Q), Price of Labor (Pl), Capital (Pk) and Fuel (Pf) to be used in the production of the output. This data set was considered in Greene (1990). Because the data set is on cost rather than production, the model to be fitted is the cost function. The homogeneous cost function is as follow:

Since we estimate the cost frontier rather than the production frontier, the composed error E now is V +U rather than V - U. As a result, some minor changes are required in the results and derivations above. In particular, the sign of ε will change throughout the derivation.

The likelihood function is maximized using “optim” command in R to obtain the estimates for all the parameters in the model, and then the estimates for technical efficiency 2. The ranking of all firms can be found in Gupta and Nguyen (2010a). Table 1 summarizes some basic statistics of the estimates for technical efficiency of all firms. The two estimates are very close. On average, the total cost was increased by 2% comparing to the minimum cost. The most efficient firm has its total cost being increased by 1% and the least efficient one is has its total cost being increased by about 12% compared to the minimum cost.

TABLE 1. Basic statistics of estimates for technical efficiency using U.S. electricity data

	TE1	TE2
Min	0.892152	0.908125
Max	0.988146	0.98834
Mean	0.976764	0.9779

4. Cauchy-Half Cauchy Model Under Panel Data. In the previous section, we derive the Cauchy-Half Cauchy model to measure technical efficiencies of firms in the case of cross-sectional data. In this section, we will derive the Cauchy-Half Cauchy model to account for panel data.

We first assume that we have observations on I producers, indexed by i = 1,…, I, where each producer is observed through Ti; i = 1,…, I time periods, indexed by t = 1,…, Ti. If Ti are the same for all i, we have the case of balanced panel data. In reality, the missing observation(s) can be in any time period(s). In other words, the set of indices of the available observations is a subset of 1,…, T where T = maxi=1,…,I Ti. In this case, we will need to re-index these subscripts to 1,…, Ti for i = 1,…, I. This will not affect the analysis since we consider models with time-invariant technical efficiency and the production/cost frontiers are assumed to have a fixed functional form over time.

To obtain the Maximum Likelihood estimates, we assume:

Ui and Vit are distributed independently of each other, and of the regressors.The procedure is performed as in Section 2, consisting of deriving E(Ui|Ei):

$$E(U_i \left| E_{it;t=1,\dots,T_i} \right.) = \frac{1}{K_i}\{\sum_{t=1}^{T_i}\frac{A_t'}{2}\ln\frac{\sigma^2}{\varepsilon_{it}^2+\sigma^2}+\frac{\pi}{2\sigma}[B_0'+\sum_{t=1}^{T_i}(-A_t'\varepsilon_{it}+B_t']+\sum_{t=1}^{T_i}\frac{A_t'\varepsilon_{it}-B_t'}{\sigma}\tan^{-1}(\frac{\varepsilon_{it}}{\sigma})\} \tag{5}$$

where A’0, B’0 , A’1,…, A’Ti, and B’1 ,…, B’Ti are:

$$A_0' = \lim_{u_i\to\infty}\frac{R_{01}'(u_i+j\sigma)+R_{02}'(u_i-j\sigma)}{u_i}$$

$$B_0' = R_{01}'(u_i+j\sigma)+R_{02}'(u_i-j\sigma)\Big|_{u_i=0}$$

$$A_t' = \lim_{u_i\to\infty}\frac{R_{t2}'(u_i+\varepsilon_{it}-j\sigma)+R_{t1}'(u_i+\varepsilon_{it}+j\sigma)\Big|_{u_i=0}}{u_i}, t=1,\dots,T_i$$

$$B_t' = R_{t2}'(u_i+\varepsilon_{it}-j\sigma)+R_{t1}'(u_i+\varepsilon_{it}+j\sigma)\Big|_{u_i=0}, t=1,\dots,T_i$$

$$j=\sqrt{-1}; R_{01}' = (u_i-j\sigma)F'\Big|_{u_i=j\sigma}; R_{02}' = (u_i+j\sigma)F'\Big|_{u_i=-j\sigma}$$

$$R_{t1}' = (u_i+\varepsilon_{it}-j\sigma)F'\Big|_{u_i=-\varepsilon_{it}+j\sigma}; R_{t2}' = (u_i+\varepsilon_{it}+j\sigma)F'\Big|_{u_i=-\varepsilon_{it}-j\sigma}, t=1,\dots,T_i$$

where

$$F' = \frac{u}{(u_i^2 + \sigma^2)\Pi_{t=1,\dots,T_i}((u_i + \varepsilon_{it})^2 + \sigma^2)}$$

$$K_i = \sum_{t=1}^{T_i} \frac{A_t}{2} \ln \frac{\sigma^2}{\sigma^2 + \varepsilon_{it}^2} + \frac{\pi}{2\sigma}[B_0 + \sum_{t=1}^{T_i}(-A_t\varepsilon_{it} + B_t)] + \sum_{t=1}^{T_i} \frac{A_t\varepsilon_{it} - B_t}{\sigma} \tan^{-1}(\frac{\varepsilon_{it}}{\sigma})$$

and where A0, B0, A1,…, ATi , and B1,…, BTi are defined as A’0, B’0, A’1,…, A’Ti , and B’1,…,B0Ti with F0 being replaced by:

$$F = \frac{1}{(u_i^2 + \sigma^2)\Pi_{t=1,\dots,T_i}((u_i + \varepsilon_{it})^2 + \sigma^2)}$$

Application to the WHO data on efficiency of the health sector as an illustration. We will apply the model to the WHO data set. This data set was used by Tandon et al. (2000) and Greene (2003) and other authors as well. The full data set is an unbalanced panel of data collected from the 191 member countries of the WHO from 1993 to 1997. We will consider the outcome variable COMP, which is the composite measure of success in 5 health goals. Two variables are modeled as the input variables of the production process of health care attainment are: Health expenditure per capita in 1997 ppp$ (HEXP) and Average years of schooling (EDUC).

The reduced translog functional form was used for the production function:

$$\ln COMP = \beta_0 + \beta_1 \ln HEXP + \beta_2 \ln EDUC + \beta_3 (\ln EDUC)^2 + E$$

TABLE 2. Ranking of countries in terms of health attainment effectiveness

Rank	Country	WHO Rank
1	Japan	10
2	Malta	5
3	Philippines	60
4	Singapore	6
5	Spain	7
…		
41	Canada	30
81	United States of American	37
…		
188	South Africa	175
189	Nigeria	187
190	Sierra Leone	191
191	Central Africa	189

Applying the Cauchy-Half Cauchy model using unbalanced panel data, the log likelihood function is maximized numerically to obtain the estimates of the parameters in the model. Then we compute the estimates for the technical efficiency $exp\ -\quad Ui|\quad i;\quad 1, \ldots,\quad i$ of each country and rank all countries with respect to health production effectiveness. The full ranking of all countries can be found in Gupta and Nguyen (2010b). The ranks of some countries are given in the first column of Table 2. The ranking of these countries produced by WHO researchers (Tandon et al., 2000) is also included in column three for comparison purposes. The two rankings are significantly different. For example, the most efficient country in health attainment according to WHO researchers was France, which is now ranked 29th. The least efficient country according to WHO ranking was Sierra Leone, which is now ranked 189th.

5. Conclusions. In this paper, we considered models to estimate technical efficiency of firms. Expressions to find point estimates for technical efficiency are provided. These models result in different sets of technical efficiency estimates compared to the existing models. Furthermore, the models proposed in this paper allow possibility of accounting for heavy-tailed data and accommodate outliers. The models are derived under both cross-sectional and panel data. In each case, an application to a real data set is presented.

Note that in this paper, we only consider technical efficiency with the assumption that all firms are allocatively efficient, i.e., the firms are able to choose the right combinations of inputs given the prices of inputs. This assumption might not hold and can be investigated in further study.

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MULTISTEP-AHEAD PREDICTORS FOR A GAUSSIAN AR(1) PROCESS WITH ADDITIVE OUTLIERS FOLLOWING THE UNIT ROOT TESTS

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ABSTRACT. *Recent works of Diebold and Kilian (2000) and Niwitpong (2007, 2009) indicated that a one-step-ahead predictor for an AR(1) process can be improved by using the preliminary unit root tests. This paper extends these mentioned concepts to the multistep-ahead predictors of a Gaussian AR(1) process with additive outliers. The following predictors are considered: the standard predictor, the predictor following the Dickey-Fuller unit root test, and the predictor following the Shin et al. (1996) unit root test. The relative efficiencies of all predictors based on the prediction mean square error are compared through simulation studies. Simulation results have shown that the unit root test can improve the preciseness of the multistep-ahead predictors for a near non-stationary AR(1) process with additive outliers.*

Keywords: AR(1) Process; Additive Outliers; Predictor; Unit Root Test

1. Introduction. Outliers, or aberrant observations, in a time series can have adverse effects on parameter estimation including prediction. Fox (1972) proposed two parametric models for studying outliers in a time series. He defined additive outliers (AO) and innovations outliers (IO). In this paper, we focus solely on the additive outliers because these outliers are more hurtful than innovations outliers (2001). Let $\{X_t\,; t = 2,3,...,n\}$ be the first-order autoregressive process, AR(1), satisfying

$$X_t = \mu + \rho(X_{t-1} - \mu) + e_t, \tag{1}$$

where μ is the mean of the process, ρ is an autoregressive parameter, $\rho \in (-1,1)$, and e_t is a sequence of independent and identically distributed $N(0,\sigma_e^2)$ random variables. If $\rho = 1$, then the model (1) is called the random walk model and hence non-stationary. The random walk model is given by

$$X_t = X_{t-1} + e_t. \tag{2}$$

However, if $|\rho| < 1$, then it can be shown that the process is stationary. For a near non-stationary process, i.e. $|\rho| \to 1$, the mean, variance and autocorrelation function of this process are not constant through time. An observed time series Y_t has an additive outlier at time T of size δ if it satisfies $Y_t = X_t + \delta I_t^{(T)}$, where $I_t^{(T)}$ is an indicator variable such that $I_t^{(T)} = 1$ if $t = T$, and $I_t^{(T)} = 0$ if $t \neq T$.

In practice, a major problem is to distinguish between a process which is stationary and one which is non-stationary. The unit root test can be used in order to select between these two processes. Namely, if the unit root test does not reject the null hypothesis; $H_0 : \rho = 1$ against the alternative hypothesis; $H_a : \rho < 1$, we can conclude that this time series is a random walk model. Nevertheless, if the null hypothesis H_0 is rejected, then the suitable model for this time series is the stationary model. Diebold and Kilian (2000) and Niwitpong (2007, 2009) applied the mentioned concepts of the unit root test in order to improve the predictor for an AR(1) process with trend and one with drift, when ρ is close to unity, respectively. Moreover, these authors also indicated that the preliminary unit root tests may help to improve a predictor from a near non-stationary and a non-stationary process. Therefore, our main aim in this paper is to extend these ideas of aforementioned authors for multistep-ahead predictors of model (1) when ρ is close to one and there are additive outliers in a time series.

The rest of the paper is organized as follows. In Section 2, we review the standard multistep-ahead predictor for a Gaussian AR(1) process. Section 3 proposes the multistep-ahead predictor for a Gaussian AR(1) process following the Dickey and Fuller (1979) (DF hereafter) unit root. Section 4 deals with the multistep-ahead predictor for a Gaussian AR(1) process following the Shin et al. (1996) (SSL hereafter) unit root test. In Section 5, we conduct simulations to investigate the performances of the proposed multistep-ahead predictors. All predictors are illustrated and compared through economic application in Section 6. Conclusions are presented in the final section.

2. Standard Multistep-Ahead Predictor for a Gaussian AR(1) Process. We review the standard multistep-ahead predictor $Y_n(\ell)$ based on data $Y_1,...,Y_n$. If we know the parameters (μ,ρ) of the model, then the optimal predictor is $\mu + \rho^{\ell}(Y_n - \mu)$. However, in practice we do not know the parameters (μ,ρ). Estimate the unknown (μ,ρ) by the estimators $(\hat{\mu},\hat{\rho})$. Hence, the estimated multistep-ahead predictor for $Y_n(\ell)$ is $\hat{Y}_n(\ell) = \hat{\mu} + \hat{\rho}^{\ell}(Y_n - \hat{\mu})$, where $\hat{\mu} = \overline{Y}$ and $\hat{\rho}$ is the estimator of ρ. For case of additive outliers, the ordinary least squares (OLS) estimator not only lacks robustness in terms of variability but also suffers from severe bias problems, Guo (2000). Furthermore, Conover (1980) pointed out that the OLS estimator was sensitive to outliers (see Section 5.5). Denby and Martin (1979) proposed a generalized M-estimator to estimate the first-order autoregressive parameter. However, the calculation of Denby and Martin's M-estimator is very complex. In this paper, we use the simple and robust estimator of ρ proposed by Guo (2000), which is denoted by $\hat{\rho}_G$. The Guo's estimator is defined as follows

$$\hat{\rho}_G \quad = \quad \text{median}(B_i), \quad i = 2,3,...,n,$$

where $B_i = Y_i / Y_{i-1}$. Thus, the standard estimated multistep-ahead predictor for $Y_n(\ell)$ is

$$\hat{Y}_n^S(\ell) = \hat{\mu} + \hat{\rho}_G^{\ell}(Y_n - \hat{\mu}). \tag{3}$$

3. Multistep-Ahead Predictor for a Gaussian AR(1) Process Following the DF Unit Root Test. A near non-stationary AR(1) process with ρ close to one will give a similar one-step-ahead predictor to those from a random walk model. However, the multistep-ahead predictors from these two models are quite different. Thus, we use the testing for a unit root to select between these models and then we use the result of the hypothesis testing to construct a multistep-ahead predictor for model (1). The null hypothesis; H_{01} and the alternative hypothesis; H_{a1} are as follows:

$$H_{01} : \rho = 1$$

and

$$H_{a1} : \rho < 1.$$

One of the two unit root tests which was proposed by Dickey and Fuller Guo (1979) uses the test statistic

$$\hat{\tau} = \frac{\hat{\rho}_G - 1}{SE(\hat{\rho}_G)}, \tag{4}$$

where $SE(\hat{\rho}_G) = \dfrac{\hat{\sigma}_e}{\sqrt{\sum_{t=2}^{n}(Y_{t-1}-\overline{Y})^2}}$ and $\hat{\sigma}_e^2 = \dfrac{\sum_{t=2}^{n}(Y_t - \overline{Y} - \hat{\rho}_G(Y_{t-1}-\overline{Y}))^2}{n-2}$.

The percentiles for the empirical of $\hat{\tau}$ given in (4) were constructed using simulation. They are shown in an Appendix. If H_{01} is rejected then the predictor for $Y_n(\ell)$ of model (1) is $\hat{Y}_n^S(\ell)$ given in (3). If H_{01} is not rejected, we propose the predictor for $Y_n(\ell)$ following the result of the unit root test. The predictor is developed based on the random walk model when H_{01} is not rejected. Namely, the optimal predictor for $Y_n(\ell)$ of random walk model is Y_n. Thus, the estimated multistep-ahead predictor following the result of the DF unit root test for $Y_n(\ell)$ is

$$\hat{Y}_n^{DF}(\ell) = \begin{cases} \hat{\mu} + \hat{\rho}_G^{\ell}(Y_n - \hat{\mu}) & \text{; If } H_{01} \text{ is rejected } (\rho<1), \\ Y_n & \text{; If } H_{01} \text{ is not rejected } (\rho=1). \end{cases} \tag{5}$$

4. Multistep-Ahead Predictor for a Gaussian AR(1) Process Following the SSL Unit Root Test. Shin et al. (1996) proposed the unit root test for time series with outliers. The procedure of this method is simple and easy-to-compute. The AOs detection and the adjustment the observations have been used accordingly in this unit root test. In the outliers detection, we use the statistic $\hat{\lambda}$ given by

$$\hat{\lambda} = \hat{\sigma}^{-1} \max\left\{ |d_t| : |d_t| > \max\{|r_t|, |r_{t+1}|\} \right\}, \tag{6}$$

where $r_t = Y_t - Y_{t-1}$, $d_t = 2^{-1/2}\left(r_{t+1} - r_t\right)$, $\hat{\sigma}^2 = (n-3)^{-1}\left[\left(\sum_{t=2}^{n} r_t^2\right) - r_T^2 - r_{T+1}^2\right]$ and T is the time point at which $\max\left\{ |d_t| : |d_t| > \max\{|r_t|, |r_{t+1}|\} \right\}$ achieves its maximum.

If $\hat{\lambda} > 3$, then we conclude that there is an AO at time T. When there is an AO at time

T, we replace the contaminated observations Y_T with its best prediction based on $\{Y_1, Y_2, ..., Y_{T-1}\}$ which is $E[Y_T \mid Y_1, Y_2, ..., Y_{T-1}] = Y_{T-1}$. The adjusted series, $\{W_t\}$, is used as the data in the next iteration to search for a new AO. If $\hat{\lambda} \le 3$, we do not adjust the observations. If an AO is found in the next iteration, we apply the above procedure to the adjusted series of the previous iteration. If a new AO is not detected, we stop and use the adjusted series $\{W_t\}$ of previous iteration to compute an estimate of ρ and to calculate the statistics $\hat{\tau}^*$ for testing of a unit root. In addition, the null hypothesis; H_{02} and the alternative hypothesis; H_{a2} are also as follows:

$$H_{02} : \rho = 1$$

and

$$H_{a2} : \rho < 1.$$

This unit root test, based on the t-test and the adjusted series $\{W_t\}$, uses the test statistic

$$\hat{\tau}^* = \frac{\hat{\rho}_{G^*} - 1}{SE(\hat{\rho}_{G^*})}, \tag{7}$$

where $\hat{\rho}_{G^*} = \text{median}(B_i^*),\ i = 2,3,...,n,\ B_i^* = W_i / W_{i-1}$, $SE(\hat{\rho}_{G^*}) = \dfrac{\hat{\sigma}_e^*}{\sqrt{\sum_{t=2}^{n} (W_{t-1} - \overline{W})^2}}$, and

$$\hat{\sigma}_e^{*2} = \frac{\sum_{t=2}^{n} (W_t - \overline{W} - \hat{\rho}_{G^*}(W_{t-1} - \overline{W}))^2}{n-2}.$$

The percentiles for the empirical of $\hat{\tau}^*$ given in (7) are similar to those for the empirical of $\hat{\tau}$. If H_{02} is rejected then the predictor for $Y_n(\ell)$ of model (1) is $\hat{\mu}^* + \hat{\rho}_{G^*}^{\ell}(W_n - \hat{\mu}^*)$ where $\hat{\mu}^* = \overline{W}$. If H_{02} is not rejected, we propose the predictor for $Y_n(\ell)$ following the result of the SSL unit root test. The predictor is developed under the random walk model in case H_{02} is not rejected. Namely, the optimal predictor for $Y_n(\ell)$ of random walk model is W_n. Therefore, the estimated multistep-ahead predictor following the result of the SSL unit root test for $Y_n(\ell)$ is given by

$$\hat{Y}_n^{SSL}(\ell) = \begin{cases} \hat{\mu}^* + \hat{\rho}_{G^*}^{\ell}(W_n - \hat{\mu}^*) & ;\text{ If } H_{02} \text{ is rejected } (\rho<1), \\ W_n & ;\text{ If } H_{02} \text{ is not rejected } (\rho=1). \end{cases} \tag{8}$$

5. Simulation Results. In this section, we present the results of using simulations to evaluate the performance of the proposed multistep-ahead predictors. The sets of ten-thousand AR(1) time series were simulated by using R statistical software (1996). All simulations are based on parameters (μ, σ_e)= (0, 1), sample sizes; n = 25, 50, 100, 250, ρ= 0.7, 0.8, 0.9, 0.95, 0.97, 0.98, 0.99, 0.999, the size of the AOs effect; $\delta = 3\sigma_e$, the percentage of outliers; $p = 5\%$, and significance level for the unit root test ; α = 0.05. The prediction mean square error (PMSE) of three-step-ahead predictors in (3), (5) and (8); $\hat{Y}_n^S(3)$, $\hat{Y}_n^{DF}(3)$ and $\hat{Y}_n^{SSL}(3)$, was investigated. The relative efficiencies of all predictors are shown in Table 1. For comparison, when ρ is close to one, $\hat{Y}_n^{DF}(3)$ and $\hat{Y}_n^{SSL}(3)$ give the PMSE lower than $\hat{Y}_n^{S}(3)$. Further, $\hat{Y}_n^{SSL}(3)$ also provides the lowest PMSE when ρ is close to one. The results shown in Table 1 have also pointed out that the unit root test can improve the accuracy of the multistep-ahead predictors for an AR(1) process when ρ is close to one and there are AOs in a time series.

TABLE 1. The relative efficiencies of the three-step-ahead predictors

n	$PMSE_S / PMSE_{DF}$							
	ρ =0.7	ρ =0.8	ρ =0.9	ρ =0.95	ρ =0.97	ρ =0.98	ρ =0.99	ρ =0.999
25	0.8836	0.9664	**1.0326**	**1.0966**	**1.1026**	**1.1013**	**1.1117**	**1.0391**
50	0.8849	0.8879	0.9348	**1.0025**	**1.0324**	**1.0447**	**1.0533**	**1.0321**
100	0.9719	0.9475	0.9288	0.9670	0.9899	**1.0070**	**1.0211**	**1.0209**
250	1.0000	0.9993	0.9790	0.9651	0.9736	0.9875	0.9993	**1.0110**
n	$PMSE_S / PMSE_{SSL}$							
	ρ =0.7	ρ =0.8	ρ =0.9	ρ =0.95	ρ =0.97	ρ =0.98	ρ =0.99	ρ =0.999
25	0.8590	0.9657	**1.0467**	**1.1123**	**1.1192**	**1.1135**	**1.1206**	**1.0421**
50	0.8216	0.8679	0.9482	**1.0230**	**1.0514**	**1.0670**	**1.0715**	**1.0389**
100	0.9081	0.8933	0.9232	0.9791	**1.0043**	**1.0224**	**1.0328**	**1.0252**
250	0.9753	0.9702	0.9395	0.9559	0.9815	0.9945	**1.0058**	**1.0156**
n	$PMSE_{DF} / PMSE_{SSL}$							
	ρ =0.7	ρ =0.8	ρ =0.9	ρ =0.95	ρ =0.97	ρ =0.98	ρ =0.99	ρ =0.999
25	0.9722	0.9992	**1.0136**	**1.0143**	**1.0151**	**1.0111**	**1.0080**	**1.0029**
50	0.9284	0.9775	**1.0144**	**1.0204**	**1.0184**	**1.0214**	**1.0173**	**1.0066**
100	0.9344	0.9428	0.9939	**1.0126**	**1.0145**	**1.0153**	**1.0115**	**1.0042**
250	0.9753	0.9709	0.9596	0.9905	**1.0081**	**1.0070**	**1.0066**	**1.0046**

TABLE 2. Three-step-ahead predictors and the absolute difference between $Y_n(3)$ and $\hat{Y}_n(3)$ of the exchange rates of us/argentina

Methods	Test statistic	Critical value ($\alpha = 0.05$)	Predictors ($\hat{Y}_n(3)$)	$\lvert Y_n(3) - \hat{Y}_n(3) \rvert$
S	–	–	2.7811	0.2389
DF	-0.1081	-1.86	2.8420	0.1780
SSL	-0.1053	-1.86	2.8420	0.1780

6. Applications. This section is devoted to study of a practical case to show the efficiency of all proposed predictors through economic time series. Consider the series of 40 yearly exchange rates between the USA and Argentina from 1970 to 2009 (base year is 2005) given by the Economic Research Service, United States Department of Agriculture. Figure 1 shows the series and sample PACF. They suggest that an AR(1) model is suitable for this series. An AR(1) model was fitted to the data: $ER_t = 0.0293 + 0.9824\, ER_{t-1} + e_t$ with $\hat{\sigma}_e = 0.73804$. By using SSL's algorithm for detecting the AOs, there is an additive outlier at $t = 20$ (or year 1989) and then we construct the three-step-ahead predictors; $\hat{Y}_n^{S}(3)$,

$\hat{Y}_n^{DF}(3)$ and $\hat{Y}_n^{SSL}(3)$ by using the time series between 1970 and 2006. As reported in Table 2, the predictors following the unit root tests provides the absolute difference between the predictor and the true value less than that of standard predictor.

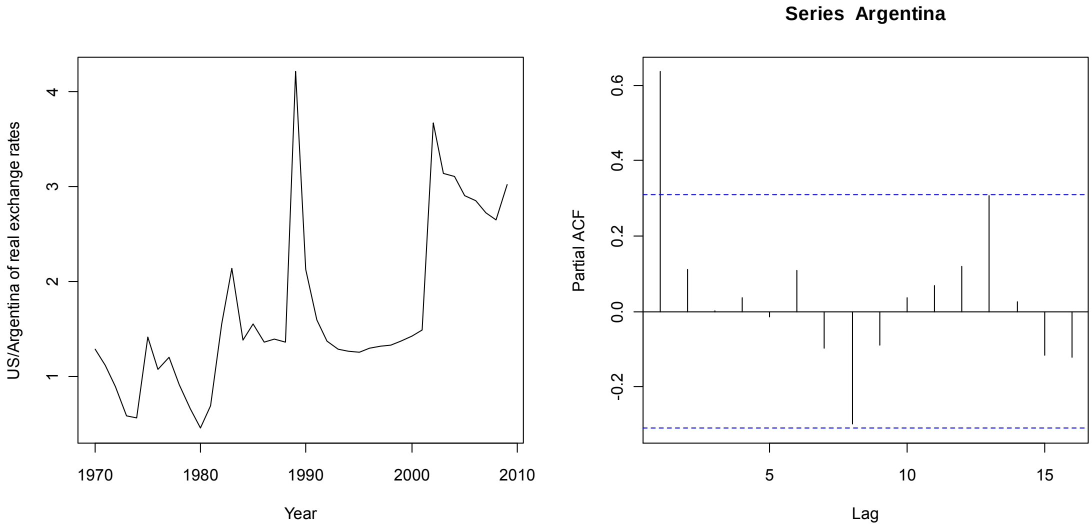

FIGURE 1. Exchange rates of US/Argentina between 1970 and 2009, with the sample PACF

7. Conclusions. In this paper, the multistep-ahead predictors for a Gaussian AR(1) process with additive outliers have been developed based on the result of the unit root test. The standard predictor, the predictor following the DF unit root test, and the predictor following the SSL unit root test are proposed and compared via the simulations. Both of predictors following the unit root tests perform better than the standard predictor in terms of the prediction mean square error. Apart from that, an economic application also confirms that the predictors following the unit root tests are more accurate than the standard predictor. Furthermore, the unit root tests can also improve the preciseness of the predictors in case the autoregressive parameter is close to unity and there are additive outliers in a time series.

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Appendix.

Empirical cumulative distribution of τ for $\rho = 1$.

n	Probability of a small value		
	0.01	0.05	0.10
25	-2.97	-1.75	-1.13
50	-3.14	-1.95	-1.32
100	-3.22	-2.05	-1.45
250	-3.28	-2.14	-1.55
∞	-3.32	-2.20	-1.61

FORECASTING MULTIPLE OBSERVATIONS BY A NEW FUZZY TIME SERIES MODEL

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ABSTRACT. *The application of fuzzy time series models to forecast has been drawing a lot of attention. This study proposes a novel fuzzy time series model to forecast with multiple observations at a single time point. The model shows how to fuzzify multiple observations into a fuzzy set. Neural networks are applied for training and then forecasting the consecutive fuzzy sets. The forecasting results are defuzzified into forecasts. We use daily observations of Taiwan Stock Exchange Capitalization Weighted Stock Index (TAIEX) as forecasting target for the period from 2001 to 2006. The TAIEX is separated into in-sample and out-of-sample observations. The in-sample observations are used for training and the out-of-sample observations are for forecasting. The empirical results demonstrate that the proposed model provides satisfactory results. Hence, this study proposes a feasible solution to forecast the problems with multiple observations at a single time point.*

Keywords: Financial Data Processing; Forecasting; Fuzzy Systems

1. Introduction. Forecasting has been considered important in various problem domains. How to model multiple observations to facilitate forecasting seems even more critical. Previous studies attempted to tackle this problem by using conventional statistical methods. However, they have been suffered from limitations of these conventional methods (Tseng et al., 2001), such as independent and identically distributed random variables (Sethuraman and Basawa, 1994a; Sethuraman and Basawa, 1994b), and stationary autoregressive (Sethuraman and Basawa, 1994b). Recent studies have also been proposed to forecast (Hsu and Wu, 2008) and to calculate correlation coefficients for interval data (Hsu and Wu, 2010), respectively.

The application of fuzzy time series models to forecast has been attracting attention. Advanced models have also been proposed, such as high order models (Aladag et al., 2009; Singh, 2009; Chen et al., 2009; Yu et al., 2009), multivariate models (Cheng et al., 2008; Huarng, 2001; Huarng, 2007; Yu and Huarng, 2008) and high order and multivariate models (Egrioglu et al., 2009; Egrioglu et al., 2009; Huarng and Yu, 2003; Park et al., 2009; Wang and Chen, 2009). The forecasting results from some of the fuzzy time series models have shown to outperform their conventional counterparts (Hsu et al., 2003; Huarng et al., 2007; Qin and Huang, 2007; Wong et al., 2009). Hence, this study advances to propose a fuzzy time series model to forecast a problem with multiple observations, such as multiple stock index readings in a day.

Fuzzy relationships play an important role in fuzzy time series models. The proposed model applies neural networks for modeling fuzzy relationships between consecutive observations. Neural networks have been popular for their capability in modeling nonlinear relationships (Indro et al., 1999; Donaldson and Kamstra, 1996). We expect that neural networks can assist the establishing and then forecasting fuzzy relationships among degrees of memberships of consecutive observations.

We use Taiwan Stock Exchange Capitalization Weighted Stock Index (TAIEX) as forecasting target for years from 2001 to 2006. The TAIEX is separated into in-sample and out-of-sample observations. The in-sample observations are used for training and the out-of-sample observations are for forecasting.

Section 2 reviews the relevant studies, including fuzzy time series models, neural networks, and fuzzy time series models with neural networks. Section 3 introduces the algorithm for the proposed model. Section 4 applies the proposed model to forecast TAIEX and follows by the conclusion.

2. Literature Review.

2.1. Fuzzy Time Series Model. Conventional time series refer to real values, but fuzzy time series are structured by fuzzy sets (Chen, 1996). Let U be the universe of discourse, such that $U = \{u_1, u_2, ..., u_n\}$. A fuzzy set A of U is defined as $A = f_A(u_1)/u_1 + f_A(u_2)/u_2 + \ldots + f_A(u_n)/u_n$, where f_A is the membership function of A, and $f_A: U \rightarrow [0, 1]$. $f_A(u_i)$ is the degree of membership of u_i in A, where $f_A(u_i) \in [0, 1]$ and $1 \le i \le n$.

Definition 1. Let $Y(t)$ (t =…, 0, 1, 2,…), a subset of a real number, be the universe of discourse on which fuzzy sets $f_i(t)$ (i = 1, 2,…) are defined and $F(t)$ is a collection of $f_1(t)$, $f_2(t)$,…. $F(t)$ is referred to as a fuzzy time series on $Y(t)$. Here, $F(t)$ is viewed as a linguistic variable and $f_i(t)$ represents possible linguistic values of $F(t)$.

If $F(t)$ is caused by $F(t-1)$ only, the relationship can be expressed as $F(t-1) \rightarrow F(t)$ (Chen, 1996). Various operations have been applied to compute the fuzzy relationship between $F(t)$ and $F(t-1)$ (Sullivan and W.H. Woodall, 1994; Hwang et al., 1998; Song and B.S. Chissom; 1994). Chen (Chen, 1996) suggested that when the maximum degree of membership of $F(t)$ belongs to A_i, $F(t)$ is considered to be A_i. Hence, $F(t-1) \rightarrow F(t)$ becomes $A_i \rightarrow A_j$. The advantage of this proposal is that it simplifies the complicated calculations, but it falls into a hurdle when the out-of-sample observations do not appear in the in-sample observations. And this problem can be solved by the proposed model in this study.

2.2. Neural Network Models. Neural networks consist of an input layer, an output layer, and one or more hidden layers. Each of the layers contains nodes, and these nodes of two consecutive layers are connected with each other. Neural networks have been shown to discover nonlinear relationships among the observations (Indro et al., 1999; Donaldson and Kamstra, 1996). There have been different applications of neural networks, including credit ratings (Kumar and Bhattacharya, 2006), Dow Jones forecasting (Kanas, 2001), customer satisfaction analysis (Gronholdt and Martensen, 2005), stock ranking (Refenes et al., 1993), and tourism demand (Martin and Witt, 1989; Palmer et al., 2006; Law, 2000; Law and Au, 1999), etc.

2.3. Fuzzy Time Series with Neural Networks. There have been studies working on fuzzy time series with neural networks. Huarng and Yu (2006) first apply neural networks to train the fuzzy relationships for fuzzy time series. Yu and Huarng (2008) propose the application of neural networks to train the fuzzy relationships for bi-variate fuzzy time series. Furthermore, Aladag et al. (2009) and Egrioglu et al. (2009) apply similar approach for forecasting high order and high order multivariate fuzzy time series models, respectively. However, these models all take $F(t-1) \to F(t)$ as $A_i \to A_j$. In other words, only the maximum degree of membership of $F(t)$ is taken into consideration for establishing fuzzy relationships. Yu et al. (2009) start to consider all the degrees of membership of $F(t-1)$ and $F(t)$ in establishing fuzzy relationships for high order fuzzy time series. Many of these models show that they provide better performance in forecasting.

3. Algorithm. The steps for implementing the fuzzy time series model for multiple observations are explained below.

Algorithm

(1) Define the fuzzy sets for the fuzzy time series as in previous fuzzy time series studies (Huarng, 2001; Huarng and Yu, 2003; Chen, 1996). We set the beginning of the universe of discourse as *s*, and the length of interval as *l*. Suppose there are *k* intervals. Then, we have the following intervals:

$$u_1 = [s, s+l],\ u_2 = [s+l, s+2l],\ \ldots u_k = [s+(k-1)l, s+kl] \tag{1}$$

We then define a fuzzy time series as follows (Chen, 1996):

$A_1 = 1/u_1+0.5/u_2+0.0/u_3+0.0/u_4+\ldots,$
$A_2 = 0.5/u_1+1.0/u_2+0.5/u_3+0.0/u_4+\ldots,$
$A_3 = 0.0/u_1+0.5/u_2+1.0/u_3+0.5/u_4+\ldots,$
…

For calculation, each A_j can also be represented by ($L_j, M1_j, M2_j, R_j$), where L_j is the left-most value; $M1_j, M2_j$ are the endpoints of the plateau; R_j is the right-most value, respectively.

(2) Determine a fuzzy observation, $\tilde{o}_t$ = (l_t, m_t, r_t), to represent all the (multiple) observations at time *t*; l_t, m_t, r_t are the left, middle, and right values of the fuzzy observation, $\tilde{o}_t$, respectively.

There can be various ways to choose from l_t, m_t, r_t. To forecast stock index, this study considers the lowest and highest values of *t* as l_t and r_t, respectively; and close price of *t* as m_t. In other words,

$l_t = \min(obs_t^z)$, for all z at t

$r_t = \max(obs_t^z)$, for all z at t

$$m_t = close_t \tag{2}$$

where obs_t^z represents an observation z at a single time point t.

(3) Calculate the fuzzy relationship, X_t, between each fuzzy observation and the defined fuzzy time series as in Step 1.

$$X_t = (x_t^1, x_t^2, \ldots x_t^k) = \sum_{j=1}^{k} \max \cdot \min(\widetilde{o}_t, A_j) \tag{3}$$

where $x_t^j \geq 0$. Each x_t^j can be calculated as follows. The detail of the deriving the equations is provided in Appendix.

For the x_t^j for m_t: $x_t^j = 1.0$.

For the x_t^j to the left of m_t: $x_t^j = \dfrac{R_j - l_t}{m_t - l_t + R_j - M2_j}$

For the x_t^j to the right of m_t: $x_t^j = \dfrac{r_t - L_j}{r_t - m_t - L_j + M1_j}$ (4)

(4) Randomly draw a certain portion from all the observations as the out of sample; the rest as the in sample.

(5) Calculate the overall relationships from all the in-sample observations. We apply back-propagation neural networks to train the relationships between consecutive fuzzy relationships, X_t. and X_{t+1}, as in Figure 1.

(6) To forecast the out-of-sample observation at t+1, we use X_t as the input to the trained neural networks. The output from the trained neural networks is the fuzzy forecast for t+1, $fr_{t,t+1} = (\mu_{t,t+1}^1, \mu_{t,t+1}^2 \ldots \mu_{t,t+1}^k)$.

(7) Defuzzify the fuzzy relationship to obtain the forecasted fuzzy observation. Weighted average by the fuzzy relationship and the midpoints of the interval is used to defuzzify the fuzzy relationship:

$$forecast_{t+1} = \frac{\sum_{g=1}^{k} \mu_{t,t+1}^g \times m^g}{\sum_{g=1}^{k} \mu_{t,t+1}^g} \tag{5}$$

where $forecast_{t+1}$ is the forecast for the out of sample at t+1; $\mu_{t,t+1}^g$ is the forecasted degrees of membership and m^g is the corresponding midpoints of the interval $\mu_{t,t+1}^g$.

(8) Evaluate the performance. We use two indicators to demonstrate the performance of the proposed model: root mean squared errors (RMSEs) and hit percentage. RMSEs have been used to measure the performance of fuzzy time series models (Huarng and Yu, 2006; Huarng and Yu, 2005; Yu, 2005):

$$RMSE = \sqrt{\frac{\sum (forecast_{t+1} - close_{t+1})^2}{q}} \tag{6}$$

where there are totally q out of samples.

Meanwhile, we are interested in knowing the percentage of the defuzzified forecast falling into the range of its forecasting fuzzy observation, *hit percentage*. Suppose the out-of-sample forecast for t+1 is $forecast_{t+1}$ and the actual fuzzy observation to forecast is $\tilde{o}_{t+1} = (l_{t+1}, m_{t+1}, r_{t+1})$. Hence, *count* =0, Loop for all the out-of-sample forecasts. If $l_{t+1} \le forecast_{t+1} \le r_{t+1}$ then *count* = *count* +1, End Loop

$$hit = \frac{count}{q} \tag{7}$$

4. Data. This study uses the Taiwan Stock Exchange Capitalization Weighted Stock Index (TAIEX) as the forecasting target, ranging from 2001 to 2006. Each year, 20% of the observations are randomly drawn as the out of sample and the rest 80% as in sample. The in sample observations are used to establish relationships and the out of sample are used to test the forecasting model.

5. Stock Forecasting. This study uses TAIEX as the forecasting target to demonstrate how the proposed model can be used to model the time series with multiple observations.

Step 1. Define the fuzzy sets for the fuzzy time series. We set the universe of discourse as [0, 12000]. The length of interval is set as 1000. Following equation (1), we have the following intervals: $u_1 = [0,1000]$, $u_2 = [1000,2000]$, … $u_k = [1000 \times (k-1), 1000 \times k]$, where k=12 in this example. We define a fuzzy time series as follows (Chen, 1996).

$A_1 = 1/u_1 + 0.5/u_2 + 0.0/u_3 + 0.0/u_4 + \ldots,$
$A_2 = 0.5/u_1 + 1.0/u_2 + 0.5/u_3 + 0.0/u_4 + \ldots,$
$A_3 = 0.0/u_1 + 0.5/u_2 + 1.0/u_3 + 0.5/u_4 + \ldots,$
…

The fuzzy time series is defined as in Figure 2.

Step 2. Determine fuzzy observations. For each day, there are multiple observations for stock index. We choose low, high, and close to determine a fuzzy observation for that day. For example, on January 4, 2001, the low is 5028.32, the close is 5136.13, and the high is 5169.13. Following equation (2), the fuzzy observation for January 4, 2001 is

$$\tilde{o}_{01/04/2001} = (l_{01/04/2001}, m_{01/04/2001}, r_{01/04/2001}) = (5028.32, 5136.13, 5169.13).$$

The fuzzy observation, $\tilde{o}_{01/04/2001}$, is depicted in Figure 3. Similarly, we can obtain the fuzzy observations for the indices of other days.

Step 3. Calculate the fuzzy relationships. Following equation (3), the fuzzy relationship for January 4, 2001 can be calculated by

$$X_{01/04/2001} = \sum_{j=1}^{12} \max \cdot \min(\tilde{o}_{01/04/2001}, A_j)$$

Following equation (4), each x_t^j is calculated as follows

$$x^6_{01/04/2001} = 1.0$$

$$x^5_{01/04/2001} = \frac{R_5 - l_{01/04/2001}}{m_{01/04/2001} - l_{01/04/2001} + R_5 - M2_5}$$
$$= \frac{6000 - 5028.31}{5136.13 - 5028.31 + 6000 - 5000} = 0.88.$$

$$x^{7}_{01/04/2001} = \frac{r_{01/04/2001} - L_7}{r_{01/04/2001} - m_{01/04/2001} - L_7 + M1_7}$$
$$= \frac{5169.13 - 5000}{5169.13 - 5136.13 + 8000 - 7000} = 0.16$$

The remaining x_t^j are all zeros.

Conceptually, we can also obtain the same results from dashed bold lines in Figure 4 and then Figure 5. Hence

$$X_{01/04/2001} = (x^1_{01/04/2001}, x^2_{01/04/2001}, \ldots x^{12}_{01/04/2001}) = \sum_{j=1}^{12} \max\cdot \min(\tilde{o}_{01/04/2001}, A_j)$$
$$= (0.0, 0.0, 0.0, 0.0, 0.88, 1.0, 0.16, 0.0, 0.0, 0.0, 0.0, 0.0).$$

The fuzzy relationships for the other fuzzy observations can be calculated similarly.

Step 4. Sampling.

As stated in the previous section, we randomly draw 20% of the observations as the out of sample and the rest 80% as in sample for every year.

Step 5. Neural network training.

A neural network is constructed as in Figure 1. We pair X_t and X_{t+1} as the input layer and output layer of the neural network. In the year of 2001, $X_t = (x_t^1, x_t^2, \ldots x_t^k)$, where k=12. Hence, there are 12 input and output nodes in the input and output layer, respectively. For example,

$$X_{01/04/2001} = (x^1_{01/04/2001}, x^2_{01/04/2001}, \ldots x^{12}_{01/04/2001})$$
$$= (0.0, 0.0, 0.0, 0.0, 0.88, 1.0, 0.16, 0.0, 0.0, 0.0, 0.0, 0.0),$$
$$X_{01/05/2001} = (x^1_{01/05/2001}, x^2_{01/05/2001}, \ldots x^{12}_{01/05/2001})$$
$$= (0.0, 0.0, 0.0, 0.0, 0.75, 1.0, 0.30, 0.0, 0.0, 0.0, 0.0, 0.0).$$

The former can serve as the input nodes and the latter the output nodes of the neural network. The relationships can then be established via the neural network training.

Step 6. Neural network forecasting. After training, we can proceed to forecast the out-of-sample observations by using the trained neural networks. For example, $\tilde{o}_{01/10/2001}$ = (5348.34, 5369.24, 5531.20) whose $X_{01/10/2001}$ = (0.0, 0.0, 0.0, 0.0, 0.60, 1.0, 0.46, 0.0, 0.0, 0.0, 0.0, 0.0). Hence, if we use that fuzzy relationship as input to the trained neural network, the output of the neural network is $fr_{01/10/2001,\ 01/11/2001}$ = ($\mu^1_{01/10/2001,01/11/2001}$, $\mu^2_{01/10/2001,01/11/2001}$, … $\mu^k_{01/10/2001,01/11/2001}$) = (0.0, 0.0, 0.000080, 0.002495, 0.599091, 0.998333, 0.463216, 0.000182, 0.0, 0.0, 0.0, 0.0).

And this is the forecast for the fuzzy relationship on January 11, 2001.

Step 7. Defuzzification. We calculate the forecasted fuzzy observation by following equation (5): (0.000080×2500+0.002495×3500+0.599091×4500+0.998333×5500+ 0.463216×6500+0.000182×7500)/(0.00008+0.002495+0.599091+0.998333+0.463216+0.000182) =5431.79

Step 8. Evaluate the performance. We calculated all the out-of-samples forecasts and then the performance indicators. The RMSEs for the years from 2001 to 2006 are listed in Table 1.

The hit percentage is also calculated, as in Table 2. We categorize the range of each observation to be forecasted, by taking the difference of the high and low, into 0-100, 100-200, and 200-300. The second row and second column represents that there are 9 hits over 24 occurrences falling in the range of 0-100 which is equal to 38%. Hence, we have the hit percentage for year 2001 to 2006, in ranges 0-100, 100-200, and 200-300, respectively.

The range average takes the sum of the hits and occurrences by range. For example, the one in range 0-100 is equal to 56%. Table 2 shows that the range averages are 56%, 64%, and 86%, respectively. The year average takes the sum of the hits and occurrences by year. For example, the one of year 2001 is equal to 50%. Table 2 shows that the year averages are between 50% and 65%. The overall average of hit percentage is 59%.

6. Conclusion. This study proposes a novel fuzzy time series model to model multiple observations for forecasting. Neural networks are applied to establish the fuzzy relationships between consecutive observations. The Taiwan stock index is taken as the forecasting example to demonstrate the forecasting process and performance. The empirical results that the range average can reach as high as 86% and the year average 65%. The average of overall hit percentage is 58%.

There are many domain problems with multiple observations at a single time point. For instance, there are many temperature readings in a day; different arriving and departing tourism numbers in a month, etc. This study proposes the fuzzy time series that can easily handle the problem of multiple observations and then forecast. The empirical results demonstrate that the proposed model provides satisfactory results.

Length of intervals is always an interesting topic to explore for fuzzy time series models (Huarng, 2001; Huarng and Yu, 2004; Huarng and Yu, 2006). The future study can examine the relationships between lengths of intervals and hit percentage to see if the smaller the lengths, the higher the hit percentage. The proposed model can also be extended to high order models as well as multivariate models.

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Appendix.

The fuzzy relationship between each fuzzy observation and the defined fuzzy time series is denoted as X_t and $X_t = (x_t^1, x_t^2, \ldots x_t^k) = \sum_{j=1}^{k} \max \cdot \min(\tilde{o}_t, A_j) \cdot$ $A_j = (L_j, M1_j, M2_j, R_j)$ and $\widetilde{o}_t$ = (l_t, m_t, r_t). To facilitate the derivation, z_t^j represents a stock reading. The calculation of x_t^j is derived below.

(1) For the x_t^j for m_t: x_t^j = 1.0.

(2) For the x_t^j ($x_t^j \geq 0$) to the left of m_t:

$$\frac{1.0}{m_t - l_t} = \frac{x_t^j}{z_t^j - l_t} \text{,i.e.}$$

$$z_t^j = l_t + x_t^j (m_t - l_t) \tag{8}$$

$$\frac{1.0}{R_j - M2_j} = \frac{x_t^j}{R_j - z_t^j}$$

$$\text{i.e., } z_t^j = R_j - x_t^j (R_j - M2_j) \tag{9}$$

From equations (8) and (9), we have

$$l_t + x_t^j (m_t - l_t) \;=\; R_j - x_t^j (R_j - M2_j)$$

Hence,

$$x_t^j = \frac{R_j - l_t}{m_t - l_t + R_j - M2_j}$$

(3) For the x_t^j ($x_t^j \geq 0$) to the right of m_t:

$$\frac{1.0}{r_t - m_t} = \frac{x_t^j}{r_t - z_t^j}$$

$$\text{i.e., } z_t^j = r_t - x_t^j (r_t - m_t) \tag{10}$$

$$\frac{1.0}{M1_j - L_j} = \frac{x_t^j}{z_t^j - L_j}$$

$$\text{i.e., } z_t^j = L_j + x_t^j (M1_j - L_j) \tag{11}$$

From equations (10) and (11), we have

$$r_t - x_t^j (r_t - m_t) \;=\; L_j + x_t^j (M1_j - L_j)$$

Hence

$$x_t^j = \frac{r_t - L_j}{r_t - m_t - L_j + M1_j}$$

TABLE 1. Forecasting RMSEs

	2001	2002	2003	2004	2005	2006
RMSE	98.10	94.03	72.17	72.98	44.48	69.73

TABLE 2. Analysis of hit percentages

Year / Range	2001	2002	2003	2004	2005	2006	Range average
0-100	9/24=38%	15/27=56%	24/41=59%	23/36=64%	30/48=63%	21/41=51%	56%
100-200	14/22=64%	15/20=75%	3/8=38%	7/11=64%	0/1=0%	5/7=71%	64%
200-300	1/2=50%	2/2=100%	-	2/2=100%	-	1/1=100%	86%
Year average	50%	65%	55%	65%	61%	55%	59%

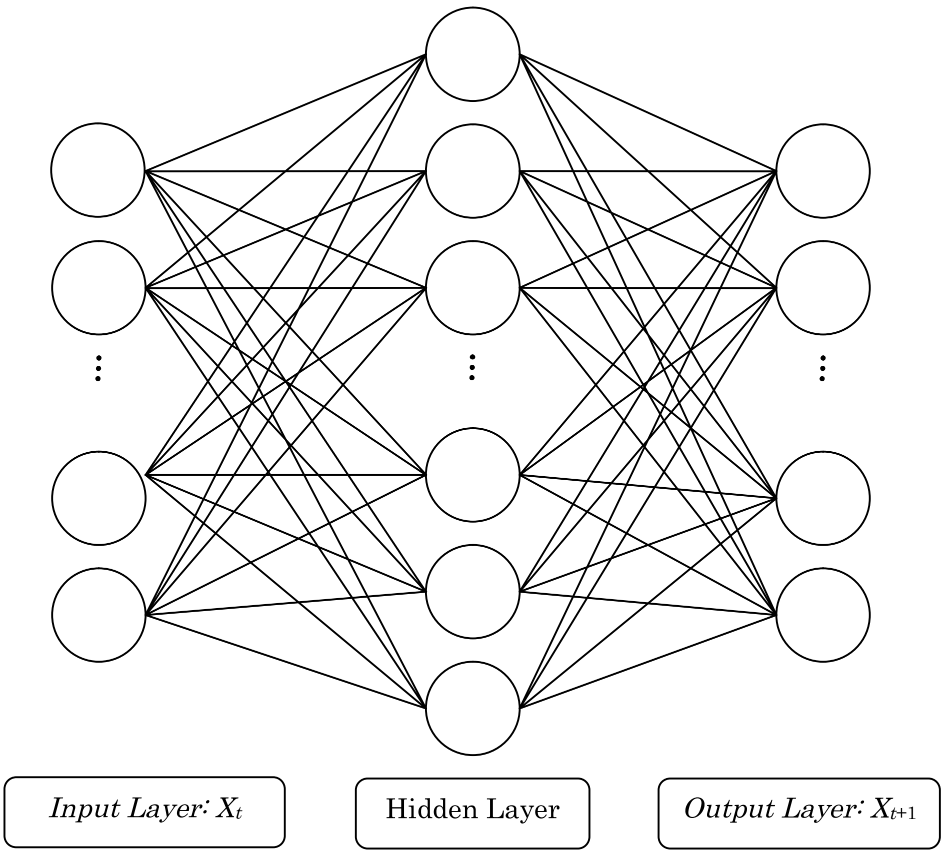

FIGURE 1. A neural network structure

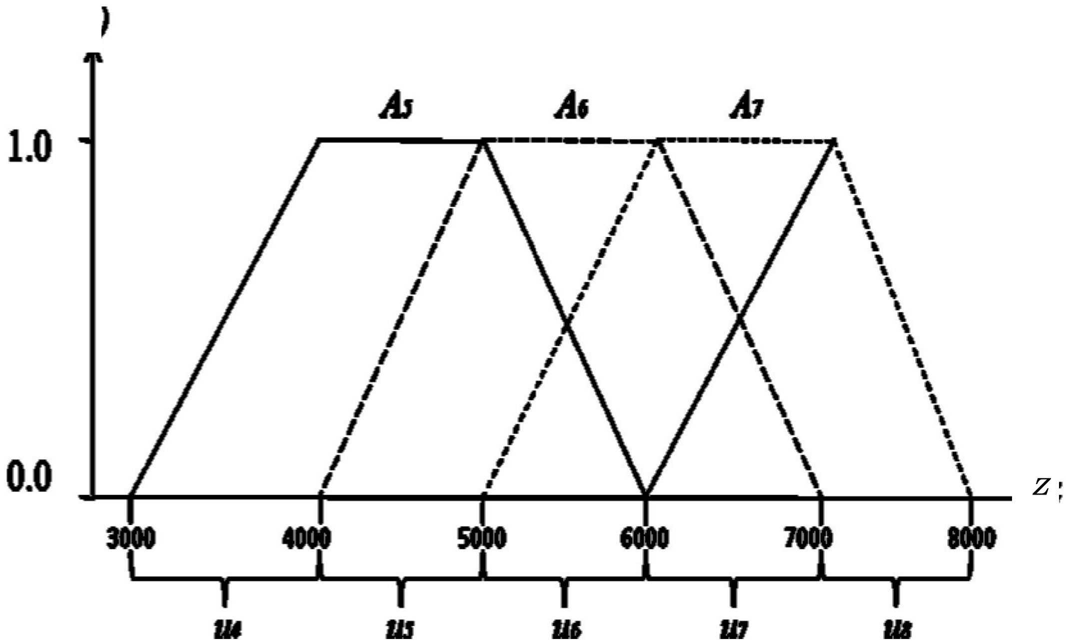

FIGURE 2. The fuzzy time series consisting of A_i

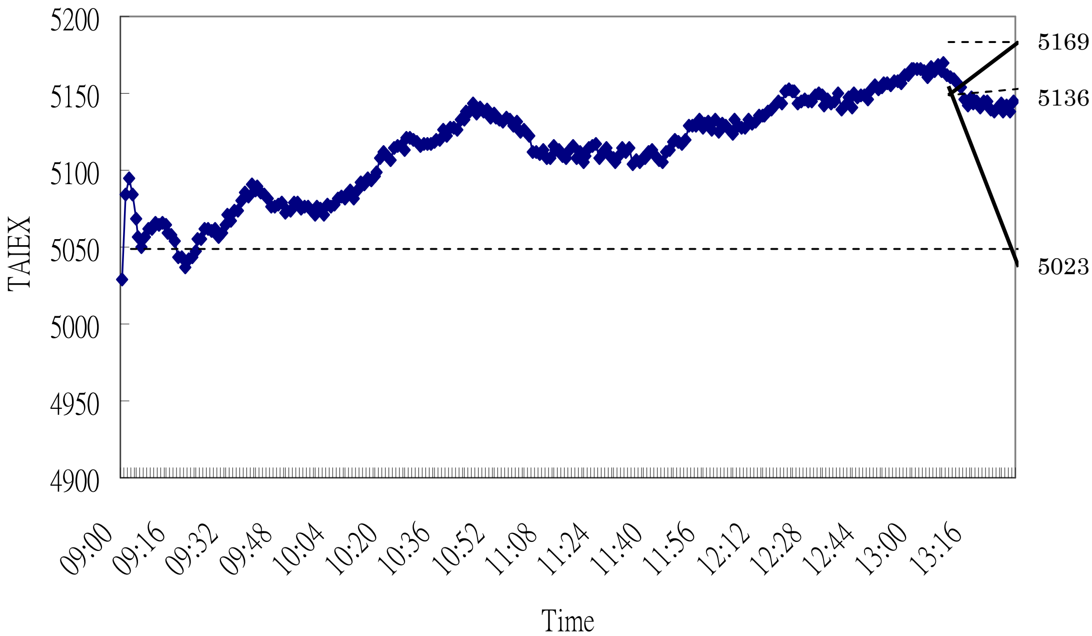

FIGURE 3. The fuzzy observation obtained from the low, close and high of the multiple observations on 01/04/2001. Hence, $\tilde{o}_{01/04/2001}$ = (5023, 5136, 5169)

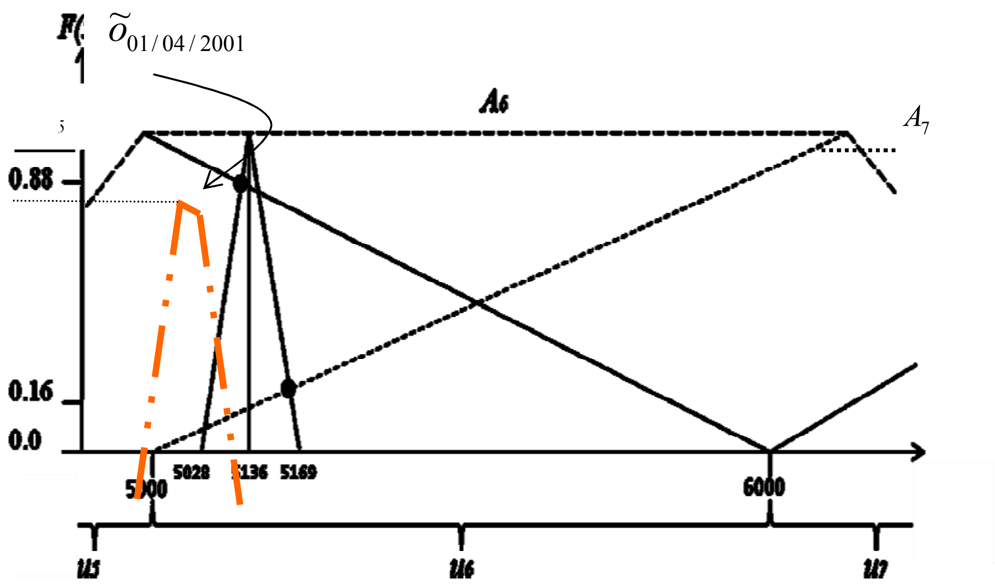

FIGURE 4. $Max \cdot \min(\widetilde{o}_{01/04/2001}, A_5)$

First, the bold dotted lines represent the $\min(\widetilde{o}_{01/04/2001}, A_5)$. then, the maximal of the $\min(\widetilde{o}_{01/04/2001}, A_5)$ is 0.88. in other words $\max \cdot \min(\widetilde{o}_{01/04/2001}, A_5)$=0.88.

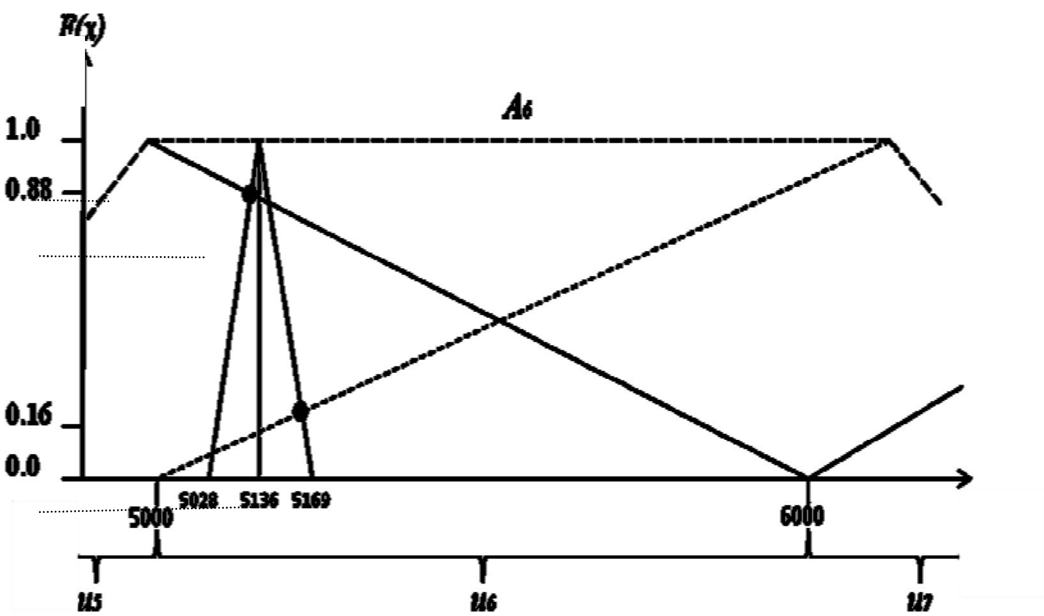

FIGURE 5. $X_{01/04/2001} = (x^1_{01/04/2001}, x^2_{01/04/2001}, \ldots x^{12}_{01/04/2001}) = \sum_{j=1}^{12} \max \cdot \min(\widetilde{o}_{01/04/2001}, A_j)$

$= (0.0, 0.0, 0.0, 0.0, 0.88, 1.0, 0.16, 0.0, 0.0, 0.0, 0.0, 0.0)$

RESEARCH ON CHOOSING EMPLOYMENT PLACE FOR COLLEGE GRADUATES

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ABSTRACT. *How to choose employment place for college graduates is a problem concerned by all students and their parents. A questionnaire is designed for graduates in our school to accurately understand the situation of graduate employment, existing problems and future development trend. Based on the investigation data and with the help of Mathematica software, the optimal decision-making scheme is obtained.*
Keywords: AHP Method; Choosing Employment Place; Decision Making Scheme

1. Introduction. Choosing employment place is a big problem directly related to students' future and social stability (Cao, 2008). In order to get more convince and pertinence, a questionnaire is designed for the students to investigate the situation of graduate employment, existing problems and future development trend (Ju, 2002; Lay, 2005; Leon, 2007). After arranging the investigation data collected from those graduates in our school and resorting to Mathematica software, we obtain the optimal scheme by AHP method (Saaty, 1980; Shao, 2000; Wang et al., 2002; Brent et al., 2007) and thus provide the decision-making scheme for the college graduates.

2. Decision-Making Problems on Employment Place.

2.1. Establishment of a Hierarchical Model. Taking the employment as the destination layer (A), different aspects of employment as the criteria layer (B), and employment places as the program layer (C), then the hierarchical model is established according to the investigation (See Figure 1).

2.2. Construction of Judgment Matrixes. Starting from the investigation data, the comparative judgment matrix of the criteria layer to the destination layer is

$$A=\begin{pmatrix} 1 & 2 & 3 & 9 \\ 1/2 & 1 & 2 & 5 \\ 1/3 & 1/2 & 1 & 2 \\ 1/9 & 1/5 & 1/2 & 1 \end{pmatrix} \tag{1}$$

and the comparative judgment matrixes of the program layer to the criteria layer are

$$B_1=\begin{pmatrix}1 & 1/3 & 7 & 5\\ 3 & 1 & 9 & 7\\ 1/7 & 1/9 & 1 & 1/3\\ 1/5 & 1/7 & 3 & 1\end{pmatrix},\quad B_2=\begin{pmatrix}1 & 1/3 & 6 & 4\\ 3 & 1 & 8 & 6\\ 1/6 & 1/8 & 1 & 1/2\\ 1/4 & 1/6 & 2 & 1\end{pmatrix}$$

$$B_3=\begin{pmatrix}1 & 1/2 & 1 & 1/7\\ 2 & 1 & 2 & 1/5\\ 1 & 1/2 & 1 & 1/7\\ 7 & 5 & 7 & 1\end{pmatrix},\quad B_4=\begin{pmatrix}1 & 1 & 3 & 5\\ 1 & 1 & 3 & 5\\ 1/3 & 1/3 & 1 & 2\\ 1/5 & 1/5 & 1/2 & 1\end{pmatrix}. \tag{2}$$

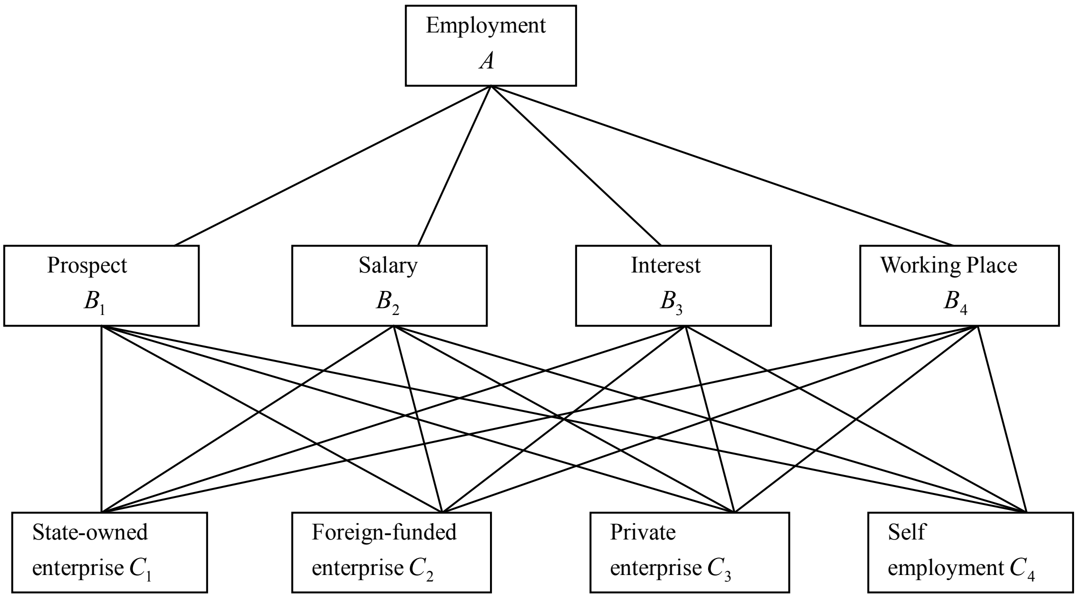

FIGURE 1. Hierarchical model

2.3. Calculation of Weight Vectors and Consistency Test of Hierarchy Single Ranking. Resorting to Mathematica software and (1), we can compute the largest eigenvalue of matrix A as 4.0193, and the corresponding eigenvector

$$x=(0.846531, 0.465437, 0.237663, 0.101341)^T. \tag{3}$$

Through normalization, the eigenvector becomes

$$w^{(2)}=(0.512747, 0.281917, 0.143954, 0.0613824)^T. \tag{4}$$

After direct calculation, the consistency index is CI =0.006433 and the random consistency index is $RI = 0.90$. Thus the consistent rate is obtained by

$$CR^{(2)}=\frac{CI}{RI}=0.0071478. \tag{5}$$

Because it is less than 0.1, the consistency is significant.

Similarly, the largest eigenvalues of matrix B_1, B_2, B_3, B_4 are

$$\lambda_1=4.16458,\ \lambda_2=4.08747,\ \lambda_3=4.01594,\ \lambda_4=4.00416 \tag{6}$$

and the corresponding eigenvectors are

$$x_1=\left(0.440082,\ 0.886288,\ 0.064577,\ 0.129041\right)^T, \tag{7}$$

$$x_2=(0.428797,0.889533,0.0810641,0.135251)^T, \tag{8}$$

$$x_3=(0.124571,0.228707,0.124571,0.957422)^T, \tag{9}$$

$$x_4=(0.68064,0.68064,0.237718,0.130191)^T. \tag{10}$$

Normalizing these vectors, we have

$$w_1=\left(0.28953,\ 0.583089,\ 0.0424852,\ 0.084896\right)^T, \tag{11}$$

$$w_2=\left(0.279411,\ 0.579634,\ 0.0528227,\ 0.0881316\right)^T, \tag{12}$$

$$w_3=\left(0.0867927,\ 0.159348,\ 0.0867927,\ 0.667067\right)^T, \tag{13}$$

$$w_4=\left(0.393618,\ 0.393618,\ 0.137474,\ 0.0752903\right)^T. \tag{14}$$

The consistency indexes are

$$CI_1=0.05486,\ CI_2=0.0291567,\ CI_3=0.0053133,\ CI_4=0.0013867. \tag{15}$$

Since each random consistency index is $RI_i=0.90$（i=1,2,3,4）, the consistent rates are

$$CR_1=0.06096，CR_2=0.032397，CR_3=0.0059037，CR_4=0.0015408. \tag{16}$$

Because CR_i <0.1，（i=1,2,3,4）， the consistency test is completed.

2.4. Calculation of Weight Vectors and Consistency Test of Hierarchy General Ranking. Through direct calculation, the ranking result of weight vectors is obtained (see Table 1).

Consequently, the weight vector of hierarchy general ranking is

$$w^{(3)}=W^{(3)}w^{(2)}=\left(0.428602,\ 0.424604,\ 0.179989,0.352033\ \right)^T \tag{17}$$

In order to test the consistency of hierarchy general ranking, we calculate the general consistency index $CI^{(3)}=\left(CI_1,CI_2,CI_3,CI_4\right)w^{(2)}$ and random consistency index $RI^{(3)}=\left[RI_1,RI_2,RI_3,RI_4\right]w^{(2)}$, thus the consistent rate is obtained by

$$CR^{(3)}=CR^{(2)}+CI^{(3)}/RI^{(3)}=0.042475. \tag{18}$$

Because $CR^{(3)}$<0.1, the significance of the test is obvious and the optimal decision making scheme for college graduates is foreign-owned enterprise.

TABLE 1. Ranking result of weight vectors

k	1	2	3	4
$w_k^{(3)}$	0.28953	0.279411	0.0867927	0.393618
	0.583089	0.579634	0.159348	0.393618
	0.0424852	0.0528227	0.0867927	0.137474
	0.084896	0.0881316	0.667067	0.0752903
λ_k	4.16458	4.08747	4.01594	4.00416

3. Conclusions. There are four different employment choices given to students, i.e., state-owned enterprises, foreign-funded enterprises, private enterprises and self employment. Based on the investigation data, we use AHP method and Mathematica software to make decision on how to choose employment place. Through analysis and calculation, the optimal scheme is obtained.

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STRATEGIES OF PROFESSIONAL DEVELOPMENT FOR THE EFL TEACHERS IN ELEMENTARY SCHOOLS

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ABSTRACT. *How to effectively evaluate and facilitate teachers' professional development has become a major concern. In this paper, we make a detailed analysis with the fuzzy statistics and soft computing methods for the fuzzy questionnaires. Using the membership function and fuzzy statistical analysis, we find the data may contribute to our understanding of the expressions under human cognition which is not easily shown. Depended on the findings from the current status and needs of English teachers' professional development, we provide suggestions for the enhancement of in-service English teachers and teacher education in an EFL context.*

Keywords: Professional Development; EFL Teachers; Fuzzy Statistical Analysis

1. Introduction. As English has been viewed as the lingua franca or English as international language (EIL), Jenkins (2006) and Ur (2009), one of the possible impacts was that many Asian countries conducted the policy of teaching English in elementary schools. The general assumption is that English ability represents competitiveness and internationalization. Under this premise, the quality of teacher workforce plays a critical role. The pursuit of raising teacher quality may have direct effects on students and school performance and indirectly affect the policy direction for enhancing student achievement, OECD(2005). In order to facilitate continuous teachers' professional development, the educational authorities or policy makers ought to provide concise directions for teachers, OECD (2010).

However, there are few studies have focused on investigating how to evaluate elementary English teachers' ability and their need for in-service education in English as a foreign language (EFL) context. Without authentic evaluation of teacher's need and ability, the policy or programs provided by the government might not be suitable for teachers.

Teachers' profession involves a wide range of elements, such as knowledge and ability, disposition, ethnics, organization and development and so on. Teachers are in the vanguard of teaching and the reformer of education innovation at school. If we enhance teachers' professional development, teachers would become the main assets in schools.

The National Council for Accreditation of Teacher Education (NCATE) (NCATE, 2002) approved and promulgated the professional standards for schools and educational institutions. They suggest that the development of teachers' professional knowledge and capacity should include the mastery of the subject matter that they plan to teach, basic knowledge of education, teaching theory and the increase of teaching practice capacity.

However, different subject areas of teacher professional development should have their special characteristics. Interstate New Teacher Assessment and Support Consortium (INTASC) (INTASC, 2002) proposes that a good EFL teacher should process the following skills: 1.Content knowledge; 2. Learner development; 3. Diversity of learners; 4. Instructional strategies; 5. Learning environment; 6. Communication; 7. Planning for instruction; 8. Assessment; 9. Reflective practice and Professional development; 10. Community.

According to the discussion above, the researchers define that the "professional development" of English teachers includes personal English ability, special knowledge about English, cultural knowledge of English and general teaching ability.

Within research area of social science, qualitative studies conduct statistics to simply and rapidly describe the basic structure of data. However, most of the events and phenomena, such as language, thinking, and decision making, consist of ambiguity and non-quantified features. Human behaviors particularly contain many equivocal preferences. Under the circumstances, Zadeh's fuzzy set theory can convey human's thinking more realistic than other method Wu and Ho (2008). Zadeh (1965) argued that human's brain utilizes fuzzy evaluation and categorization toward dynamic environment. By the principles, researchers can provide solutions with more stable illustration to multiple and complicated ambiguous phenomena. Fuzzy statistics can improve the limitations that subjects' answer has been narrowed by traditional questionnaire of binary logic approach. The fuzzy weight is defined between 0 and 1. If the importance is much higher, the weight value will be much closer to 1. On the contrary, the weight value will be much closer to 0. The soft computing makes researchers analyze more precisely than crisp statistics.

In recent years, more and more researchers utilized the fuzzy statistical analysis and applications in the fields of social science. For instance, Wu and Sun (2001) demonstrated the concepts of fuzzy statistic and applied it to social survey; Wu and Tseng (2002) used fuzzy regression method of coefficient estimation to analyze Taiwan monitoring index of economic. Moreover, Wu and Hsu (2004) identified the model construction through qualitative simulation. For an extensive treatment of the theory of fuzzy statistics the interested reader may refer to see Nguyen and Wu (2006).

In the study, we implemented fuzzy questionnaire survey and soft computing method to discuss evaluation and strategies for elementary EFL teachers' professional development in Taiwan. According to the former statement, the main purposes of the study are as follows:

(1) Supply dimension: discuss the current status of English teachers' professional competences in elementary school in Taiwan.

(2)Need dimension: discuss the need of English teachers' professional development in elementary school in Taiwan.

(3)Dynamic balance dimension: discuss the background variables of English teachers' professional development in terms of sex, age, position, educational background, certification, school size, and seniority.

(4)Strategic dimension: To cope with fewer children and internationalization, the study reexamines strategies for EFL English teachers' professional development.

2. Evaluation for Teachers' Professional Development.

2.1. Research Procedure. In order to give a systematic analysis for the EFL teachers' evaluation we propose the following procedure:

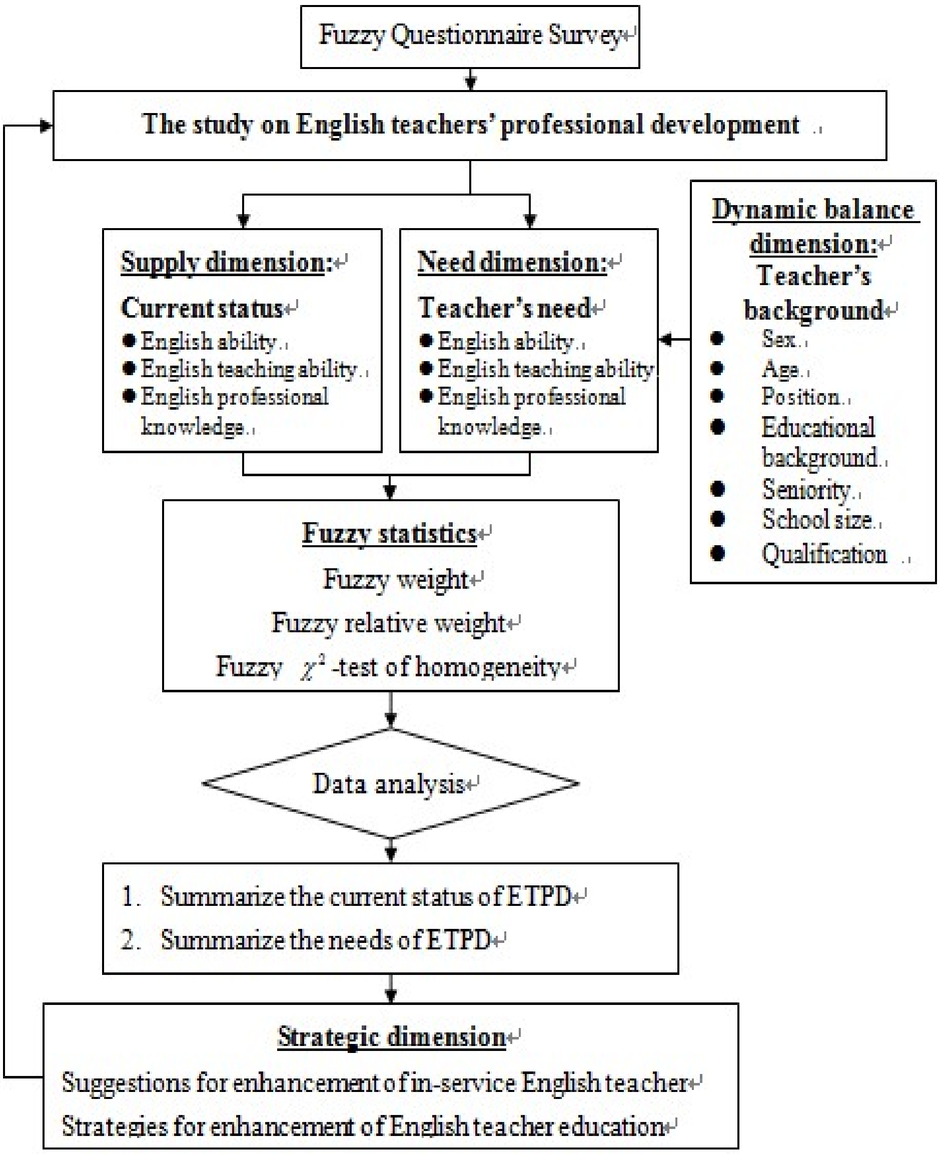

FIGURE 1. Research procedure

2.2. M embership Me asure and F uzzy S tatistic. Membership statistics differs from traditional statistics in terms of logic concepts and frameworks. Teachers' need on English professional knowledge of culture listed in Table 1.

TABLE 1. Teachers' need on English professional knowledge of culture

	English culture	English children literature	English drama & movie	Internationalization education
Teacher		0.5	0.2	0.3

In this example, we consider the universe set X={English teacher}, one of the element in X is x, and defined as some professional development, let membership set of X, F={English professional knowledge of culture}, the cut of F set $\{C_1, C_2, C_3, C_4\}$={English culture, English children literature, English drama & movie, Internationalization education}.

According to traditional statistics, the arithmetic is 1 point for1 item. The subject can only choose one of the four choices. The answer can't display the relationships among the choices. If we use fuzzy statistics, the subject can completely express the ambiguous phenomenon in his or her mind. The results are closer to real situation than the traditional method and follow the rule "1 point for 1 item."

In traditional statistics, mean score is presented by point, so it's called point estimation. However, in fuzzy statistics, the data are fuzzy intervals. We use interval to display the centralized trend of data. The arithmetic ideas are based on related definitions of traditional statistics. On the other hand, for the same subject, the value obtained by traditional questionnaire must be included in the fuzzy interval that obtained by fuzzy questionnaire of the same question. Therefore, these two kinds of data to some extent possess correlation. Related concepts of fuzzy statistics using in this paper are illustrated as follows:

Definition 2 .1. Fuzzy weight (FW). We consider universe of discourse $S = \{S_1, S_2, \cdots, S_k\}$,utility sequence $r_1 \prec r_2 \prec \cdots \prec r_f$, and S_i in r_f membership is $u_{s_i f}$. Then the Fuzzy weight $FW = (FW_{s_1}, \cdots, FW_{s_k})$ is defined as:

$$FW_{s_i} = \frac{\sum_{l=1}^{f} \mu_{s_i l}}{r_l} = \frac{\mu_{s_i 1}}{r_1} + \frac{\mu_{s_i 2}}{r_2} + \cdots + \frac{\mu_{s_i f}}{r_f}; i = 1, \ldots, c. \quad (1)$$

In the fuzzy set, membership ranges from 0 to 1, and every language variable, such as shape, represents a possible distribution. The results of the distribution might be different from different subjects. We can average the answers from the subjects to make the utility sequence *r* of universe of discourse *S* membership u_s reasonable distribution (Wu, 2005).

Definition 2 .2. Fuzzy relative weight analysis. If we consider utility sequence $r = \{r_1, r_2, \ldots r_f\}$, then define $r_1 \prec r_2 \prec \ldots \prec r_f$ as utility increasing sequence; otherwise, $r_1 \succ r_2 \succ \ldots \succ r_f$ is utility decreasing sequence.

According to the sort of utility sequence, the computing of the fuzzy relative weight is: Consider universe of discourse $S = \{S_1, S_2, \ldots S_k\}$, utility sequence $r = \{r_1, r_2, \ldots r_f\}$, and

$\mu_{s_i f}$ is the membership of r_f in S_i. Then the fuzzy weight for element of universe of discourse $FW = \{FWS_1,...FW_{S_k}\}$ is defined as:

$$FW_{s_i} = \sum_{i=1}^{f} \mu_{S_i l} / r_l + \mu_{S_i 1} / r_1 + \mu_{S_i 2} / r_2 + ... + \mu_{S_i f} / r_f \, ; i = 1,..., c \quad (2)$$

2.3. Fuzzy χ^2 -Test of Homogeneity (with Discrete Data). Consider a K-cell multinomial vector n={$n_1, n_2, ..., n_k$} with $\sum_i n_i = n$. The Pearson chi-squared test ($\chi^2 = \sum_i \sum_j \frac{n_{ij} - e_{ij}}{e_{ij}}$) is a well known statistical test for investigating the significance of the differences between observed data arranged in K classes and the theoretically expected frequencies in the K classes. It is clear that the large discrepancies between the observed data and expected cell counts will result in larger values of χ^2.

However, a somewhat ambiguous question is whether (quantitative) discrete data can be considered categorical and use the traditional χ^2 -test. For example, suppose a child is asked the following question: "how much do you love your sister?" If the responses is a fuzzy number (say, 70% of the time), it is certainly inappropriate to use the traditional χ^2 -test for the analysis. Wu (2005) presents a χ^2 -test for fuzzy data as follows:

2.3.1. Procedures for Testing Hypothesis of Homogeneity for Discrete Fuzzy Samples.

(1) Sample: Let Ω be a domain, $\{L_j, j = 1,...,k\}$ be ordered linguistic variables on Ω, and $\{a_1, a_2, \cdots, a_m\}$ and $\{b_1, b_2, \cdots, b_n\}$ are random fuzzy sample from population A, B with standardized membership function mA_{ij}, mB_{ij}.

(2) Hypothesis: Two populations A, B have the same distribution ratio. i.e

$$H_0 : F\mu_A =_F F\mu_B$$

W*here*

$$F\mu_A = \frac{\frac{1}{m} MA_1}{L_1} + \frac{\frac{1}{m} MA_2}{L_2} + ... + \frac{\frac{1}{m} MA_k}{L_k}$$

$$F\mu_B = \frac{\frac{1}{n} MB_1}{L_1} + \frac{\frac{1}{n} MB_2}{L_2} + ... + \frac{\frac{1}{n} MB_k}{L_k}$$

$$MA_j = \sum_{i=1}^{m} mA_{ij} \, , \, MB_j = \sum_{i=1}^{n} mB_{ij}$$

(3) Statistics: $\chi^2 = \sum_{i \in A,B} \sum_{j=1}^{c} \frac{([Mi_j] - e_{ij})^2}{e_{ij}}$. (In order to perform the Chi-square test for fuzzy data, we transfer the decimal fractions of Mi_j in each cell of fuzzy category into the integer Mi_j by counting 0.5 or higher fractions as 1 and discard the rest.)

(4) Decision rule: under significance level α, if $\chi^2 > \chi^2_\alpha(k-1)$,then we reject H_0.

2.3.2. Procedures for Testing Hypothesis of Homogeneity for Interval Fuzzy Samples.

(1) Sample: Let Ω be a discussion domain, $\{L_j, j=1,...,k\}$ be ordered linguistic variables on the total range of Ω，and $\{a_i=[a_{li}, a_{ui}], i=1,...,m\}$ } and $\{b_i=[b_{li}, b_{ui}], i=1,...,n\}$ and are random fuzzy sample from population A, B with standardized membership function mA_{ij}, mB_{ij}.

(2) Hypothesis: Two populations A, B have the same distribution ratio. i.e

$$H_0 : F\mu_A =_F F\mu_B$$

Where

$$F\mu_A = \frac{\frac{1}{m}MA_1}{L_1} + \frac{\frac{1}{m}MA_2}{L_2} + ... + \frac{\frac{1}{m}MA_k}{L_k}$$

$$F\mu_B = \frac{\frac{1}{n}MB_1}{L_1} + \frac{\frac{1}{n}MB_2}{L_2} + ... + \frac{\frac{1}{n}MB_k}{L_k}$$

$$MA_j = \sum_{i=1}^{m} mA_{ij},\ MB_j = \sum_{i=1}^{n} mB_{ij}.$$

(3) Statistics: $\chi^2 = \sum_{i\in A,B}\sum_{j=1}^{c}\frac{([Mi_j]-e_{ij})^2}{e_{ij}}$. (In order to perform the Chi-square test for fuzzy data, we transfer the decimal fractions of Mi_j in each cell of fuzzy category into the integer Mi_j by counting 0.5 or higher fractions as 1 and discard the rest.)

(4) Decision rule: under significance level α, if $\chi^2 > \chi^2_\alpha(k-1)$, then we reject H_0.

Example 2.1. The educational authority wants to know the degree of effectiveness from an English teacher training program. Suppose they are interested in how the sex will make a difference about the curriculum. They conduct a sampling survey and ask the people with two methods for reply: traditional reply and fuzzy reply. The results are as follows:

TABLE 2. Replies for teachers on the degree of curriculum effectiveness

	Effectiveness of curriculum			Effectiveness of curriculum		
Category	Profe-ssional	Cultural	Instruc-tional	Profess-ional	Cultural	Instruc-tional
Male	220	280	100	216.2	268.5	114.3
Female	170	150	80	158.1	154.7	87.2
χ^2 -test of homogeneity	χ^2 =8.27 >5.99 = $\chi^2_{0.05}(2)$			χ^2 =3.78 < 5.99 = $\chi^2_{0.05}(2)$		

Null Hypothesis: H_0 ：there is no difference of the degree of effectiveness for sexes. H_1: there is no difference of the degree of effectiveness for sexes. Under the significance level α =0.05, we can find that there exists difference Statistical testing conclusion: for traditional reply, we will reject the null hypothesis. While for the fuzzy reply, we will accept the null hypothesis.

Example 2.2. In order to set up a professional development strategy, the research center of English teacher education wants to know the studying expense (monthly) between school X and school Y. They randomly choose 50 samples from X and Y. during the answering process, teachers are asked to write their studying expense by interval instead of real number. For instance, they can write the studying expense as: 1500~2500 with membership 0.7, 2500~4000 with membership 0.3. Then they sum up the memberships and get the following Table 3

TABLE 3. Monthly studying expense for school X and Y

	0~1500	1500~2500	2500~4000	4000~6000	6000+
X	2.8	10.3	19.7	14.2	5.0
Y	7.1	21.6	20.9	6.8	2.6

Null Hypothesis H_0 ：The distribution (ratio) for studying expense between school X and Y has no difference. H_1 ：School X has a higher living studying than Y.

Computing the statistics χ^2 , we find χ^2 =8.43> $\chi^2_{0.05}(4)$ =7.78. Hence under the significant level α=0.1. We reject H_0 ：The distribution (ratio) for studying expense between is no difference. Examining again the data, we may say that the school X has a higher studying expense than school Y.

3. E mpirical Analysis and Discussion. This section discussed the results on English teachers' professional development in terms of supply, need, dynamic balance, and strategies.

TABLE 4. The membership of current status on English teachers' professional competences

	Excellent	Very well	Well	Not so good	Poor
English ability	0.01	0.90	1.81	1.19	0.18
English professional knowledge	0.00	0.89	1.46	1.18	0.49
English Cultural knowledge	0.05	1.12	1.21	1.20	0.43
English teaching ability	0.39	2.20	1.27	0.39	0.10
Whole ability	0.41	5.78	7.81	5.13	1.44

3.1. Supply Dimension: the Curr ent S tatus of En glish Teachers' Professional Competences. Table 4 presents the sum of membership on different language variables with respects to English ability (four skills) and English professional knowledge, including phonetics, syntax, morphology, and pragmatics. As for English ability, most of the distributions lie on "well" and "not so good", while English teaching ability displays higher distribution of membership on "very well."

Table3.2 shows that several background variables, including "school size", "educational background", and "qualification", reach significant differences on "English ability", "English cultural knowledge", " English teaching ability."

TABLE 5. The differences of current status on English teachers' professional competences

	English ability	English professional knowledge	English cultural knowledge	English teaching ability
Sex				
Age				
School size			**	
Educational background			**	**
Seniority				
Position				
Qualification	**		***	*

*** p<.01, **p<.05, *p<.1

TABLE 6. The membership of English teachers' need for professional development

English ability	Listening	Speaking	Reading	Writing	-
	0.34	0.42	0.10	0.15	-
English professional knowledge	Phonetics	Syntax	Morphology	Pragmatics	SLA
	0.21	0.19	0.15	0.23	0.22
English cultural knowledge	English culture	English children literature	English drama & movie	Internationali-zation education	-
	0.18	0.40	0.15	0.27	-
English teaching ability	Curriculum design	Teaching method	Evaluation	Application of teaching recourses	-
	0.28	0.33	0.12	0.27	-

3.2. Need Dimension: English Teachers' Needs for Professional Development. Table3.3 expresses the membership for sub-categories of professional development with respect to teachers' need. At English ability level, teachers reveal higher membership on listening and speaking ability. At English professional knowledge level, the distribution is about average. As for English cultural knowledge, teachers have greater needs for children literature and internationalization education. For English teaching ability, the sequential needs are teaching method, curriculum design, application of teaching recourses, and evaluation.

3.3. Dynamic Balance: the Evaluation of Different Backgrounds. Table 7 displays the results from fuzzy χ^2-test of homogeneity toward the differences of needs for professional competences among English teachers in Taiwan.

TABLE 7. The differences of needs for English professional competences

	English ability	English professional knowledge	English cultural knowledge	English teaching ability
Sex		***		
Age				
School size		***	**	
Educational background				*
Seniority		***	*	
Position			***	
Qualification	***			

*** p<.01, **p<.05, *p<.1

TABLE 8. Membership of needs for improving English ability

Qualification	Listening	Speaking	Reading	Writing	χ^2-test of homogeneity
major/minor in English related departments	3.5	4.6	1.1	3	$\chi^2_{0.05}(3)$=12.75 > 7.81
English training program run by county or city bureaus	6.4	7.9	2	1.7	

TABLE 9. The membership of needs for English professional knowledge

		Phonetics	Syntax	Morphology	Pragmatics	SLA	χ^2-test of homogeneity
Sex	Male	3.7	1.7	1.1	1.2	2.2	$\chi^2_{0.05}(4)$=28.97 >9.48
	Female	2.5	4	3.4	5.6	4.6	
School size	6～24	3.3	2.5	1.5	2.2	1.4	$\chi^2_{0.05}(4)$=16.97 >9.48
	24～	2.9	3.2	3	4.6	5.4	
Seniority	0～5	1.6	1.5	1.1	0.9	1	$\chi^2_{0.05}(8)$=32.54 >15.50
	6～10	3.3	2.4	2.7	3.6	4.9	
	11～20	1.3	1.8	0.7	2.3	0.9	

3.3.1. The Needs for Improving English Ability. According to Table3.4, teachers with certificate by county or city bureaus have greater needs on improving their listening and speaking ability than those of major/minor in English related departments.

3.3.2. The Needs for English Professional Knowledge. In Table 9, male English teachers have greater needs on phonetics, whereas female teachers show their needs on syntax, morphology, pragmatics, and second language acquisition (SLA). Teachers in schools of more than 24 classes prefer pragmatics and SLA, while those in small school size prefer phonetics and syntax.

3.3.3. The Needs for English Cultural Knowledge. Table 10 reveals that teachers of different position, seniority, and school size express high needs for English children literature, internationalization.

TABLE 10. Membership of needs for English cultural knowledge

		English culture	English children literature	English drama & movie	Internationali-zation education	χ^2 -test of homogeneity
School size	6～24	1.3	5.1	1.4	3.2	$\chi^2_{0.05}(3) =$
	24～	4.4	7.2	3.3	4.1	8.51>7.81
Seniority	0～5	1.1	2.9	1.1	0.9	$\chi^2_{0.1}(6) =$
	6～10	4	6.2	2.4	4.4	11.34>10.64
	11～20	0.6	3.2	1.2	2	
Position	Subject	3.2	3.5	1.8	3.5	$\chi^2_{0.05}(3) =$
	Home	2.5	8.8	2.9	3.8	14.99>7.81

3.4. Strategic Dimension: EFL Teachers' Professional Development Strategies Reacting to Fewer Children and Internationalization. Depended on the research results above, the strategies for English teacher professional development are as follows:

3.4.1. Establish Certification and Reward System for English Teacher Professional Development.

(1) Build up evaluation indicators for English teacher and researcher references.
(2) Set up cloud management platform to monitor human capital development.
(3) Establish reward system for in-service learning, teaching and professional seminar to promote the positive interaction and development for English teachers.

3.4.2. Strengthen the Shortages of Teachers' Competence, and Enhance the Advantages to Be Excellent.

(1) Develop English teacher professional community in each area.
(2) Improve teachers' ICT (information communication technology) ability for a higher teaching and evaluating effects.
(3) Utilize instruction advisory team at central and local level to promote school teachers' competence.

3.4.3. Cross Country Cooperation on English Teacher Professionalism and Culture.

(1) Invite international scholars and excellent English teachers to long stay in Taiwan.
(2) Select teachers with high potential to study and train abroad.
(3) Utilize International Exchange Program for teachers to enhance international education competence.

3.4.4. Cooperate with Higher Education to Facilitate English Teachers' Professional Development.

(1) Build up local English teaching research center to conduct the short, mid, long term studies in Taiwan.
(2) Provide multiple in-service programs according to teachers' need.
(3) Examine and modify the structure of curricular for English teacher in high education to suit the future requirement.

4. Conclusion. Taiwan belongs to EFL context, and the success of English education need multi-dimensional cooperation and endeavor. The professional development of English teacher is the assurance for quality English teacher. Only via ongoing estimating, monitoring, and checking teachers' ability and need can we effectively catch the core of teachers' professional development. The study is the first step to establish a framework for evaluating English teachers' professional development. We focus on different subjects, such as secondary English teachers, extend the geographical area, compare with other countries, and conduct longitudinal studies. Hopefully, our efforts to construct a database will help English teachers' professional development in the future.

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ANALYSIS AND EVALUATION OF ENTERPRISE INNOVATION ABILITY CONVERSION

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ABSTRACT. *The quantity of Patents, especially high quality patents is becoming a key competitive factor between countries. We take the survey of corporate patent in Zhejiang province and analyze the specialization index and patent aggregation in enterprise authorized patent application areas. The article points out that the innovation ability of enterprise is different in different regions, but the innovation output of different industries appear to be convergent, which weakens the economic development and progress brought by industrial division of labor. These analyses are significant for further development and implementation of patent and the transformation in Zhejiang province.*

Keywords: Innovation; Transformation Capability; Difference; Evaluation

1. Introduction. With the advent of knowledge economy, the volume of patents owned by a company or a country has become an important indicator to measure competitiveness.

A research paper pointed out that the countries whose patent applications volume ranks top have faster economic growth rate and high-level Industrialization by World Intellectual Property Organization (WIPO). With increasingly attention on intellectual property rights, research on patent output catches the eyes of domestic and foreign researchers. Schmookler (1966) used patent data as an indicator of technical innovation to compare technical innovation current situation in different nations. Analysis of patent data has long been considered as an important method to estimate various aspects of technical change. Schiffel and Kitt (1978), Bosworth (1984) and Paci and Sassu (1997) used it to estimate the national research and innovation process; Archibugi and Pianta (1996), Ashton and Sen (1988), Basberg (1987), Mogee (1991) and Liu and Shyu (1997) estimated some specific sectors and enterprises' technological development level. Huizinga and Leaven (2008) analyzed the influence of patent transformation in different countries, and compare positive roles on the technology development in these countries brought about by patent transformation. Liu (2003) analyzed and researched patent current situation from industries, thought that the inventing patent has the highest quality and reflects innovative ability, how to increase the output of inventing patents, thereby enhance the innovation capability. Li (2009) found that regional innovation output transformation capability decreased gradually over time and convergence is obvious throughout the nation by analyzing innovation output transformation capability in 30 provinces in China.

We can see that Domestic and foreign scholars have made a convincing conclusion in patent research from respects of output structure, incentives for technical innovation and industries relationship. But we are still lack of relative argumentation for output in different regions and the factors influencing the output, empirical analysis of specific situations is necessary.

2. Indicators and Data.

2.1. Indicators. We use Specialization index and patent aggregation which measures Patent strength in different regions. They are classified into specialization index between regions, regional patent aggregation index and industrial patent aggregation index .We use the number of authorized patents as patent data.

2.2. Regional Patent Aggregation. Regional patent aggregation examine the distribution of authorized patents in all regions of one target industry, reflecting innovation ability of the target industry in one region.

$$\mathrm{Re}\,gionalpatentaggregation = \frac{p_{ij}}{\sum p_j} \tag{1}$$

p_{ij} represents the number of authorized patents in industry j owned by region i, p_j represents the number of authorized patents in industry j owned by all regions. High regional patent aggregation in region i means that compare with other regions, i has a strong potential for technological innovation of industry j and can develop j into a promising industry. Conversely, regional patent aggregation means that industry j is not dominant and needs adjustment of industrial structure in this region. The index of is of great value in comparison of patent strength of different regions, it can also judge the region's location in the development of industry j.

2.3. Industry Patent Aggregation. Industry patent aggregation examines the distribution of authorized patents of all industries in one target region, reflecting innovation ability of the one industry in the target region.

$$Industrypa\ tentaggreg\ ation = \frac{p_{ij}}{\sum p_i} \tag{2}$$

p_{ij} represents the number of authorized patents in industry j owned by region i, p_j represents the number of authorized patents in all industries owned by region i.A high industry patent aggregation means a strong ability of technical innovation and development potential for industry j in region I, so we can develop j into a promising industry. Conversely, industry j has no advantage in industry j. An average industry patent aggregation for different industries in one region means that less prominent Industry characteristics; A greater the difference in the patent industry aggregation means prominent Industry characteristics.

2.4. Specialisation Index between Regions Index. Specialisation index between regions index is a index put forward by krugman which examines the structural differences across regions and professional level of manufacturing.

$$k_{ij} = \sum_k \left| p_i^k - p_j^k \right| \tag{3}$$

i represents region i, j represents region j , and k represents industry k. p_i^k represents the proportion of k's output value in all industries' output value in region i (E_i^k), and

$$p_i^k = E_i^k / \sum_k E_i^k \tag{4}$$

Similarly, we calculate region j with the same. Be explained, we replace output value with the number of authorized patents and replace all industries' output value with all industries' total number of authorized patents. The new indicator whose value is between 0and 2 can measure the degree of different structure of manufacturing innovation between two cities. A closer value to 0 means low degree of different structure of manufacturing innovation between two cities. Conversely, a closer value to 2 means a high degree of difference.

2.5. Data. Zhejiang Intellectual Property Office and China Jiliang University conducted a survey "sample survey of invention patent implementation in Zhejiang province" from July to September of 2009, focusing on Hangzhou, Ningbo and so on, totaling 12 areas (specific questionnaire as table 1 shows).

The selected 406 authorized patent enterprises of Zhejiang distribute in many sectors like Equipment industry; electrical machinery and equipment manufacturing; communications equipment, computers and other electronic equipment manufacturing; chemical materials and chemical products manufacturing, petroleum processing nuclear fuel and so on. Taking the convenience of the data in calculation into account and industry representation of the economy in Zhejiang, we choose 10 industries to analyze.

3. Calculation and Analysis. We use specialization index between regions, regional patent aggregation index and industrial patent aggregation index to analyze invention patent data in the 10 industries.

3.1. Regional Patent Aggregation Index. We get regional patent aggregation of the 10 selected industries in Hangzhou, Ningbo and Jiaxing etc. As table 2 shows.

TABLE 1. The percentage of total number of enterprises and questionnaires

	Hang zhou	Ning bo	Wen zhou	JIa xing	Hu zhou	Shao xing	Jin hua	Qu zhou	Zhou shan	Tai zhou	LI shui	YI wu	Total
Questionnaires	466	156	52 28		20	71 1	9	14	2	58	2	13	901
Valid questionnaires	429	140	46 26		20	67 1	9	13	2	58	2	13	835
Invalid questionnaires	37	16	6 2		0	4	0	1	0	0 0		0	66
Enterprises	150	17	21 1	0	1	96 33		32	29	6	2	9	406

TABLE 2. Regional patent aggregation of the 10 industries in 8 regions (unit %)

	Hang zhou	Hu zhou	Jia xing	Jin hua	Ning bo	Shao xing	Taiz hou	Wen zhou
Special equipments	25.93 7	.41	1.85	0	40.74	11.11	5.56	7.41
Electrical Machinery	23.07 3	.85	7.69	1.92	26.92	11.54	5.77	19.23
Communications equipment	70.27 2	.70	5.40	2.70	16.21	0	2.70	0
Chemical materials and chemical products	41.30 4	.35	2.17	8.69	19.56	10.87	6.52	6.52
Pharmaceutical Industry	42.5 7	.5	2.5	10	2.5	12.5	22.5	0
Artwork and Other Manufacturing	22.22 5	.56	5.56	11.11	27.78	11.11	11.11	5.56
Transport Equipment	20 0		10	0	10	0	40	20
Leather Fur Feather (hair)	29.41 5	.88	23.52	5.88	17.64	17.64	0	0
Metal smelting and rolling processing industry	23.07 7	.69	7.69	7.69	30.76	0	7.69	15.28
Instruments, Cultural and Office Machinery	37.93 0		0	3.45	41.38	0	3.45	13.79

As table 2 shows, Ningbo has the advantage on special equipment manufacturing industry, followed by Hangzhou and Shaoxing, a few other areas in Zhejiang are relatively weak. Ningbo, Hangzhou, Wenzhou and Shaoxing has a strong advantage on electrical machinery and equipment manufacturing industry, other areas are weak. Hangzhou has the absolute advantage on communications equipment, computers, and other electronic equipment manufacturing, followed by Ningbo and other areas are weak. Hangzhou also has the absolute advantage on chemical materials and chemical products manufacturing, petroleum fuel processing industry, followed by Ningbo and other areas are weak. Hangzhou and Taizhou has an advantage on pharmaceutical industry, other parts are weak. Ningbo has an advantage on Artwork and other manufacturing, followed by Hangzhou, Shaoxing, Jinhua, other areas are weak. Taizhou has an advantage on transportation equipment manufacturing industry, followed by Hangzhou and Wenzhou, other areas are weak; Hangzhou has an advantage on leather fur feather (down) and its products, textiles and clothing and shoes manufacturing, followed by Jiaxing, Ningbo and Shaoxing, the rest areas are weak; Ningbo has an advantage on metal smelting and rolling processing, instruments, cultural and office machinery industry, followed by Hangzhou and Wenzhou, other areas are weak. Hangzhou and Ningbo have obvious advantages on the 10 industries as a whole, Hangzhou has an advantage on Communications equipment, computers and other electronic equipment manufacturing, chemical materials and chemical products manufacturing, petroleum f uel p rocessing industry; p harmaceutical i ndustry; leather fur feather (down) and its products, textiles and clothing and shoes manufacturing. Ningbo has an a dvantage on s pecial E quipment, e lectrical machinery and equipment m anufacturing; handicrafts and ot her m anufacturing; m etal sm elting, rolling processing and products industry; instruments, meters, cultural and office machinery manufacturing. Taizhou has an advantage on transport equipment.

TABLE 3. Industry patent aggregation in all regions (unit %)

	Hang zhou	Hu zhou	Jia xing	Jin hua	Ning bo	Shao xing	Tai zhou	Wen zhou
Special equipments	12.39	26.67	6.25	0	28.57	22.22	11.11	15.38
Electrical Machinery and Equipment	10.62 13	3	25	6.67	18.18	22.22	11.11	38.46
Communications equipment	23.01 6	.67	12.5	6.67	7.79	0	3.7	0
Chemical materials and chemical products	16.81 13	3	6.25	26.67	11.68	18.51	11.11	11.54
Pharmaceutical Industry	15.0 20		6.25	26.67	1.24	18.51	33.33 0	
Artwork and Other Manufacturing	3.54 6.6	7	6.25	13.3	6.49	7.4	7.4	3.84
Transport Equipment	1.77	0	6.25	0	1.29	0	14.8	7.69
Leather Fur Feather (hair)	4.42	6.67	25	6.67	3.89	11.11	0	0
Metal smelting and rolling processing industry	2.65 6	.67	6.25	6.67	5.19	0	3.7	7.69
Instruments, Cultural and Office Machinery	9.73 0		0	6.67	15.58	0	3.7	15.38

3.2. Industry Patent Aggr egation. We ge t industry patent aggregation of Ha ngzhou, Ningbo and JIax ing ect. By calculating th e inv ention patent qu antity, th e res ults are as Table 3 shows.

It ca n be seen fro m T able 3 th at Hang zhou h as an adv antage on co mmunications equipment, co mputers, and oth er ele ctronic e quipment m anufacturing; Hu zhou h as a n advantage on special equipments; Jiaxing and We nzhou ha ve advantages o n e lectrical machinery a nd e quipment; Ji nhua has a n a dvantage on Chemical materials and c hemical products m anufacturing, pet roleum processing n uclear f uel and pharmaceutical industry; Ningbo has an a dvantage on special equipmen ts; Ta izhou has an adv antage on pharmaceutical in dustry; S haoxing has an advantage on s pecial e quipment a nd e lectrical machinery and equipment. An convergence of industrial advantages of Huzhou, Shaoxing, Wenzhou and JIaxing are shown from Table 3.

3.3. Specialisation between Regions. We get specialization index of special equipments in Hangzhou, Ningbo and Jiaxing ect. By calculating the invention patent quantity, the results are as Table 4 shows.

TABLE 4. Specialisation indexes of special equipments in all regions

	Hangzhou	Huzhou J	iaxing	Jinhua	Ningbo	Shaoxing	Taizhou
Huzhou 0	.143						
JIaxin 0	.062	0.204					
Jinhua 0	.124	0.267	0.063				
Ningbo	0.162 0.019		0.223 0.2	86			
Shaoxing	0.098 0.044		0.159 0.2	22	0.063		
Taizhou	0.013	0.156	0.049	0.111 0.1	75 0.1	11	
Wenzhou	0.029	0.113	0.091	0.154 0	.132 0	.068	0.043

The specialization indexes of special equipments in Zhejiang are close to 0, the indexes in few regions are about 0.1 or 0.2, which means that although block economy is the main mode of Zhejiang, the convergence of technical innovation is obvious. We can also get specialization i ndexes of Elect rical m achinery an d e quipment manufacturing i ndustry, communication e quipment, c omputers, a nd other e lectronic e quipment m anufacturing, chemical mat erials and c hemical products m anufacturing, p etroleum fuel processing, pharmaceutical manufacturing, handicrafts a nd oth er m anufacturing, the conclusions ar e similar with special equipments.

4. Conclusions.

4.1. Take Government's Macro Managements on Patent as the Guidance to Industrial Innovation Path. The survey of 835 major franchise companies patents are private, and the relative development of bet ter mechanisms of market ec onomy a nd the promotion of Zhejiang p atent pol icy to p romote access to its mark et return. Ho wever, the gov ernment needs to c reate a favorable market e nvironment a nd strengthen g uiding r ole of rele vant policies, e specially provide s ome financial s upport a nd ta x i ncentives, to promote th e implements of patent. In order to coordinate intellectual property information and facilitate technology transfer, th e fed eral government of USA passed a Bi ll in 199 1 a nd found ed "National Technology Transfer Ce nter (NTTC)" in 1992 .NTTC's main jobs are o ffering information and training on in tellectual property m anagement, establishing information files, putting the nation's more than 700 laboratories and results of thousands of R&D data into the "Appl ications Information Systems (FLC)" Cooperation, do ing t echnical evaluation, market research and technology intermediaries, etc. through the National 6 "Regional Technology Transfer Center (RTTE)". Now NTTC is largest intellectual property management and services agency supported by the U.S. government. Therefore, on one hand, the government should step in building a platform to promote the spread of the patent transformation, develop and guide patent intermediary agencies. On the other hand, enterprises should use various means to operate and protect patents, and secure the best economic and social benefits for the end.

4.2. Strengthen the Operational Capacity of Corporate Intellectual Property Rights; Strengthen the Comprehensive Use of Intellectual Property. Two reasons lead to the enterprises owing authorized patents not good at operating intellectual property. On one hand, Intellectual property patent quality is low and operation market is immature, on the other hand, enterprises regard IP technology as the enterprise's own reserves or the use of enterprise production and business activities, but did not consider intellectual property as a way to expand market competitiveness and influence. Therefore, enterprises in Zhejiang must strengthen the awareness of intellectual property operations and regard the application, operation, protection and diffusion as a whole system. They can enhance the competitiveness by implementing intellectual property strategy.

Therefore, in order to make enterprises initiative to combine patent activities with market competition closely, the implementation of intellectual property strategy becomes a key. Intellectual property strategy should be combined with technological innovation strategy, marketing innovation strategy and management strategy to get a coordinated development. Enterprises can establish a sound intellectual property management systems and institutions, improve the intellectual property related with incentive systems, select and use intellectual property portfolio for business strategy, cultivate a sense of innovation and intellectual property professionals, therefore improving the overall business level of IPR creation, use, and protection and management capabilities.

4.3. Promote the Formation of Patent Characteristic Block by Using the Policy Technology Commissioner Effectively. Technology Commissioner Policy plays a key role in the development of Zhejiang's economy, especially of the poor areas. However, we know that the characteristics of patent block economy are not very prominent, especially invention patents, as the most valuable type of technological innovation, its convergence are the obstruction for economic progress, and what's more, convergence in innovation leads to a convergence of division of work in different industries. Therefore, innovation and industry can be combined effectively to get a consistency through technology commissioner policy.

4.4. A Weak Sense of Tracking Future Technologies via Patents or the Implementation of Patents. Analyzing future development through patents and distributing technology effectively has become an important business tool in patent strategies in U. S., EU and Japan. A research company in America CHI brought science paper into patent field to analyze competitive trends, technology tracking and other industrial technology. CHI invested heavily in building up a patent database containing more than one million non-patent reference data and standards of thousands of companies lists ,serving for national macro policies analysis and research, offering special data resource for economic analysis of enterprises. CHI cooperates with U.S. Technology Policy Office of Commerce Department and U.S. Competitiveness Council Cooperation to establish patent specifications by analyzing patent approvals data of United States Patent and Trademark Office. It also makes a comparative analysis on technology competitiveness, technical strength and the direction of technology development in 5 important technology fields in United States, Europe, Japan and China ect., which plays an important role in supporting and promoting the implementation of intellectual property strategy of U.S. government and enterprises.

4.5. Enhance the Awareness of Patent Implementation, Avoid Patent Convergence. Entrepreneur's patent implementation policy plays an important role in the implementation of enterprise patent. However, a phenomenon that inventing for invention is obvious on few entrepreneurs. Some invent for national award, they do not implement the patents after obtaining the award. Some enterprise invent to capture the market, do not take that whether they are relate to their main industry , so convergence phenomenon can easily be made. Of course, our current patent model that transferring patent through patent agencies has also weakened the implementation of effective transformation.

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RESIDUALS EVALUATION FOR THE ADJUSTED FUZZY LINEAR REGRESSION MODEL

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ABSTRACT. *The fuzzy regression analysis has been widely applied in modeling economic or financial data. It is a necessary work to survey the forecast validity of the fitted fuzzy regression model similar to the ones of the traditional regression analysis. The goal of this study is to construct residuals which can measure the deviation between the observed value and the fitted value in the fuzzy regression model. In this research, the residuals in the fuzzy regression model are evaluated in terms of the standard fuzzy arithmetic and the general crisp logic, respectively. Moreover, the mean squared error constructed by the crisp-logic residuals is used to exhibit the fitness degree of the fuzzy regression model.*

Keywords: Fuzzy Regression Model; Fuzzy Coefficient; Least Squares Method; Fuzzy Residual; Mean Squared Error

1. Introduction of the Fuzzy Regression Model. Originally regression analysis is a statistical stechnique focusing on modeling and analyzing the relationship among several variables. So far regression analysis has been extensively applied in various fields. Tanaka et al. (2000) proposed the study in linear regression analysis using fuzzy set theory. They consider the estimated value be a fuzzy number. Isshibuchi and Tanaka (1992) presented an interval regression analysis base on the back-propagation neural networks. Yang and Ko (1997) proposed a cluster-wise fuzzy in two approaches: the two stage weighted fuzzy regression and the one stage generalized fuzzy regression. Wu and Tseng (2002) proposed a new approach on fuzzy regression models by using fuzzy number and method of least square.

By extending the concept of traditional regression, Tanaka et al. (1982) proposed the linear fuzzy regression analysis using fuzzy set theory. They consider the model form as

$$\tilde{Y}(\mathbf{x}_i) = A_0 + A_1 x_{i1} + A_2 x_{i2} + \ldots + A_p x_{ip},\ i = 1,2,\ldots,n\ , \tag{1}$$

The coefficient A_j is assumed to be the symmetric fuzzy numbers with the membership function

$$\mu_{A_j}(t) = \max\left\{1 - \frac{|t - c_j|}{r_j} \ , \ 0\right\} , \quad -\infty < t < \infty, j = 1,2,...,p ,$$

where c_j and r_j denote the center and radius of the membership, respectively. The explanatory variables $x_{i1}, x_{i2}, ..., x_{ip}$ from the ith trial are real-value numbers, denoted as $\mathbf{x}_i = [x_{i0} \quad x_{i1} \quad x_{i2} \quad \cdots \quad x_{ip}]$ where $x_{i0} = 1$. Applying the fuzzy arithmetic, the output $\tilde{Y}(\mathbf{x}_i)$ is also the symmetric fuzzy numbers, indexed by $\mathbf{x}_i$, having the membership function

$$\mu_{\tilde{Y}(\mathbf{x}_i)}(t) = \max\left\{ \ 1 - \left| t - \sum_{j=0}^{p} c_j x_{ij} \right| \Big/ \sum_{j=0}^{p} r_j |x_{ij}| \ , \ 0 \ \right\} , \quad -\infty < t < \infty ,$$

For simplicity, a symmetric fuzzy number N with center c and radius r can be expressed as $N = \langle c \ , r \rangle$. Thus, the fuzzy coefficient A_j and output $\tilde{Y}(\mathbf{x}_i)$ can also be represented as

$$A_j = \langle c_j \ , r_j \rangle$$

and

$$\tilde{Y}(\mathbf{x}_i) = \langle c_0 \ , r_0 \rangle + \langle c_1 \ , r_1 \rangle x_{i1} + \langle c_2 \ , r_2 \rangle x_{i2} + ... + \langle c_p \ , r_p \rangle x_{ip} ,$$

respectively.

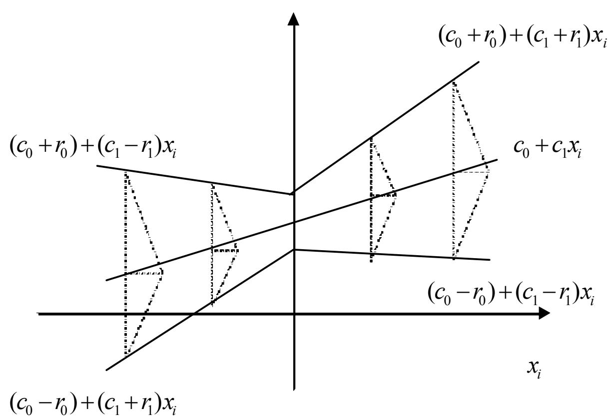

FIGURE 1. Simple fuzzy regression model

The fuzzy regression model proposed by Tanaka has a crucial feature: $\sum_{j=0}^{p} r_j |x_{ij}|$ increases as $|x_{ij}|$ increases, where $r_j \geq 0$ for $j = 1,...,p$. That means the radius of $\tilde{Y}(\mathbf{x}_i)$ will follow the absolute value of x_{ij} to tend to infinity. Let's take a simple linear model to describe this feature. With the single explanatory variable x_i, the membership function of $\tilde{Y}(\mathbf{x}_i)$ is

$$\mu_{\tilde{Y}(\mathbf{x}_i)}(t) = \max\left\{\ 1 - \left| t - (c_0 + c_1 x_i) \right| / (r_0 + r_1 |x_i|)\ \ ,\ \ 0\ \right\},\quad -\infty < t < \infty .$$

Then the middle line and the boundary lines are all displayed in Figure 1.

From Figure 1.2 it is seen that the distance between the upper boundary and the lower boundary get increasing as $|x_{ij}|$ tends to infinity.

2. Estimation of the Fuzzy Coefficients. In the fuzzy regression model (1) the fuzzy coefficient A_j is often unknown in practice; that is, the center c_j and radius r_j of A_j are required to estimate.We introduce two approaches used to estimate the fuzzy coefficient A_j: (1) the possibilistic method and. (2) the least squares method.

2.1. Possibilistic Method. The possibilistic method proposed by Tanaka et al. (1982) is an optimization by minimizing the sum of radiuses of the fuzzy outputs, subject to including all sample data within specified feasible interval. Assume that $(\mathbf{x}_i, Y_i)$ is the observed fuzzy sample in ith trial in which Y_i is the isosceles-triangle fuzzy number with center c_{yi} and radius r_{yi}. Let h_i denote the degree of fitness between the fuzzy sample Y_i and the output $\tilde{Y}(\mathbf{x}_i)$, defined by

$$h_i = \max\left\{ h \middle| [Y_i]_h \subset [\tilde{Y}(\mathbf{x}_i)]_h \right\},$$

where $[Y_i]_h$ and $\tilde{Y}(\mathbf{x}_i)$ are the h-cut set for Y_i and $\tilde{Y}(\mathbf{x}_i)$, respectively. To minimize the sum of radiuses of $\tilde{Y}(\mathbf{x}_i)$, the objective function is defined by

$$O_f = \sum_{i=1}^{n}\sum_{j=0}^{p} r_j \left| x_{ij} \right| . \tag{2}$$

For maintaining a suitable fitness between Y_i and $\tilde{Y}(\mathbf{x}_i)$, it is natural to make the assumption that h_i should be large than a significant level H, i.e. $h_i \geq H$ for all *i*. That assumption induces the following inequalities:

$$\begin{aligned} c_{yi} &\geq \sum_{j=0}^{p} c_j x_{ij} - (1-H)\sum_{j=0}^{p} r_j \left| x_{ij} \right| + (1-H) r_{yi}, \text{ and} \\ c_{yi} &< \sum_{m=0}^{p} c_j x_{ij} + (1-H)\sum_{j=0}^{p} r_j \left| x_{ij} \right| - (1-H) r_{yi} \quad \text{for all } i , \end{aligned} \tag{3}$$

The inequalities ensure that the observed fuzzy sample adjusted by the h-cut value is contained within the estimated fuzzy output adjusted by the h-cut value. Therefore, minimizing O_f in (2) is subject to Inequalities (3). The linear programming technique is employed for searching the solution of c_j and r_j in the optimization.

2.2. Least-Squares Method. Considering the statistical characteristic for imprecise measurement of observed sample, Wu and Tseng (2002) constructed the fuzzy coefficient estimation with the least squares technique. This approach is to minimize the sum of the squares of the error resulting from the upper and lower bound, respectively, of the membership function of $\tilde{Y}(\mathbf{x}_i)$.Different from the possibilistic method's assumption that Y_i must be covered by $\tilde{Y}(\mathbf{x}_i)$, the least squares method assumes that Y_i should approach $\tilde{Y}(\mathbf{x}_i)$ as near as possible.

Given a h-cut value H, the upper and lower bound of $[\tilde{Y}(\mathbf{x}_i)]_H$ are expressed as the following regression lines, respectively,

$$U_{[\tilde{Y}(\mathbf{x}_i)]_H} = \beta_0^U + \beta_1^U x_{i1} + \beta_2^U x_{i2} + \ldots + \beta_{ip}^U x_p \tag{4}$$

and

$$L_{[\tilde{Y}(\mathbf{x}_i)]_H} = \beta_0^L + \beta_1^L x_{i1} + \beta_2^L x_{i2} + \ldots + \beta_{ip}^L x_p , \tag{5}$$

where $U_{[\tilde{Y}(\mathbf{x}_i)]_H}$ and $L_{[\tilde{Y}(\mathbf{x}_i)]_H}$ denote the upper and lower bound of the h-cut set $[\tilde{Y}(\mathbf{x}_i)]_H$. Note that all of variables in (4) and (5) are crisp values, not fuzzy numbers; that is, both Equation (4) and (5) are considered as the traditional regression lines.

To minimize the sum of the squares of the error for the upper and lower bounds of $\tilde{Y}(\mathbf{x}_i)$, respectively, the two objective function are defined by

$$Q_U = \sum_{i=1}^n (U_{Yi} - U_{[\tilde{Y}(\mathbf{x}_i)]_H})^2 = \sum_{i=1}^n (U_{Yi} - \beta_0^U - \beta_1^U x_{i1} - \ldots - \beta_{ip}^U x_p)^2$$

and

$$Q_L = \sum_{i=1}^n (L_{Yi} - L_{[\tilde{Y}(\mathbf{x}_i)]_H})^2 = \sum_{i=1}^n (L_{Yi} - \beta_0^L - \beta_1^L x_{i1} - \ldots - \beta_{ip}^L x_p)^2 ,$$

where U_{Yi} and L_{Yi} are the upper and lower bound of the fuzzy sample Y_i. From the two objective functions, by using the matrix representation we can get the least squares estimates of β_j^U and β_j^L, $j = 0,1,\ldots,p$, as follows

$$\hat{\beta}^U = \begin{bmatrix} \hat{\beta}_0^U \\ \vdots \\ \hat{\beta}_p^U \end{bmatrix} = (X'X)^{-1} X'U_Y \quad \text{and} \quad \hat{\beta}^L = \begin{bmatrix} \hat{\beta}_0^L \\ \vdots \\ \hat{\beta}_p^L \end{bmatrix} = (X'X)^{-1} X'L_Y$$

where

$$X = \begin{bmatrix} 1 & x_{11} & \cdots & x_{1p} \\ \vdots & \vdots & & \vdots \\ 1 & x_{n1} & \cdots & x_{np} \end{bmatrix}, \quad U_Y = \begin{bmatrix} U_{Y1} \\ \vdots \\ U_{Yn} \end{bmatrix} \quad \text{and} \quad L_Y = \begin{bmatrix} L_{Y1} \\ \vdots \\ L_{Yn} \end{bmatrix}.$$

Then the estimated membership function of the fuzzy coefficient A_j can be written as

$$\mu_{A_j}(t) = \max \left\{ 1 - \frac{\left| t - \left(\dfrac{\hat{\beta}_j^U + \hat{\beta}_j^L}{2} \right) \right|}{\left(\dfrac{\hat{\beta}_j^U - \hat{\beta}_j^L}{2(1-H)} \right)} \quad , \quad 0 \right\},$$

or equivalently

$$A_j = \langle c_j, s_j \rangle = \left\langle \frac{\hat{\beta}_j^U + \hat{\beta}_j^L}{2}, \frac{\hat{\beta}_j^U - \hat{\beta}_j^L}{2(1-H)} \right\rangle,$$

Moreover the estimated membership function of $\tilde{Y}(\mathbf{x}_i)$ is expressed as

$$\mu_{\tilde{Y}(\mathbf{x}_i)}(t) = \max\left\{ 1 - \left| t - \sum_{j=0}^{p} \left(\frac{\hat{\beta}_j^U + \hat{\beta}_j^L}{2} \right) x_{ij} \right| \Big/ \sum_{j=0}^{p} \left(\frac{\hat{\beta}_j^U - \hat{\beta}_j^L}{2(1-H)} \right) |x_{ij}| \;\; , \;\; 0 \right\},$$

where $x_{i0} = 1$. Finally, we get the estimated fuzzy regression model

$$\begin{aligned}\tilde{Y}(\mathbf{x}_i) = &\left\langle \frac{\hat{\beta}_0^U + \hat{\beta}_0^L}{2}, \frac{\hat{\beta}_0^U - \hat{\beta}_0^L}{2(1\text{-}H)} \right\rangle + \left\langle \frac{\hat{\beta}_1^U + \hat{\beta}_1^L}{2}, \frac{\hat{\beta}_1^U - \hat{\beta}_1^L}{2(1\text{-}H)} \right\rangle x_{i1} \\ &+ \left\langle \frac{\hat{\beta}_2^U + \hat{\beta}_2^L}{2}, \frac{\hat{\beta}_2^U - \hat{\beta}_2^L}{2(1\text{-}H)} \right\rangle x_{i2} + \ldots\ldots + \left\langle \frac{\hat{\beta}_p^U + \hat{\beta}_p^L}{2}, \frac{\hat{\beta}_p^U - \hat{\beta}_p^L}{2(1\text{-}H)} \right\rangle x_{ip}, \\ &i = 1,\ldots,n\end{aligned}$$

Generally in estimation of the fuzzy regression model the least squares method is performed more simply than the linear programming method. The least squares method has a secret worry: LSE $\hat{\beta}_j^U$ and $\hat{\beta}_j^L$ cannot associate with the feature that $\sum_{j=0}^{p} s_j |x_{ij}| \uparrow$ as $|x_{ij}| \uparrow$, but the linear programming method hasn't such a problem.

3. Adjustment for the Fuzzy Regression Model. We have mentioned that the fuzzy regression model (1) requests the radius to enlarge as $|x_{ij}|$ increases. The requests can be illustrated by a special graph in which the ends of the both trumpets-like shapes join at y-axis, as shown in Figure 1.2. This feature, however, is apparently restricted and irregular when the model (1) is applied to some practical cases. In order to get better fitting, in this study we will conduct some adjustments for the skeleton of the fuzzy regression model.

Definition 3.1. Adjusted fuzzy regression model. Suppose the output $\tilde{Y}(\mathbf{x}_i)$, indexed by the explanatory $\mathbf{x}_i = [1 \;\; x_{i1} \;\; \cdots \;\; x_{ip}]$, is the symmetric fuzzy number with the membership function

$$\mu_{\tilde{Y}(\mathbf{x}_i)}(t) = \max\left\{ 1 - \left| t - \sum_{j=0}^{p} v_j c_j x_{ij} \right| \Big/ \sum_{j=0}^{p} v_j r_j x_{ij} , \;\; 0 \right\}, \; -\infty < t < \infty , \tag{6}$$

where $v_j = \pm 1$ and $\sum_{j=0}^{p} v_j r_j x_{ij} > 0$ for $i = 1,\ldots,n$,. Membership function (6) is denoted by the representation

$$\tilde{Y}(\mathbf{x}_i) = v_0 A_0 + v_1 A_1 x_{i1} + v_2 A_2 x_{i2} + \ldots + v_p A_p x_{ip},$$

called the adjusted fuzzy regression model.

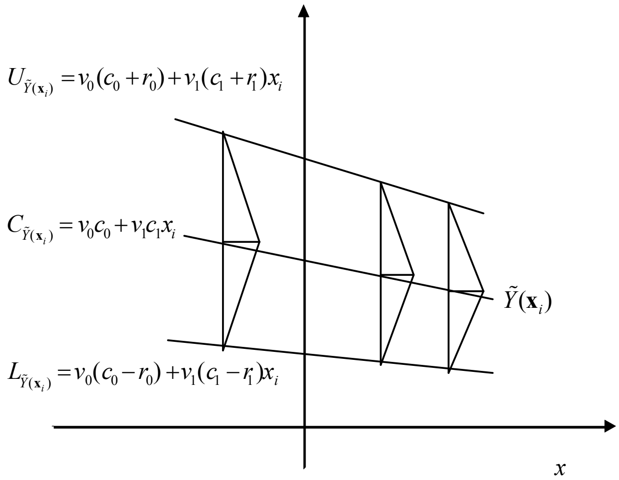

FIGURE 2. Adjusted simple fuzzy regression model

In Definition 3.1 the parameter restriction $\sum_{j=0}^{p} v_j r_j x_{ij} > 0$ can ensure the radius of $\tilde{Y}(\mathbf{x}_i)$ to be positive. Let the adjusted fuzzy regression model be a simple linear model. Then the membership function of $\tilde{Y}(\mathbf{x}_i)$ is given by

$$\mu_{\tilde{Y}(\mathbf{x}_i)}(t) = \max\left\{ 1 - \left| t - (v_0c_0 + v_1c_1x_i) \right| \big/ (v_0r_0 + v_1r_1x_i),\ 0 \right\}, \quad -\infty < t < \infty ,$$

with the parameter restriction $v_0r_0 + v_1r_1x_i > 0$ for $i = 1,\ldots,n$. Then the middle line $C_{\tilde{Y}(\mathbf{x}_i)}$, the upper boundary $U_{\tilde{Y}(\mathbf{x}_i)}$ and lower boundary $L_{\tilde{Y}(\mathbf{x}_i)}$ are all displayed in Figure 2.

In Figure 2 it can be seen that the crucial feature of Model (1) mentioned above has been removed. Because of inviting the variable $v_j = \pm 1$ into Model (6), the radius $\sum_{j=0}^{p} v_j r_j x_{ij}$ of $\tilde{Y}(\mathbf{x}_i)$ can vary freely as $\left| x_{ij} \right|$ increases.

The least squares method is still employed to construct the estimation of fuzzy coefficient $A_j = \left\langle c_j,\ r_j \right\rangle$ and v_j in (11). Based on the membership function (6), given a h-cut value H, the upper and lower bound of $[\tilde{Y}(\mathbf{x}_i)]_H$ are determined as follows, respectively,

$$U_{[\hat{Y}(\mathbf{x}_i)]^H} = \sum_{j=0}^{p} v_j [c_j + (1-H) r_j] x_{ij}$$

and

$$L_{[\hat{Y}(\mathbf{x}_i)]^H} = \sum_{j=0}^{p} v_j [c_j - (1-H) r_j] x_{ij} .$$

The both equation can be re-expressed as

$$U_{[\hat{Y}(\mathbf{x}_i)]^H} = \beta_0^U + \beta_1^U x_{i1} + \beta_2^U x_{i2} + \ldots + \beta_p^U x_{ip} \tag{7}$$

and

$$L_{[\hat{Y}(\mathbf{x}_i)]^H} = \beta_0^L + \beta_1^L x_{i1} + \beta_2^L x_{i2} + \ldots + \beta_p^L x_{ip} , \tag{8}$$

where

$$\beta_j^U = v_j[c_j + (1-H)s_j] \text{ and } \beta_j^L = v_j[c_j - (1-H)s_j]. \tag{9}$$

Note that Equation (7) and (8) has a parameter restriction

$$(\beta_0^U - \beta_0^L) + (\beta_1^U - \beta_1^L)x_{i1} + \ldots + (\beta_p^U - \beta_p^L)x_{ip} \geq 0$$

in them.

To minimize the sum of the squares of the error resulting from the upper and low bound of $\tilde{Y}(\mathbf{x}_i)$, respectively, the two objective function are defined by

$$Q_U = \sum_{i=1}^{n}(U_{Yi} - U_{[\tilde{Y}(\mathbf{x}_i)]_H})^2 = \sum_{i=1}^{n}(U_{Yi} - \beta_0^U - \beta_1^U x_{i1} - \ldots - \beta_p^U x_{ip})^2$$

and

$$Q_L = \sum_{i=1}^{n}(L_{Yi} - L_{[\tilde{Y}(\mathbf{x}_i)]_H})^2 = \sum_{i=1}^{n}(L_{Yi} - \beta_0^L - \beta_1^L x_{i1} - \ldots - \beta_p^L x_{ip})^2 .$$

where U_{Yi} and L_{Yi} are the upper and lower bound of the fuzzy sample Y_i. Using the matrix representation the least squares estimates of β_j^U and β_j^L are written by

$$\hat{\beta}^U = \begin{bmatrix} \hat{\beta}_1^U \\ \vdots \\ \hat{\beta}_p^U \end{bmatrix} = (X'X)^{-1}X'U_Y \text{ and } \hat{\beta}^L = \begin{bmatrix} \hat{\beta}_1^L \\ \vdots \\ \hat{\beta}_p^L \end{bmatrix} = (X'X)^{-1}X'L_Y$$

where

$$U_Y = \begin{bmatrix} U_{Y1} \\ \vdots \\ U_{Yn} \end{bmatrix} \text{ and } L_Y = \begin{bmatrix} L_{Y1} \\ \vdots \\ L_{Yn} \end{bmatrix}.$$

Then, according to Relation (9) we can obtain the formulas about $\hat{c}_j$ and $\hat{r}_j$

$$\hat{c}_j = (\hat{\beta}_j^U + \hat{\beta}_j^L)/2v_j = v_j(\hat{\beta}_j^U + \hat{\beta}_j^L)/2$$

$$\hat{r}_j = (\hat{\beta}_j^U - \hat{\beta}_j^L)/2(1-H)v_j = v_j(\hat{\beta}_j^U - \hat{\beta}_j^L)/2(1-H)$$

By judging whether $\hat{\beta}_j^U - \hat{\beta}_j^L \geq 0$ ($\because r_j \geq 0$), we can get the least square estimate of v_j, c_j and r_j as follows:

(1) If $\hat{\beta}_j^U - \hat{\beta}_j^L < 0$, then

$$\hat{v}_j = -1, \hat{c}_j = -(\hat{\beta}_j^U + \hat{\beta}_j^L)/2, \hat{s}_j = -(\hat{\beta}_j^U - \hat{\beta}_j^L)/2(1-H);$$

(2) If $\hat{\beta}_j^U - \hat{\beta}_j^L \geq 0$, then

$$\hat{v}_j = 1, \hat{c}_j = (\hat{\beta}_j^U + \hat{\beta}_j^L)/2, \hat{r}_j = (\hat{\beta}_j^U - \hat{\beta}_j^L)/2(1-H)$$

Finally the estimated fuzzy coefficient is given by

$$\hat{A}_j = \langle \hat{c}_j, \hat{r}_j \rangle . \tag{10}$$

There is an alternative way to find the estimate of the fuzzy coefficient A_j. The center and radius of $\tilde{Y}(\mathbf{x}_i)$ can also be considered to build the objective function. Given a h-cut value H, the middle line $C_{\tilde{Y}(\mathbf{x}_i)}$ and the radius line $R_{\tilde{Y}(\mathbf{x}_i)}$ of $[\tilde{Y}(\mathbf{x}_i)]_H$ can be expressed as

$$C_{\tilde{Y}(\mathbf{x}_i)} = \beta_0^c + \beta_1^c x_{i1} + \beta_2^c x_{i2} + \ldots + \beta_p^c x_{ip}$$

and

$$R_{[\tilde{Y}(\mathbf{x}_i)]_H} = \beta_0^r + \beta_1^r x_{i1} + \beta_2^r x_{i2} + \ldots + \beta_p^r x_{ip} , \tag{11}$$

where

$$\beta_j^c = v_j c_j , \quad \beta_j^r = (1-H)v_j r_j , \quad j = 1, \ldots, p . \tag{12}$$

Note that Equation (11) has a parameter restriction $\beta_0^r + \beta_1^r x_{i1} + \beta_2^r x_{i2} + ... + \beta_p^r x_{ip} \ge 0$ in it. The two objective functions are defined by

$$Q_c = \sum_{i=1}^n (C_{Yi} - C_{\tilde{Y}(\mathbf{x}_i)})^2 = \sum_{i=1}^n (C_{Yi} - \beta_0^c - \beta_1^c x_{i1} - ... - \beta_p^c x_{ip})^2$$

and

$$Q_r = \sum_{i=1}^n (R_{Yi} - R_{\tilde{Y}(\mathbf{x}_i)})^2 = \sum_{i=1}^n (R_{Yi} - \beta_0^r - \beta_1^r x_{i1} - ... - \beta_p^r x_{ip})^2 \ .$$

where C_{Yi} and R_{Yi} are the center and radius of the fuzzy sample Y_i. Then the least squares estimates of β_j^U and β_j^L are

$$\hat{\beta}^C = \begin{bmatrix} \hat{\beta}_1^c \\ \vdots \\ \hat{\beta}_p^c \end{bmatrix} = (X'X)^{-1} X'C_Y \quad \text{and} \quad \hat{\beta}^r = \begin{bmatrix} \hat{\beta}_1^r \\ \vdots \\ \hat{\beta}_p^r \end{bmatrix} = (X'X)^{-1} X'R_Y$$

where

$$C_Y = \begin{bmatrix} C_{Y1} \\ \vdots \\ C_{Yn} \end{bmatrix} \quad \text{and} \quad R_Y = \begin{bmatrix} R_{Y1} \\ \vdots \\ R_{Yn} \end{bmatrix}.$$

Then, according to Relation (12) we can obtain the formulas about $\tilde{c}_j$ and $\tilde{r}_j$

$$\tilde{c}_j = \hat{\beta}_j^c / v_j = v_j \hat{\beta}_j^c$$

$$\tilde{r}_j = \hat{\beta}_j^s / (1-H) v_j = v_j \tfrac{1}{(1-H)} \hat{\beta}_j^s$$

due to

$$v_j = \pm 1 .$$

By judging whether $\hat{\beta}_j^r > 0$, we can get the least square estimate of v_j, c_j and r_j as follows:

(3) If $\hat{\beta}_j^r < 0$, then

$$\tilde{v}_j = -1, \ \tilde{c}_j = -\hat{\beta}_j^c \ \text{ and } \ \tilde{r}_j = -\hat{\beta}_j^r / (1-H)$$

(4) If $\hat{\beta}_j^r \ge 0$, then

$$\tilde{v}_j = 1, \ \tilde{c}_j = \hat{\beta}_j^c \ \text{ and } \ \tilde{r}_j = \hat{\beta}_j^r / (1-H)$$

The estimated fuzzy coefficient is

$$\tilde{A}_j = \langle \tilde{c}_j, \tilde{r}_j \rangle . \tag{13}$$

Property 3.1. In the adjusted fuzzy regression model (6), LSE $\hat{A}_j$ in (10), based on the upper and lower bound of $\tilde{Y}(\mathbf{x}_i)$, is identical to $\tilde{A}_j$ in (13), based on the center and radius of $\tilde{Y}(\mathbf{x}_i)$.

4. Evaluation of Residuals. Residuals are highly useful for examining departure from the assumed model in the traditional regression analysis. By figuring fuzzy residuals we want to study the fitness degree of a specified fuzzy regression model to the observed fuzzy sample. Concerning the measurement of fitness degree in the fuzzy regression system, the key issue is how to calculate the deviation of the fuzzy sample around the fitted fuzzy model. In this research, the fuzzy residuals are considered in terms of two principles: (1) the standard fuzzy arithmetic and (2) the general crisp logic, respectively.

4.1. Residuals Based on the Fuzzy Arithmetic. Before computing the fuzzy residuals based on the fuzzy arithmetic, several definitions relevant to basic fuzzy arithmetic must be given.

Definition 4.1. Operation of symmetric fuzzy number. Let $N_1 = \langle c_1 \quad r_1 \rangle$ and $N_2 = \langle c_2 \quad r_2 \rangle$ be symmetric fuzzy numbers. The fuzzy addition, scalar multiplication and subtraction are defined as follows.

Addition:

$$N_1 + N_2 = \langle c_1 \quad r_1 \rangle + \langle c_2 \quad r_2 \rangle = \langle c_1 + c_2 \quad r_1 + r_2 \rangle .$$

Scalar multiplication:

$$kN_1 = k\langle c_1 \quad r_1 \rangle = \langle kc_1 \quad |k| r_1 \rangle$$

where k is a scalar. Subtraction:

$$N_1 - N_2 = N_1 + (-N_2) = \langle c_1 \quad r_1 \rangle + \langle -c_2 \quad r_2 \rangle = \langle c_1 - c_2 \quad r_1 + r_2 \rangle .$$

Basically the ith residual should be the difference between the observed data Y_i and the corresponding fitted output $\tilde{Y}(\mathbf{x}_i)$. Based on subtraction operation in Definition 4.1 we can definite the fuzzy residual for the adjusted fuzzy regression model (6).

Definition 4.2. H-cut residual based on fuzzy arithmetic. Given a h-cut value H, the residual e_i^H has the form

$$e_i^H = Y_i - \hat{Y}_i^H = \langle c_{Y_i} \quad r_{Y_i} \rangle - \langle \hat{c}_{[\tilde{Y}(\mathbf{x}_i)]_H} \quad \hat{r}_{[\tilde{Y}(\mathbf{x}_i)]_H} \rangle = \langle c_{Y_i} - \hat{c}_{[\tilde{Y}(\mathbf{x}_i)]_H} \quad r_{Y_i} + \hat{r}_{[\tilde{Y}(\mathbf{x}_i)]_H} \rangle ,$$

where $\hat{Y}_i^H$ is a fuzzy number with the membership function

$$\mu_{\hat{Y}_i^H}(t) = \max \left\{ 1 - \frac{\left| t - \hat{c}_{[\tilde{Y}(\mathbf{x}_i)]_H} \right|}{\hat{r}_{[\tilde{Y}(\mathbf{x}_i)]_H}} \quad , \quad 0 \right\} ,$$

i.e., $\hat{Y}_i^H = \langle \hat{c}_{[\tilde{Y}(\mathbf{x}_i)]_H} \quad \hat{r}_{[\tilde{Y}(\mathbf{x}_i)]_H} \rangle$. e_i^H is called the ith H-cut FA residual.

Note that $Y_i \neq \hat{Y}_i^H + e_i^H$ due to fuzzy arithmetic. The H-cut FA residual has a number of properties listed below.

Property 4.1.

(1) $\sum_{i=1}^n e_i^H = \langle 0 \quad 2\sum_{i=1}^n \hat{r}_{[\tilde{Y}(\mathbf{x}_i)]_H} \rangle$

(2) For every j, $\sum_{i=1}^n x_{ij} e_i^H = \langle 0 \quad \sum_{i=1}^n |x_{ij}| r_{Y_i} + \sum_{i=1}^n |x_{ij}| \hat{r}_{[\tilde{Y}(\mathbf{x}_i)]_H} \rangle$

(3) $\sum_{i=1}^n \hat{c}_{[\tilde{Y}(\mathbf{x}_i)]_H} e_i^H = \langle 0 \quad \sum_{i=1}^n \left| \hat{c}_{[\tilde{Y}(\mathbf{x}_i)]_H} \right| r_{Y_i} + \sum_{i=1}^n \left| \hat{c}_{[\tilde{Y}(\mathbf{x}_i)]_H} \right| \hat{r}_{[\tilde{Y}(\mathbf{x}_i)]_H} \rangle$

From Property 4.1 it is seen that $\sum_{i=1}^n e_i^H$, $\sum_{i=1}^n x_{ij} e_i^H$ and $\sum_{i=1}^n \hat{c}_{[\tilde{Y}(\mathbf{x}_i)]_H} e_i^H$ all have zero center, but their radius don't vanish. That is because no matter what kind of operation, the radius of the calculated fuzzy numbers is to accumulate.

4.2. Residuals Based on the Crisp Logic. The accumulation of the radius of the H-cut FA residual may disturb measurement of fitness degree. Thus, alternative kind of residuals is considered.

Definition 4.3. H-cut residual based on crisp arithmetic. Given a h-cut value H, by the center and radius, respectively, the two types of residuals are defined by

$$e_{ci} = c_{Y_i} - \hat{c}_{\tilde{Y}(\mathbf{x}_i)} \quad \text{and} \quad e_{ri}^H = r_{Y_i} - \hat{r}_{[\tilde{Y}(\mathbf{x}_i)]_H} .$$

Similarly, by the upper and lower bound, respectively, the two types of residuals are defined by

$$e_{Ui}^{H} = U_{Y_i} - \hat{U}_{[\tilde{Y}(\mathbf{x}_i)]_H} \text{ and } e_{Li}^{H} = L_{Y_i} - \hat{L}_{[\tilde{Y}(\mathbf{x}_i)]_H} .$$

Then the four types of residuals e_{ci}, e_{ri}^{H}, e_{Ui}^{H} and e_{Li}^{H} are called H-cut CA Residuals.

e_{ci}, e_{ri}^{H}, e_{Ui}^{H} and e_{Li}^{H} have a number of properties similar to the properties of the traditional regression model.

Property 4.2.

(1) $\sum_{i=1}^{n} e_{ci} = 0$, $\sum_{i=1}^{n} e_{ri}^{H} = 0$, $\sum_{i=1}^{n} e_{Ui}^{H} = 0$ and $\sum_{i=1}^{n} e_{Li}^{H} = 0$.

(2) For every j, $\sum_{i=1}^{n} x_{ij} e_{ci} = 0$, $\sum_{i=1}^{n} x_{ij} e_{ri}^{H} = 0$, $\sum_{i=1}^{n} x_{ij} e_{Ui}^{H} = 0$ and $\sum_{i=1}^{n} x_{ij} e_{Li}^{H} = 0$.

(3) $\sum_{i=1}^{n} \hat{c}_{\tilde{Y}(\mathbf{x}_i)} e_{ci} = 0$, $\sum_{i=1}^{n} \hat{r}_{[\tilde{Y}(\mathbf{x}_i)]_H} e_{ri}^{H} = 0$, $\sum_{i=1}^{n} \hat{U}_{[\tilde{Y}(\mathbf{x}_i)]_H} e_{Ui}^{H} = 0$ and $\sum_{i=1}^{n} \hat{L}_{[\tilde{Y}(\mathbf{x}_i)]_H} e_{Li}^{H} = 0$.

(4) $e_{Ui}^{H} = e_{ci} + e_{ri}^{H}$ and $e_{Li}^{H} = e_{ci} - e_{ri}^{H}$.

The degree of fitness of a fitting model is the most concern of the analysts in the regression analysis. It will influence the accuracy of estimation and the efficiency of the forecasting. Considering which residual should be used as material for making the criteria of fitness degree, the residual based on crisp arithmetic is more suitable candidate than one based on fuzzy arithmetic. The following will define the criteria for analyzing the fitness degree.

Definition 4.4. Mean squared error for fuzzy regression model. In the adjusted fuzzy regression model (11), let e_{ci} and e_{ri}^{H} be H-cut CA Residuals by the center and radius, respectively. Then the sum squared error is given by

$$SSE = \sum_{i=1}^{n} (\varepsilon_{ci})^2 + \ln\left[1 + \sum_{i=1}^{n} (\varepsilon_{ri}^{H})^2\right] \tag{14}$$

and the mean squared error is

$$MSE = SSE/n .$$

In Equation (14) operation 'ln' is responsible to inhibit the effect of the radius to SSE.

5. Conclusion. In this research we relieve crucial restriction existing in the fuzzy regression model to make a more suitable adjusted system. In the presented model the LSE estimation of the fuzzy coefficient is carefully discussed. From the statistical point of view, using the least square to estimate the boundaries of fuzzy number exhibits more appropriate and its computation is also more efficient. For exhibiting the fitness degree in the fuzzy regression system, we considered two principles, the fuzzy and crisp arithmetic, to define residuals, respectively. Finally among the two principles the residual based on crisp arithmetic is chosen to make the criteria of fitness degree.

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COMPARISON OF BAYESIAN MCMC AND MARGINAL MAXIMUM LIKELIHOOD METHODS IN ESTIMATING THE ITEM PARAMETERS FOR 2PL IRT MODEL

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ABSTRACT. *One way to evaluate if a particular method of estimation performed well is to conduct a simulation study. In the item response model, this would require simulating the item parameters and the response stings for examinees based on these parameters. The purpose of this study is to investigate how well the frequentist approach to estimation recovers the simulated item parameters compared to a Bayesian approach. The results shows that Bayesian Markov Chain Monte Carlo (MCMC) procedure to estimate item parameters for a 2PL IRT model resulted in the best recovery of simulated item parameters. In addition, the application of MCMC in estimating item parameters is quite robust with different priors. Use the exact prior only slightly outperformed than the non-informative prior in the absolute number of true item parameters recovered.*

Keywords: Simulation Study; MCMC; 2 PL IRT; MML

1. Introduction. In psychometrics there are two major theories of test scores. The first, typically known as classical test theory (CTT) postulates that a test score is made up of a true, yet unknowable, score and the error score. Much of CTT attempts to estimate this error score which in turn gives the psychometrician estimates of such concepts as the standard error of measure and reliability. Using CTT, test scores are always reported as either a total correct score or in some transformation of the total correct score. Psychometricians who use CTT obtain item level statistics as well, such as item difficulty and discrimination index. Item difficulty is simply the proportion of examinees that get the item correct. The discrimination index is typically a point-biserial or biserial correlation. This index essentially indicates to what degree those who obtain a high or low total score get a particular item correct. However, nothing in CTT utilizes this information when attempting to determine an examinees true score. For example, an examinee could get the 10 most difficult items correct and another examinee could get the 10 easiest items correct, both resulting in a total score of 10. Many people might say that such a state of affairs is unfair. This is the crux of psychometrics, how do we determine which examinees have a higher or lower level of achievement in a particular subject.

Item Response Theory (IRT) was developed in an attempt to answer that question. Perhaps the major difference between CTT and IRT is that IRT uses the information about item difficulty, discrimination, and in some models even how easy it is to guess the correct answer, as well as the mathematical model used to estimate a true score. IRT began to gain prominence as a test theory mainly in the 1950's when both Lawley and Lord separately published on IRT (du Toit, 2003; Linn, 1989). IRT models all have two things in common, they use parameters – estimates of item characteristics – and they all attempt to estimate theta – an estimate of the underlying ability. The most popular and researched models in psychometrics are the unidimensional models. All these models have strong assumptions which include (1) unidimensionalty, which requires that there be only one underlying trait for the data, and (2) local independence, which requires that when theta is held constant that the probability examinees getting one item correct is independent of all other items.

The unidimensional models vary in the number of item parameters that used. Rasch (Lord, 1980) focused on a one-parameter model, which are now known as Rasch models. This model assumed that all items have an equal discrimination index and the probability of guessing an item correctly is zero. Lord (Hambleton, 1989; Lord, 1980) focused on a three-parameter model using a normal ogive, in which all three item parameters varied across items. A third model is known as the two-parameter model in which only the item difficulty and discrimination indices vary across items. Birnbaum (Lord, 1980) saw what Lord was doing and recommended using a logistic function rather than the normal ogive.

As with CTT, IRT has an item discrimination index, typically called the "a" parameter. Unlike CTT, the "a" parameter is proportional to the slope at the point on the theta scale that equals the difficulty parameter Hambleton (1989). The difficulty parameter, typically called the "b" parameter is the point on the theta scale at which an examinee has 50% chance of getting the item correct, Hambleton (1989). Lord and Novick, Toit (2003) showed that when using the normal ogive both the "a" and "b" parameters are functions of the CTT discrimination index, specifically the biserial version of the index. The last item parameter is called the guessing parameter but is really the lower asymptote parameter, and is typically called the "c" parameter. This parameter estimates what the probability of getting the item correct is when an examinee does not know the answer.

Certainly when high stakes decisions such as admissions to graduate school, meeting high school graduation exit exam requirements, receiving a professional license, and so on depend upon test scores it is imperative that those scores be precise but accurate as well. One way to determine if a particular method of estimation achieves this is to perform a simulation study. In IRT this would require simulating the item parameters and the response stings for examinees based on these parameters. This is in fact the main research question of this study. How well does the frequentist approach to estimation recover these simulated item parameters compared to using a Bayesian approach?

Perhaps the most popular software used in practice for estimating item parameters and examinee abilities is BILOG-MG, Zimowski et al. (1996). BILOG-MG uses two methods to estimate item parameters and three methods to estimate examinee abilities. For examinee abilities the choices are maximum likelihood(ML), expected a posteriori (EAP), or maximum a posteriori (MAP). For item parameters the two methods are marginal maximum likelihood (MML) or maximum marginal a posteriori (MMAP). BILOG-MG suggests using MMAP when there are less than 250 examinees to base item parameter estimates on, or if some items are either too easy or difficult, du Toit (2003). MMAP limits priors on the item parameters to be normal for the "b" parameter and log-normal for the "a" parameter, du Toit (2003). The MML method uses two method to solve the marginal likelihood equations, the EM method and Newton-Gauss or Fisher scoring iterations, du Toit (2003). To choose between MML and MMAP the user simply supplies the prior option in the item calibration step of the program.

Previous research has looked at the application of Markov Chain Monte Carlo (MCMC) methods for estimating item parameters and examinee abilities. However, several of these papers coded their own Gibbs samplers which utilizes the Metropolis-Hastings within Gibbs algorithm (Patz and Junker, 1999; Yao et al. 2002). Patz and Junker (1999) primarily focused on developing a Gibbs sampler rather than on the performance of the program to accurately estimate item parameters. None of the studies reviewed used WinBUG, SSpiegelhalter et al. (2004) and all rely upon proposal densities as part of the algorithm utilized.

The Patz and Junker (1999) study used six constructed response items and 3,000 examinees from the National Assessment of Educational Progress (NAEP) and compared the results of their sampler to those from BILOG, Mislevy and Bock (1985). This study used a two-parameter logistic (2PL) model and placed normal priors on both ability estimates (theta) and the difficulty parameter (beta), Patz and Junker (1999). They placed a log-normal prior on the discrimination parameter (alpha). These priors are consistent with both BILOG-MG and NAEP, Patz and Junker (1999). It appears from the study that only one Markov chain was used and what the authors termed short chain – 7,400 iterations with 400 iteration burn-in – and long chain – 37,000 iterations with 2,000 iteration burn-in. Based on the short chain MCMC estimates the results compared to BILOG were essentially identical for both the item parameters and their standard errors.

Jones and Nediak (2000) looked at actual test data for 28,184 examinees and also 21,116 simulated examinees for 101 items on the Law School Admissions Test (LSAT). This study also used a modification to the Patz and Junker (1999) sampler. Results of the MCMC were compared to estimates from BILOG utilizing a 3PL model. As with the previous two studies it appears only one Markov chain was used and in this case 7,000 iterations with a 2,000 iteration burn-in was used. The priors on the item parameters were uniform on a rectangular region of (-6, 6) by (.5, 2.5) by (0.0, 0.5).

As with the previous studies when applied to actual test data the estimates between BILOG and MCMC were similar. When applied to simulated data with known parameters the MCMC method appears to recover the known parameters better than BILOG. In most cases MCMC estimates differed from the known parameter by 0.05, whereas BILOG differed by over 1/10th.

The cursory review of the literature suggests that the use of Bayesian methods and MCMC can lead users of IRT to better estimates of item parameters. All studies reviewed state that the use of MCMC results in estimates of the joint posterior distribution of the item parameters where as programs such as BILOG and PARDUX give only point estimates (Jones and Nediak, 2000; Patz and Junker, 1999; Yao et al. 2002).

A major drawback to typical users of IRT is the accessibility of the MCMC methods. The studies reviewed here either coded the sampler in S-Plus or developed proprietary software. WinBUGS is a free downloadable program that uses Bayesian and MCMC methods that is available to any user of IRT. This study with make use of WinBUGS to see how well it recovers known item parameters versus BILOG-MG utilizing a 2PL model:

$$p_i\left[\theta\right]=\frac{1}{1+e^{-1.7\alpha_i(\theta-\beta_i)}} \tag{1}$$

where α is the discrimination parameter, β is the difficulty parameter and θ is the ability parameter. The 1.7 puts the logistic function on a "normal" metric.

2. Methods. The data for this study was simulated using a SAS routine. Parameters for 30 items were simulated using a log-normal (0, 4)[i] for alpha and a normal (0, 1) for beta. For theta a normal (0, 1) was used to simulate 1,000 examinees. Based on these simulated parameters, 1,000 item response strings, coded 0 for wrong and 1 for correct, was obtained. This was done 15 times and the dataset with the fewest number of simulated examinees who either got all items correct or all items incorrect was chosen. This was done to avoid problems that MML has in estimating theta for perfect scores.

The simulated data was run through BILOG-MG to obtain item parameters estimates based on MML. The same data was then run through WinBUGS using two different sets of priors on the item parameters. The first run, termed the exact prior, placed a normal (0, 1) prior on beta and a log-normal (0, 4). The second run, termed the non-informative prior, place a normal (0, 0.001) on beta and a log-normal (0, 0.001) prior on alpha. For both runs of WinBUGS the prior on theta remained normal (0, 1). Three separate chains were run for each set of priors. Initial starting values were generated using WinBUGS.

WinBUGS (Spiegelhalter et al. 2003) is a computer program which employs MCMC methods to facilitate Bayesian analysis in many application areas. It is written in Component Pascal running in Oberon Microsystems's Black Box environment. The user specifies a model either by drawing a directed graph (Lauritzen and Spiegelhalter, 1988) or by using an S-like language. The software then constructs the transition kernel for a Markov Chain to generate samples from the joint distribution of the unknowns in the model, Cowles (2004). The user provides the data and initial values, the number of parallel MCMC chains to be run, the number of iterations, the unknown model quantities to monitor for analysis and the types of convergence evaluation and summaries. The final output provides numerical and graphical summaries of the requested model quantities. WinBUGS can be downloaded from http://www.mrc-bsu.cam.ac.uk/bugs/winbugs/contents.

The slice sampling algorithms are used by WinBUGS for non log-concave densities on a restricted range. This has a tuning phase of 500 iterations. For nonconjugate continuous full conditional distributions with an unrestricted range, the random walk Metropolis algorithm (Metropolis et al. 1953) is used. The use of Metropolis algorithms in WinBUGS is based on a symmetric normal proposal distribution, whose standard deviation is tuned over the first 4000 iterations to obtain an acceptance rate of between 20% and 40%. WinBUGS provides diagnostics graphs, such as Gelman and Rubin statistics, history plots and lag 1 autocorrelations to examine the convergence of MCMC procedures.

3. Results. Five hundred iterations were used by WinBUGS in its adaptation phase, an additional 500 iterations were used for burn-in and an additional 1,000 iterations were used

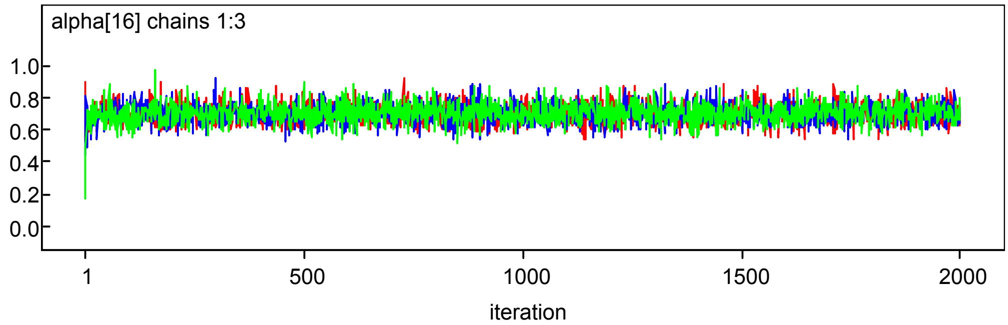

FIGURE 1. MCMC history plot for alpha on item 16

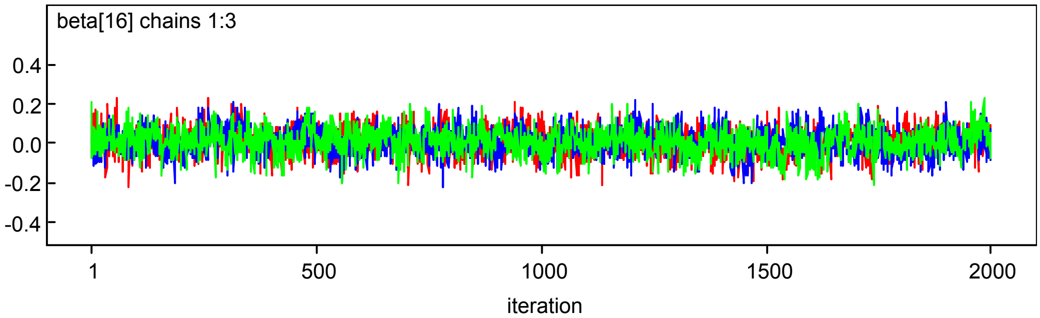

FIGURE 2. MCMC history plot for beta on item 16

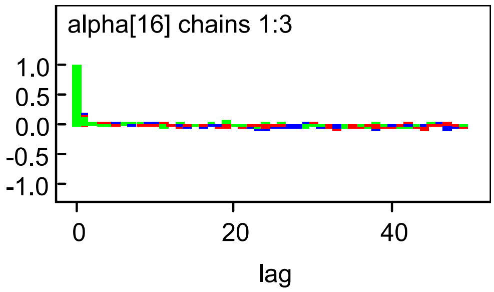

FIGURE 3. Autocorrelation plot for alpha on item 16

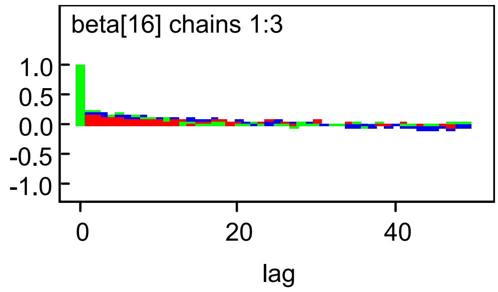

FIGURE 4. Autocorrelation plot for beta on item 16

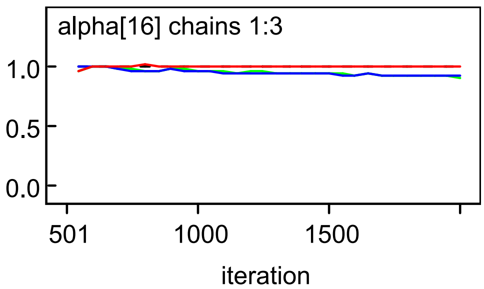

FIGURE 5. BGR statistic for alpha on item 16

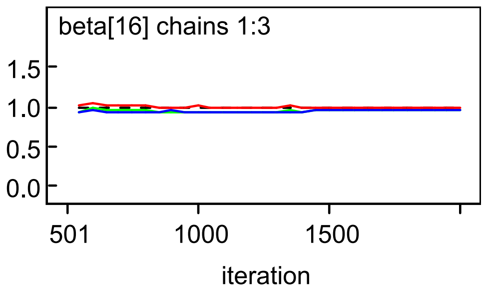

FIGURE 6. BGR statistic for beta on item 16

TABLE 1. Estimates of the alpha parameter

ITEM	MML		Exact prior		Non-informative prior		True α
	$\tilde{a}$	SD	$\tilde{a}$	SD	$\tilde{a}$	SD	
1	0.33	**(0.23,0.43)***	0.36	**(0.28,0.44)***	0.31	**(0.21,0.41)***	0.45
2	0.88	(0.72,1.04)	0.90	(0.74,1.06)	0.88	(0.76,1)	0.95
3	0.66	(0.54,0.78)	0.68	(0.56,0.8)	0.65	(0.24,1.06)	0.69
4	2.26	(1.87,2.65)	2.29	(1.9,2.68)	2.29	(2.13,2.45)	2.37
5	1.05	(0.89,1.21)	1.07	(0.91,1.23)	1.05	(0.78,1.32)	1.09
6	1.37	(1.08,1.66)	1.41	(1.14,1.68)	1.37	(1.23,1.51)	1.36
7	0.87	(0.73,1.01)	0.89	(0.75,1.03)	0.87	(0.71,1.03)	0.84
8	0.92	(0.78,1.06)	0.94	(0.78,1.1)	0.91	(0.67,1.15)	0.87
9	1.32	(1.07,1.57)	1.36	(1.12,1.6)	1.32	(1.2,1.44)	1.32
10	0.66	(0.54,0.78)	0.69	(0.55,0.83)	0.66	(0.35,0.97)	0.67
11	1.47	(1.16,1.78)	1.50	(1.19,1.81)	1.47	(1.18,1.76)	1.46
12	1.60	**(1.33,1.87)***	1.63	(1.34,1.92)	1.60	(1.31,1.89)	1.88
13	1.32	(1.05,1.59)	1.36	(1.07,1.65)	1.32	(1.14,1.5)	1.25
14	0.87	(0.71,1.03)	0.91	(0.73,1.09)	0.87	(0.63,1.11)	0.89
15	1.49	(1.27,1.71)	1.52	(1.27,1.77)	1.50	(1.38,1.62)	1.40
16	0.68	(0.56,0.8)	0.70	(0.58,0.82)	0.68	(0.43,0.93)	0.71
17	1.63	(1.38,1.88)	1.67	(1.4,1.94)	1.64	(1.42,1.86)	1.61
18	1.40	**(1.18,1.62)***	1.43	**(1.21,1.65)***	1.40	**(1.26,1.54)***	1.12
19	0.70	(0.58,0.82)	0.72	(0.6,0.84)	0.69	(0.53,0.85)	0.8
20	0.84	(0.68,1)	0.88	(0.72,1.04)	0.84	(0.72,0.96)	0.91
21	0.67	(0.55,0.79)	0.69	(0.57,0.81)	0.67	(0.51,0.83)	0.70
22	0.98	(0.82,1.14)	1.01	(0.85,1.17)	0.98	(0.9,1.06)	0.91
23	0.32	**(0.24,0.4)***	0.35	(0.27,0.43)	0.31	**(0.21,0.40)***	0.41
24	0.84	(0.7,0.98)	0.86	(0.7,1.02)	0.83	(0.73,0.93)	0.77
25	0.52	(0.42,0.62)	0.54	(0.44,0.64)	0.51	(0.37,0.65)	0.54
26	0.52	(0.4,0.64)	0.57	(0.45,0.69)	0.50	(0.3,0.7)	0.55
27	1.30	(1.12,1.48)	1.33	(1.11,1.55)	1.31	(1.15,1.47)	1.44
28	0.61	(0.45,0.77)	0.65	(0.51,0.79)	0.60	(0.44,0.76)	0.63
29	0.94	(0.78,1.1)	0.97	(0.81,1.13)	0.94	(0.78,1.1)	1.01
30	0.74	(0.58,0.9)	0.79	(0.63,0.95)	0.74	(0.58,0.9)	0.85

Note: An "*" indicates that the true parameter is NOT within the 95% confidence interval for the MML or a 95% credible set for the MCMC methods.

TABLE 2. Estimates of the beta parameter

ITEM	MML		Exact prior		Non-exact prior		True β
	$\tilde{b}$	95%CI	$\tilde{b}$	95%CI	$\tilde{b}$	95%CI	
1	1.32	(0.91,1.73)	1.2	(0.87,1.53)	1.4	**(1.03,1.77)***	1.02
2	-1.34	(-1.54,-1.14)	-1.32	(-1.52,-1.12)	-1.35	(-1.55,-1.15)	-1.26
3	-0.04	(-0.16,0.08)	-0.05	(-0.19,0.09)	-0.04	(-0.18,0.1)	-0.01
4	0.16	(0.1,0.22)	0.14	(0.06,0.22)	0.16	(0.08,0.24)	0.13
5	-0.36	(-0.46,-0.26)	0.37	(0.25,0.49)	-0.37	(-0.49,-0.25)	-0.39
6	1.56	(1.38,1.74)	1.51	(1.33,1.69)	1.56	(1.38,1.74)	1.43
7	-0.46	(-0.58,-0.34)	0.46	(0.34,0.58)	-0.46	(-0.6,-0.32)	-0.51
8	0.88	(0.76,1)	0.82	(0.68,0.96)	0.86	(0.7,1.02)	0.81
9	-1.16	(-1.28,-1.04)	-1.14	(-1.28,-1)	-1.17	(-1.31,-1.03)	-1.22
10	-1.52	(-1.77,-1.27)	-1.49	(-1.74,-1.24)	-1.54	(-1.81,-1.27)	-1.55
11	1.71	(1.53,1.89)	1.66	(1.46,1.86)	1.71	(1.51,1.91)	1.61
12	1.12	(1.02,1.22)	1.08	(0.94,1.22)	1.12	(1,1.24)	1.12
13	1.91	(1.69,2.13)	1.85	(1.63,2.07)	1.92	(1.68,2.16)	1.89
14	1.63	(1.41,1.85)	1.57	(1.33,1.81)	1.65	(1.4,1.9)	1.58
15	-0.59	**(-0.67,-0.51)***	-0.59	(-0.69,-0.49)	-0.59	(-0.69,-0.49)	-0.68
16	0.02	**(-0.1,0.14)***	0.00	(-0.14,0.14)	0.02	**(-0.11,0.16)***	-0.12
17	-0.69	(-0.77,-0.61)	-0.69	(-0.79,-0.59)	-0.7	(-0.8,-0.6)	-0.64
18	0.64	**(0.56,0.72)**	0.6	(0.5,0.7)	0.62	(0.52,0.72)	0.53
19	1.23	(1.03,1.43)	1.18	(0.98,1.38)	1.24	(1.02,1.46)	1.11
20	-1.65	(-1.89,-1.41)	-1.6	(-1.84,-1.36)	-1.67	(-1.92,-1.42)	-1.48
21	-0.65	(-0.81,-0.49)	-0.64	(-0.8,-0.48)	-0.66	(-0.82,-0.5)	-0.74
22	-0.72	**(-0.84,-0.6)***	-0.71	**(-0.83,-0.59)***	-0.72	(-0.86,-0.58)	-0.85
23	0.46	(0.21,0.71)	0.41	(0.16,0.66)	0.48	(0.19,0.77)	0.5
24	1.28	(1.1,1.46)	1.23	**(1.03,1.43)***	1.29	(1.09,1.49)	1.44
25	-0.87	(-1.09,-0.65)	-0.85	(-1.07,-0.63)	-0.88	(-1.1,-0.66)	-0.76
26	2.30	(1.81,2.79)	2.11	(1.7,2.52)	2.41	(1.84,2.98)	2.2
27	0.29	(0.21,0.37)	0.27	(0.17,0.37)	0.29	(0.19,0.39)	0.26
28	-2.33	(-2.8,-1.86)	-2.21	(-2.6,-1.82)	-2.39	(-2.92,-1.86)	-2.49
29	1.14	(0.98,1.3)	1.10	(0.94,1.26)	1.15	(0.97,1.33)	1.14
30	1.92	(1.61,2.23)	1.83	(1.54,2.12)	1.95	(1.62,2.28)	1.74

Note: An "*" indicates that the true parameter is NOT within the 95% confidence interval for the MML or a 95% credible set for the MCMC methods.

to estimate to posterior means of alpha and beta. Below are representative history, BGR, and autocorrelation plots for alpha and beta based on all possible iterations. The autocorrelation and BGR statistics suggest that chains reached an acceptable convergence on the stationary distribution.

Table 1 lists estimates of alpha using MML, MCMC procedures with exact priors, MCMC procedures with non-informative priors and the "true" alpha for the 30 simulated items. Similarly, Table 2 lists estimates of beta and the "true" beta for the items.

Estimates based on the MML method using BILOG-MG resulted in the true alpha parameter not being included in a 95% confidence interval for items 1, 12, 18 and 23. As for the beta parameter estimate the MML method resulted in the true parameter not being included in a 95% confidence interval for items 15, 16, 18, and 22. Using exact priors in WinBUGS resulted in the true alpha parameter not being included in a 95% credible set for items 1 and 18, and for the true beta parameter items 22 and 24 not being included in the 95% credible set. For the non-informative prior in WinBUGS the true alpha parameter was not covered by the 95% credible set for items 1, 18, and 23, and for the true beta parameter items 1 and 16 were not covered by a 95% credible set.

4. Dis cussion. Overall, the use of WinBUGS to estimate item parameters for a 2PL IRT model resulted in the best recovery of simulated item parameters. Using what has been termed the exact prior, those based on the parameters of the distributions used to create the simulated data, only slightly outperformed using a non-informative prior in the absolute number of true item parameters recovered. With regards to the alpha parameter the exact prior failed to recover only two items, determined by whether or not the true parameter was within the 95% credible set. The non-informative prior failed to recover three items, two of which were the same as the exact prior. The MML method failed to recover four items, three of which were the same as the non-informative prior. All three methods failed to recover the true alpha parameter for items 1 and 18.

The results revealed a similar picture with regards to the beta parameter. The use of an exact prior and a non-informative prior both resulted in two items not being recovered. However, there was no overlap in the items not recovered by these prior assumptions. The MML again failed to recover four items. Two of these items overlap with one item that each of the exact and non-informative prior failed to recover.

MML failed to recover both parameters for item 18 and the non-informative prior failed to recover both parameters for item 1. All three methods failed to recover at least one parameter on each of these items suggesting that neither of these items may fit the data well. It is also worth noting that the MML and MCMC method resulted in exactly the same parameter estimate but the true parameter was not in corresponding confidence interval but was include in the credible set, for example the alpha parameter for item 12.

Based on the results of this study, using WinBUGS even with a non-informative prior resulted in better recovery of item parameters over BILOG-MG. This of course requires that one accept the priors used. One option within BILOG-MG is to use MMAP which assumes the same prior distributions that were used in this project so it seems reasonable to accept the priors as ones typically used in psychometrics. It may be safe to assume that if MCMC recovers item parameters better than MML on simulated data it would perform similarly on actual test data. This should result in better estimates of an examinee's ability and ultimately in better decisions based on test scores.

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[i] From this point forward the parameterization of normal and log-normal distributions is in terms of mean and precision which is consistent with WinBUGS.

APPLYING THE MIXED RASCH MODEL TO THE FRACTION CONCEPT OF PUPILS

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ABSTRACT. *The purpose of this study is to investigate fraction concepts of the first graders and the second graders based on mixed Rasch model. Fraction concepts play an important role in mathematics learning of elementary schools. Especially, these exists many factors which influence construction of fraction concepts. It is prospective to analyze the fraction concepts based on sample clustering in accordance with their cognitive features. Mixed Rasch model combines latent class model and Rasch model so that it could present proper classes of sample with the corresponding latent trait. Results of this study show that both the first graders and the second graders could be classified into two classes. However, features of these two classes differ with grade. In addition, comparisons on the features of classes could reveal some possible reasons which influence construction of fraction concepts. Finally, based on the findings of this study, some suggestions for future research are provided.*
Keywords: Cognitive Diagnosis; Fraction Concept; Mixed Rasch Model; Rasch Model

1. Introduction. Mathematics is the foundation of science and other fields. Students begin to learn its formal representation since they are students in the elementary schools. However, quite a few researches reveal that students own intuitive thinking or misconceptions in the process of concept construction. As to fraction concept, it is the foundation of further mathematics like ratio and division, de Castro (2008), Cramer et al. (2002). Therefore, investigation on fraction concepts for pupils should be prospective. On the other hand, sample clustering based on homogeneity of fraction concepts should be useful for remedial instruction. It is because design of adaptively remedial instruction could depend on the information of cognitive diagnosis, Lin (2010). For this purpose, application of mixed Rasch model could reflect the cognitive information of measurement data. Therefore, this study will adopt mixed Rasch model to analyze fraction concept of pupils who are the first graders and the second graders.

2. Literature Review. Issue of fraction concepts related to its construction and misconceptions is discussed. In addition, model description of mixed Rasch model will also be discussed.

2.1. Fraction Concepts of Pupils. Fraction is one of the most difficult concepts to comprehend for elementary school students, Charalambous and Pitta-Pantazi (2006). Many literatures indicate there are misconceptions for students in the process of learning, Chan et al. (2007). Even adults exist conceptual deficiencies in fraction, Stafylidou and Vosniadou (2004). Erroneous fraction concepts exist in both conceptual knowledge and procedural knowledge, Moseley and Okamoto (2010), Panaoura et al. (2009).

There are multiple meanings as to fraction concept. It includes part-whole relation, expression of division, quotients, another form of decimal, operator, ratio and measures, rau et al. (2009). The characteristics of multiple meanings in fraction easily result in the learning obstruction of students, Charalambous (2007). As to the first graders and the second graders, they mainly comprehend the representation and expression of fraction. Generally, equal sharing concept, simple fraction concept and units concept are the main three components for pupils. However, owing to the representation and mathematical language, performance of fraction concepts vary across grade. Therefore, it is worthwhile to apply mixed Rasch model in investigating the fraction concepts of pupils..

2.2. Description of Mixed Rasch Model. Rasch model is one popular model of item response theory. Let θ_i be the latent trait of task-taker i and b_k is the difficulty parameter of item k. Rasch model is

$$P_k(\theta_i) = \frac{e^{\theta_i - b_k}}{1 + e^{\theta_i - b_k}} = \frac{1}{1 + e^{-(\theta_i - b_k)}} \tag{1}$$

Rost extended Rasch model to mixed Rasch model, Rost and Rasch(1990), Rost (1991). Mixed Rasch model considered the task-takers who belong to different classes have distinct response probability on items. In addition, item difficulty will be different in accordance with various classes. Let b_{kc} be the item difficulty of item k on class c and θ_{ic} be the latent trait of task-taker i who belong to class c. Combined with Rasch model and latent class model, the mixed Rasch model is, Rost and Rasch(1990), Rost and von Davier (1994).

$$P_{kc}(\theta_{ic}) = \frac{e^{(\theta_{ic} - b_{kc})}}{1 + e^{(\theta_{ic} - b_{kc})}} = \frac{1}{1 + e^{-(\theta_{ic} - b_{kc})}} \tag{2}$$

Let $P(X_i)$ be the probability of response vector X_i from task-taker i. It is

$$P(X_i) = \sum_{c=1}^{C} \alpha_c \prod_{k=1}^{K} \left(\frac{1}{1 + e^{-(\theta_{ic} - b_{kc})}}\right)^{x_{ik}} \left(\frac{e^{-(\theta_{ic} - b_{kc})}}{1 + e^{-(\theta_{ic} - b_{kc})}}\right)^{1 - x_{ik}} \quad \text{with} \quad \sum_{c=1}^{C} \alpha_c = 1 \tag{3}$$

α_c is the latent class parameter to represent the ratio of sample size in class c. It is $x_{ik} = 1$ when task-taker i give correct answer on item k; otherwise, it is $x_{ik} = 0$. EM algorithm and unconditional maximum likelihood estimation is adopted to iterate so as to find the optimal parameters above. As to the model selection, AIC (Akaike Information Criterion), BIC (Bayesian Information Criterion) and CAIC (Consistent Akaike Information Criterion) are three popular indices to determine class number of mixed Rasch model, (Hamaker, 2009; Bozdogan, 1987; Akaike, 1978). The smaller the index is, the better the model will be.

3. Assessment and Sample. The fraction concept assessment is designed by the author. In order to conform to mathematics textbooks of each grade respectively, there are two kinds of assessment and each assessment contains six items which measure the same fraction concepts in the two assessments. The only difference between these two assessments is the mathematical description and fraction representation of items. As shown in Table 1, these three concepts are A1(equal sharing concept), A2 (simple fraction concept) and A3(units concept). The item- concept matrix represents the concepts measured by items. For example, item 1 measures concept A1 (equal sharing concept) and item 4 measures concept A1 (equal sharing concept) concept A2 (simple fraction concept). The sample are stratified sampled from Taiwan. There are about one thousand and two hundreds pupils for each grade.

TABLE 1. The item-concept matrix of the fraction concept assessment

Items	Concept Attribute		
	A1 (Equal Sharing Concept)	A2 (Simple Fraction Concept)	A3 (Units Concept)
1	1	0	0
2	0	1	0
3	0	0	1
4	1	1	0
5	1	1	1

4. Main Results. Mixed Rasch model is the statistical model to analyze the empirical data and WINMIRA 2001 is the software, von Davier (2000).

4.1. The First Grade. Three indices are used to evaluate the model selection. As shown in Table 2, it shows that there exists minimum value when the class number is 2. Therefore, the best number of class for first graders is 2.

TABLE 2. Criteria of model selection for the first Graders

Class Number	AIC	BIC	CAIC
2	8219.16	8285.88	8298.88
3	8223.19	8325.84	8345.84
4	8230.70	8369.28	8396.28
5	8243.99	8418.50	8452.50
6	8255.04	8465.47	8506.47
7	8267.42	8513.78	8561.78
8	8280.83	8563.12	8618.12

Table 3 displays the number of students in each class for the first graders. Statistical test Pearson Chi-square shows that $\chi^2 = 4.761$ ($df = 1$, $p < .05$). Therefore, there is significant difference on the class distribution for gender. It appears that male students tend to belong to class II but female students tend to belong to class I.

TABLE 3. Number of students in each Class for the first Graders

Latent Class	Gender		Sum
	Female	Male	
Class I	344	316	660
Class II	272	320	592
Sum	616	636	1252

4.2. The Second Grade. Based on the three indices described in Table 4, it shows that there exist minimum value of BIC and CAIC when number of class is 2. However, the minimum value of AIC exists when class number is 3. Since there is little difference on AIC when class number is 2 or 3, it is reasonable to decide that proper class number is 2.

TABLE 4. Criteria of model selection for the second Graders

Class Number	AIC	BIC	CAIC
2	7283.93	7350.20	7363.20
3	7282.52	7384.48	7404.48
4	7294.29	7431.94	7458.94
5	7307.00	7480.34	7514.34
6	7320.94	7529.97	7570.97
7	7334.26	7578.98	7626.98
8	7348.02	7628.43	7683.43

Table 5 displays the number of students in each class for the second graders. Statistical test Pearson Chi-square shows that Pearson $\chi^2 = .001$ ($df = 1$, $p = .972$). There is no difference on the class distribution for gender. It also means that performance on fraction concepts is the same as to gender.

TABLE 5. Number of students in each Class for the second Graders

Latent Class	Gender		Sum
	Female	Male	
Class I	402	446	848
Class II	172	190	362
Sum	574	636	1210

4.3. Comparisons on Both Graders. The line chart of conditional probability of items within classes in accordance with both graders is depicted in Figure 1. In the first grade, it shows that class I performs better a little bit than class II on item 2 and item 3 but has deficiency on item 1, item 4 and item 5. As to item 1, item 2, item 4 and item 5, it seems to exist much difference on conditional probability between two classes. However, class II perform quite poor on item 3 and item 3 is to measure units concept which is the foundation of fraction. Therefore, it may exist cognitive deficiency as to the units concept for Class II. Remedial instruction on this concept especially for class II is needed. As to the second grade, it shows the two lines are almost parallel and class I performs better on all items than class II. It means that the two classes only has difference on mastery of fraction concepts. These is no interactive distinction among concepts like the performance of the first graders. Hence, the design of remedial instruction for the second graders is unlike the first graders.

In comparison with these two graders, it reveals their fraction concepts differ. The second graders do not perform better on all items than the first graders. In the fraction concept, although items of different grade measure the same concept attribute, their mathematical representation and description vary. It means the importance of representation and description for fraction.

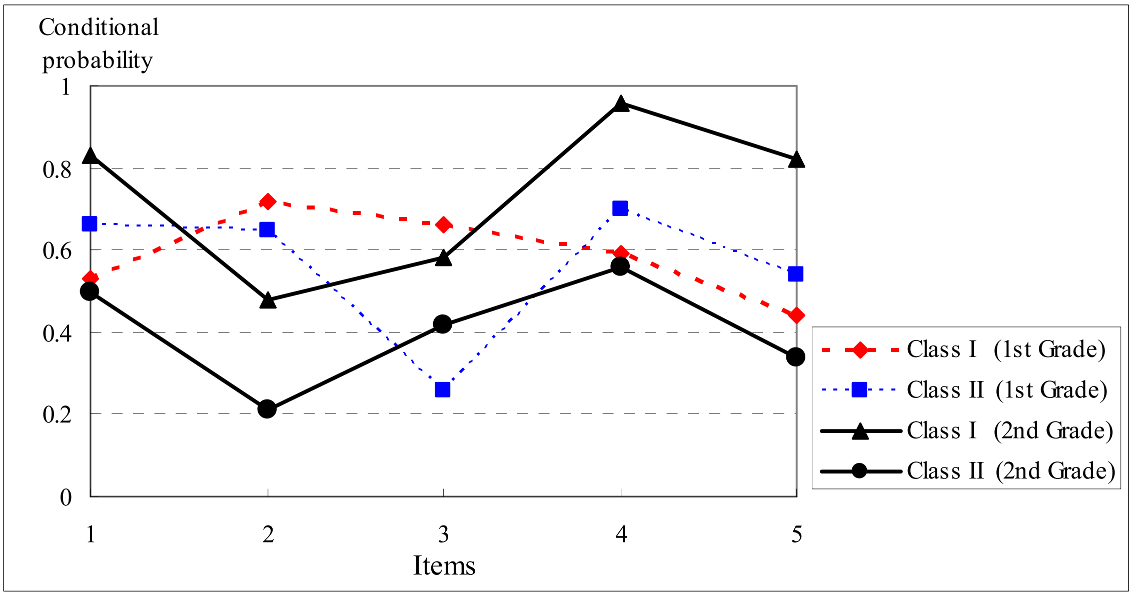

FIGURE 1. Line chart of conditional probability on items for the both Graders

TABLE 6. Latent trait in each Class for the first Graders

Total Score	Latent trait of the first graders		Latent trait of the second graders	
	Class I	Class II	Class I	Class II
0	-2.546	-2.608	-3.171	-2.550
1	-1.190	-1.259	-1.505	-1.200
2	-0.369	-0.430	-0.416	-0.379
3	0.366	0.342	0.522	0.361
4	1.190	1.256	1.511	1.199
5	2.551	2.756	2.988	2.580

The corresponding relationship latent trait and total score is described in Table 6. Because total score is the sufficient statistics of latent trait, each total score will correspond with one latent trait. However, each class has its own cognitive features and the same total score of different class and grade has distinct latent trait.

5. Conclusion. The study investigates the fraction concepts of pupils by using mixed Rasch model. Although both two graders own two classes, the distribution of gender and the features of these classes differ. One is concluded that there is cognitive deficiency in units concept for the first graders of class II. The second graders do not have interactive distinction among concepts. Furthermore, remedial instruction of these graders should depend on the features of concept structures with meaning of mathematical representation and description in items.

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INTERVAL ESTIMATION FOR THE COEFFICIENT OF VARIATION OF A NORMAL DISTRIBUTION

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Abstract. *In this paper, we consider the interval estimation for a coefficient of variation (COV) of a normal distribution. Based on parametric bootstrap (PB) and generalized inference, two methods for interval estimation are proposed. To evaluate the coverage probabilities, a simulation study is conducted. The results indicate that the generalized confidence interval performs well under all examined conditions.*

Keywords: Coefficient of Variation, Parametric Bootstrap, Generalized Confidence Interval, Coverage Probability.

1. **Introduction.** The coefficient of variation (COV) is a dimensionless number that quantifies the degree of variability relative to the mean, which has long been a widely used descriptive and inferential quantity in various areas of science, economics and others. In finance, the coefficient of variation can be used as a measure of relative risk, see Miller et al. (1977). Thus, scientists, engineers, and portfolio managers are interested in obtaining confidence intervals on population coefficients of variation.

Various ways of obtaining the confidence intervals have appeared in the literature. McKay (1932) gave an approximation of the distribution of a statistics derived from the sample COV based on the chi-squared distribution. Miller (1991) indicated that this approximation is not accurate when COV is bigger. Vangel(1996) observed that the approach of Johnson and Welch(1940) is computational cumbersome, and he proposed an approximate method for obtaining confidence intervals on COVs which he called the modified McKay's confidence interval. However, the modified McKay's confidence interval work well only for small COV is and large sample.

In some complicated situations, Efron (1979) proposed the bootstrap method for statistical inference. Free of population distributions and parameters, the bootstrap theory has been greatly developed and expanded for the last three decades, and now this technique is wildly used in various fields of statistics, see DiCiccio and Efron (1996), Chen and Tong (2003), etc. Recently, the generalized inference has attracted a great amount of attention due to its advantage of handling the inference problems under certain complex situations. The concepts of generalized inference introduced by Tsui and Weerahandi (1989) and Weerahandi (1993) appear to be appropriate for the above problem, which are to develop hypothesis tests in situations where traditional frequentist approaches do not provide useful solutions. See for instance, Mathew and Webb (2005), Li et al. (2007).

The main work of this paper is to give the interval estimations of COV of a normal distribution based on the parametric bootstrap method and the generalized inference method. Numerical simulations are conducted to compare these two methods mentioned above.

2. **Interval Estimation of** COV**.** Let $X = (X_1, X_2, \ldots, X_n)$ be a random sample from the normal distribution $N(\mu, \sigma)$, the population COV is defined as σ/μ . Let $\bar{X}$ and S^2

be the sample mean and the sample deviation respectively, then the typical estimator of COV is given as $S/\bar{X}$. In the following, we propose two confidence intervals of COV based parametric bootstrap (PB) method and generalized inference method, respectively.

2.1. **The Parametric Bootstrap Method.** The parametric bootstrap involves sampling from the estimated models. That is, samples or sample statistics are generated from parametric models with the parameters replaced by their estimates. It is easy to know that

$$\bar{X} \sim N(\mu, \sigma^2/n), \quad \text{and } S^2 \sim \chi^2_{n-1}. \tag{1}$$

Using these facts, the parametric bootstrap pivot variable can be developed as follows. Let $\bar{X}_B \sim N(\bar{X}, S^2/n)$, and $(n-1){S_B}^2 \sim S^2\chi^2_{n-1}$. It can be easily verified that the PB pivot variable for COV is distributed as

$$COV_B = \frac{S_B}{\bar{X}_B} = \frac{S\chi_{n-1}/\sqrt{n-1}}{\bar{X} + \frac{S}{\sqrt{n}\chi_{n-1}}Z}, \tag{2}$$

where Z is a standard normal random variable. For fixed x , the above probability does not depend on any unknown parameters, so it can be estimated using Monte Carlo simulation given in algorithm 1.

Algorithm 1.

1) For a given x , calculate $\bar{x}$ and s^2.
2) Generate $\bar{X}_B \sim N(\bar{x}, s^2/n)$, and ${S_B}^2 \sim s^2\chi^2_{n-1}/(n-1)$, respectively.
3) Compute COV_B using (2).
4) Repeat step (2)-(3) for N (=10,000) times and get corresponding COV_B.
5) For the given confidence coefficient $1-\alpha$, sort the COV_B 's in an ascending order.

Find their $\alpha/2$ and $1-\alpha/2$ percentiles denoted by $COV_{B,L}$ and $COV_{B,U}$, respectively. Then the bootstrap confidence interval of is $[COV_{B,L},\, COV_{B,U}]$.

2.2. **The Generalized Inference Method.** The concepts of generalized inference introduced by Tsui and Weerahandi (1989) and Weerahandi (1993). Consider an observable random vector X with a probability distribution $P_\xi(\cdot)$ and sample space X, where ξ is an unknown vector. Let $\theta(\xi)$ be a real-valued parameter of interest, ν be the nuisance parameter such that ξ and (θ, ν) is 1-1 transformation.

Let $R = r(X; x, \xi)$ be a function of X, the observed value x of X and the parameters $\nu = (\theta, \xi)$. R is said to be a generalized pivotal quantity if it has the following two properties:

(1). R has a probability distribution free of unknown parameters.

(2). $r_{obs} = r(x; x, \xi)$ does not depend on the nuisance parameter δ.

Given the observation x of X, and a confidence coefficient γ, let R_γ be the 100γth percentile of R. Then R_γ is $100(1-\gamma)\%$ lower bound for θ, and $[R_{\gamma/2}, R_{1-\gamma/2}]$ is a $100\gamma\%$ two-sided generalized confidence interval for θ.

Define

$$T_{COV}(X; x, \mu, \sigma^2) = \frac{\frac{s}{S}\sigma}{\bar{x} - \frac{s}{S}(\bar{X}-\mu)} = \frac{\sqrt{n-1}\frac{s}{V}}{\bar{x} - \frac{\sqrt{n-1}}{\sqrt{n}}\frac{s}{V}W},$$

where $W \sim N(0,1)$, and $V \sim \chi^2_{n-1}$ are mutually independent. Since the observed value of $T_{COV}(X; x, \mu, \sigma^2)$ is $T_{COV}(x; x, \mu, \sigma^2) = \frac{\sigma}{\mu}$. Furthermore, by (1), we have Define

$$T_{COV}(X; x, \mu, \sigma^2) = \frac{\sqrt{n-1}\frac{s}{V}}{\bar{x} - \frac{\sqrt{n-1}}{\sqrt{n}}\frac{s}{V}W}, \tag{3}$$

then the distribution of T_{COV} does not depend on any parametric, T_{COV} is a generalized pivotal quantity .

Hence, for given $1-\alpha$, the generalized confidence interval of COV is $[T_p(\alpha/2), T_p(1-\alpha/2)]$, where $T_p(\gamma)$ is the 100γ quantile of T_{COV}.

Similar to PB method, the distribution of T_{COV} does not epend on any unknown parameters, the generalized confidence interval can be estimated using Monte Carlo simulation

Algorithm 2.

1) For a given x , calculate $\bar{x}$ and s^2.

2) Generate $W \sim N(0,1)$, and $V \sim \chi^2_{n-1}$, respectively.

3) Compute T_{COV} using (3).

4) Repeat step (2)-(3) for N (=10,000) times and get corresponding T_{COV}.

5) For the given confidence coefficient $1-\alpha$, sort the T_{COV}'s in an ascending order.

Find their $\alpha/2$ and $1-\alpha/2$ percentiles denoted by $T_{COV,L}$ and $T_{COV,U}$, respectively. Then the generalized confidence interval of is $[T_{COV,L}, T_{COV,L}]$.

3. **Simulation Results.** This section is devoted to the comparison of the parametric bootstrap interval (PB) and generalized confidence interval (GC) using numerical simulation. In general, the mutual comparison of the above two methods should consider the coverage probabilities (CP). In order to evaluate the interval estimation of the above two methods, we here apply Monte Carlo simulation to estimate CP. For given μ and σ^2 and n, generate $M(=5,000)$ samples, compute the parametric bootstrap interval and generalized confidence interval under the nominal level $1-\alpha = 95\%$ using the related algorithms put forward in section 2, and finally calculate the proportion of the intervals containing COV. The simulation results are shown in Figure 1.

The numerical results in Figure 1 indicate that the CPs of the generalized confidence intervals are close to the stated level, however, PBs generally smaller than the stated level for small sample size n. Under this condition, the generalized inference method performs more satisfactorily than the parametric bootstrap method. When n is moderately large, the CPs of the two kinds of intervals are close to each other. Therefore, we can conclude that the generalized confidence intervals would not be affected by the value of COV and n.

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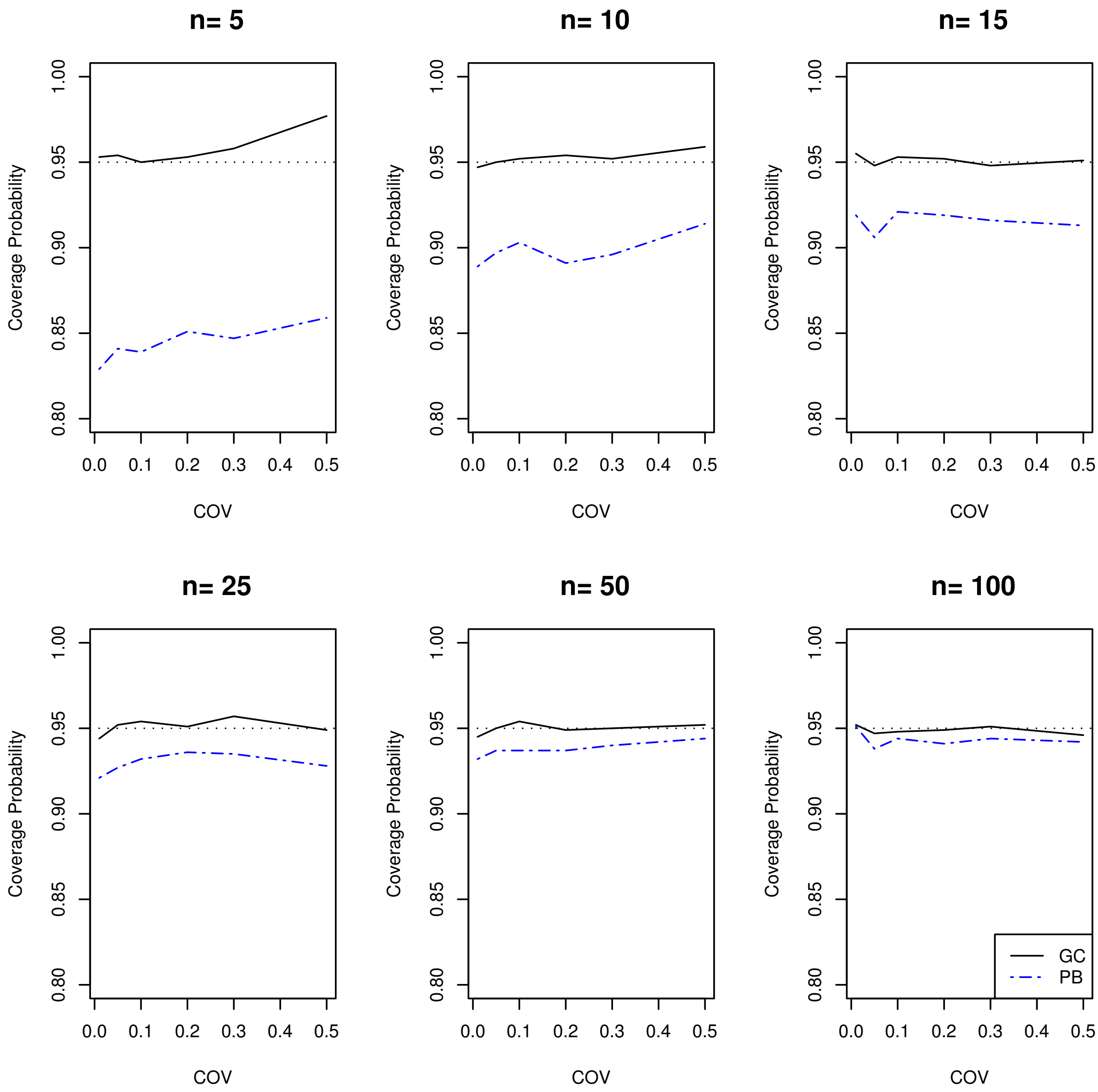

FIGURE 1. Coverage probability of PB and GC.

APPLYING SYMMETRIC TRIANGULAR APPROXIMATIONS TO FUZZY LINEAR REGRESSION ANALYSIS

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ABSTRACT. *In this paper, we study the problem of least-squares multiple regression with fuzzy data, that is to find a symmetry triangular fuzzy number* $\tilde{A}_0$ *and real numbers* $\beta_1, \ldots, \beta_m$ *that minimize the observation error* $\mathrm{d}(\tilde{Y}, \tilde{A}_0 + \beta_1 \tilde{X}_1 + \ldots, \beta_m \tilde{X}_m)$*, where* $\tilde{X}_i$ *and* $\tilde{Y}$ *are fuzzy data. By applying the symmetric triangular approximation of fuzzy numbers, a new method for determining* $\tilde{A}_0$ *and* $\beta_1, \ldots, \beta_m$ *is proposed. For cross-referencing the previous contributions, some examples are illustrated.*

Keywords: Linear Regression; Fuzzy Data; Least Squares Estimates; Triangular Approximation

1. Introduction. In 1982, Tanaka et al. (1982) first examined fuzzy regression analysis with real independent (or explanatory) and fuzzy dependent (or response) variables, that is to find symmetry triangular fuzzy numbers $\tilde{A}_0, \tilde{A}_1, \ldots, \tilde{A}_m$ that minimize the observation error $\mathrm{d}(\tilde{Y}, \tilde{A}_0 + \tilde{A}_1 X_1 + \ldots, \tilde{A}_m X_m)$, where X_i are real and $\tilde{Y}$ is fuzzy. Afterwards, many scholars studied this type fuzzy regression analysis by generalizing the coefficients $\tilde{A}_i$ to more general fuzzy numbers, D'Urso and Santoro (2006), Hong and Hwang (2004), R. Korner and W. Nather(1998), Wang et al. (2006).

In 1992, Sakawa and Yano (1992) considered fuzzy linear regression models with fuzzy data, that is to find regression coefficients $\tilde{A}_0, \tilde{A}_1, \ldots, \tilde{A}_m$ that minimize the observation error $\mathrm{d}(\tilde{Y}, \tilde{A}_0 + \tilde{A}_1 \tilde{X}_1 + \ldots, \tilde{A}_m \tilde{X}_m)$, where $\tilde{X}_i$ and $\tilde{Y}$ are fuzzy data. Subject to the regression coefficients of being real, the least-squares estimation was further studied by Diamond (1988), and the existence was proved by Kratschmer (2006). In 1992, Bardosy et al. (1992) presented normal equations systems depended on signs of regression coefficients to estimate the regression coefficients. In 2002, Kao and Chyu (2002) proposed a two-stage method. Most of the recent approaches have to consider 2^m optimization cones, then determine the regression coefficients by comparing observation errors of these possible estimators, where m is the number of independent variables. It will take a lot of time to find the best one. An iterative algorithm (numerical method) was proposed by Bargiela et al. (2007). In 2009, Yeh (2009b) showed that the multiple regression problem can be replaced with a 0-1 programming problem, and provided a formula for computing the regression coefficients in one-variable models.

For more general case, the constant coefficient $\tilde{A}_0$ of being fuzzy, Diamond and Korner (1997) generalized their previous results via Hukuhara difference. Wunsche and Nather (2002) turned to study on the restriction that the data are of normal distributions. Chen and Hsueh (2009) used the least-squares method to determine regression coefficients in multiple-variable models. Also, there are many other contributions to this type, Hong and Hwang (2004), Kao and Chyu (2003), Kim et al. (2008). In this paper, we combine symmetric triangular approximation Yeh (2009c) with Yeh's method Yeh (2009b) to offer a new approach to fuzzy linear regression analysis. Some illustrate examples are presented.

2. Problem Statement and Main Theorem. An arbitrary fuzzy number $\tilde{A}$ can be represented by an ordered pair of left continuous functions $[A^l(t), A^u(t)],\ 0 \le t \le 1$, which satisfy the following conditions: (1) $A^l = A^l(t)$ is increasing on [0,1], (2) $A^u = A^u(t)$ is decreasing on [0,1], (3) $A^l(t) \le A^u(t),\ t \in [0,1]$. Let $F(\mathbb{R})$ and $\mathbb{R}$ denote the sets of all fuzzy numbers and all real numbers, respectively. We always place a "~" over a letter to denote a fuzzy number, for example $\tilde{X}_i,\ \tilde{A} \in F(\mathbb{R})$ and $a,\tau,\beta_i \in \mathbb{R}$. Let $\tilde{A} = [A^l(t), A^u(t)]$ and $\tilde{B} = [B^l(t), B^u(t)] \in F(\mathbb{R})$. The Euclidean distance between $\tilde{A}$ and $\tilde{B}$ is defined as

$$\mathrm{d}(\tilde{A}, \tilde{B}) := \left[\int_0^1 |A^l(t) - B^l(t)|^2\, dt + \int_0^1 |A^u(t) - B^u(t)|^2\, dt\right]^{\frac{1}{2}}.$$

Recall that, the fuzzy operations on fuzzy numbers can be described as follows:

$$\tilde{A} \oplus \tilde{B} := [A^l(t) + B^l(t), A^u(t) + B^u(t)] \quad \text{and} \quad a \odot \tilde{A} := \begin{cases} [aA^l(t), aA^u(t)], & \text{if } a \ge 0, \\ [aA^u(t), aA^l(t)], & \text{if } a < 0. \end{cases}$$

Given fuzzy vectors $\vec{\tilde{Y}} = (\tilde{Y}_1, \ldots, \tilde{Y}_n)$ and $\vec{\tilde{X}}_i = (\tilde{X}_{i1}, \ldots, \tilde{X}_{in}) \in F(\mathbb{R})^n,\ 1 \le i \le m$, the problem of fuzzy linear regression analysis is to find the regression coefficients $\tilde{A}_0$ and $\tilde{\beta}_1, \ldots, \tilde{\beta}_m \in F(\mathbb{R})$, which minimize the observation error

$$\mathrm{d}^2(\vec{\tilde{Y}}, \tilde{A}_0 \odot \vec{1} \oplus \tilde{\beta}_1 \odot \vec{\tilde{X}}_1 \oplus \cdots \oplus \tilde{\beta}_m \odot \vec{\tilde{X}}_m) := \sum_{j=1}^{k} \mathrm{d}^2(\tilde{Y}_j, \tilde{A}_0 \odot \vec{1} \oplus \tilde{\beta}_1 \odot \tilde{X}_{1j} \oplus \cdots \oplus \tilde{\beta}_m \odot \tilde{X}_{mj}),$$

where $\vec{1} := (1, \ldots, 1)$. In this paper, we study on the restrictions that $\tilde{A}_0$ is symmetric triangular and $\tilde{\beta}_i,\ 1 \le i \le m$, are real (hence, use β_i instead of $\tilde{\beta}_i$).

Let $L_2[0,1]$ stand for the set of L_2-integrable functions, which is well-known an inner product space. In Yeh (2009c), Yeh showed that $F(\mathbb{R})$ can be embedded into the Cartesian product space $L_2[0,1] \times L_2[0,1]$. An element in $L_2[0,1] \times L_2[0,1]$ is called a vector and denoted by a "~" over a letter, too. The vector operations on $L_2[0,1] \times L_2[0,1]$ are defined as follows:

$$\tilde{A} + \tilde{B} := [A^l(t) + B^l(t), A^u(t) + B^u(t)],\ \tilde{A} - \tilde{B} := [A^l(t) - B^l(t), A^u(t) - B^u(t)],$$
$$a\tilde{A} := [aA^l(t), aA^u(t)].$$

For any $\tilde{A}, \tilde{B} \in F(\mathbb{R})$, it is easy to verify that the inheriting inner product of $\tilde{A}$ and $\tilde{B}$ is

$$\langle \tilde{A}, \tilde{B} \rangle = \int_0^1 \left[A^l(t)B^l(t) + A^u(t)B^u(t)\right]\, dt$$

and that $\tilde{A} \oplus \tilde{B} = \tilde{A} + \tilde{B}$, hence $\mathrm{d}^2(\tilde{A}, \tilde{B}) = \langle \tilde{A} - \tilde{B}, \tilde{A} - \tilde{B} \rangle$. Besides, for any $a \ge 0$, we have $a \oplus \tilde{A} = a\tilde{A}$ and $(-a) \odot \tilde{A} = a \cdot [-A^u(t), -A^l(t)]$.

Recall that, every fuzzy number $\tilde{A} = [A^l(t), A^u(t)]$ can be represented by its CR-representation (Yeh, b), that is $\tilde{A} = [A^c(t), A^r(t)]_{CR}$, where

$$A^c(t) := \tfrac{1}{2}(A^l(t) + A^u(t)) \text{ and } A^r(t) := \tfrac{1}{2}(A^u(t) - A^l(t)). \tag{1}$$

For any fuzzy vector $\vec{\tilde{A}} := (\tilde{A}_1, \ldots, \tilde{A}_n)$ with CR-representations $\tilde{A}_i = [A_i^c(t), A_i^r(t)]_{CR}$,

$1 \leq i \leq n$, we define $\vec{\tilde{A}}^c := (A_1^c, \ldots, A_n^r)$ and $\vec{\tilde{A}}^r := (A_1^r, \ldots, A_n^r) \in L_2[0,1]^n$ and the mean of $\vec{\tilde{A}}$ as follows

$$E(\vec{\tilde{A}}) := \frac{1}{n}\sum_{i=1}^{n} \tilde{A}_i. \tag{2}$$

Also, the CR-representation of $E(\vec{\tilde{A}})$ is denote by $[E^c(\vec{\tilde{A}}), E^r(\vec{\tilde{A}})]_{CR}$.

Note that, $\tilde{A}$ is said to be symmetric if $A^c(t)$ is constant, symmetric triangular if $\tilde{A} = [\tau, \sigma(1-t)]_{CR}$, $\tau \in \mathbb{R}$, $\sigma \geq 0$, and real (crisp) if $\tilde{A} = [\tau, \tau]$, $\tau \in \mathbb{R}$. Let V be a vector subspace of $L_2[0,1] \times L_2[0,1]$ and $P_V(\tilde{A})$ be the projection of $\tilde{A}$ onto V. Denote by $[P_V^c(\tilde{A}), P_V^r(\tilde{A})]_{CR}$ the CR-representation of $P_V(\tilde{A})$. V is said to be fuzzy symmetric if each vector $\tilde{A} \in V$ satisfies that $A^c(t)$ is constant.

Main Theorem. Let V be a fuzzy symmetric vector subspace of $L_2[0,1] \times L_2[0,1]$, $\vec{\tilde{Y}} = (\tilde{Y}_1, \ldots, \tilde{Y}_n)$, $\vec{\tilde{X}}_i = (\tilde{X}_{i1}, \ldots, \tilde{X}_{in}) \in F(\mathbb{R})^n$, $1 \leq i \leq m$,
And

$$\vec{c} := \left(\langle \vec{\tilde{Y}}^c - P_V^c(E(\vec{\tilde{Y}}))\vec{1}, \vec{\tilde{X}}_1^c - P_V^c(E(\vec{\tilde{X}}_1))\vec{1} \rangle, \ldots, \langle \vec{\tilde{Y}}^c - P_V^c(E(\vec{\tilde{Y}}))\vec{1}, \vec{\tilde{X}}_m^c - P_V^c(E(\vec{\tilde{X}}_m))\vec{1} \rangle \right),$$

$$\vec{r} := \left(\langle \vec{\tilde{Y}}^r - P_V^r(E(\vec{\tilde{Y}}))\vec{1}, \vec{\tilde{X}}_1^r - P_V^r(E(\vec{\tilde{X}}_1))\vec{1} \rangle, \ldots, \langle \vec{\tilde{Y}}^r - P_V^r(E(\vec{\tilde{Y}}))\vec{1}, \vec{\tilde{X}}_m^r - P_V^r(E(\vec{\tilde{X}}_m))\vec{1} \rangle \right),$$

and let

$\Phi = [\Phi_{ij}]$ and $\Psi = [\Psi_{ij}]$ be $m \times m$ matrices defined by

$$\Phi_{ij} := \langle \vec{\tilde{X}}_i^c - P_V^c(E(\vec{\tilde{X}}_i))\vec{1}, \vec{\tilde{X}}_j^c - P_V^c(E(\vec{\tilde{X}}_j))\vec{1} \rangle,$$
$$\Psi_{ij} := \langle \vec{\tilde{X}}_i^r - P_V^r(E(\vec{\tilde{X}}_i))\vec{1}, \vec{\tilde{X}}_j^r - P_V^r(E(\vec{\tilde{X}}_j))\vec{1} \rangle.$$

Assume that $U\Phi U + \Psi$ is invertible for any $U \in \Im$, where

$$\Im := \{\ m \times m \text{ diagonal matrices whose } (i,i)\text{-entries are 1 or -1}\}. \tag{3}$$

Let $\hat{U} \in \Im$ be the best matrix that maximizes the function $g : \Im \to \mathbb{R}$ defined by

$$g(U) = (\vec{c}U + \vec{r})[U\Phi U + \Psi]^{-1}(\vec{c}U + \vec{r})^T$$

and satisfies $(\vec{c}\hat{U} + \vec{r})(\hat{U}\Phi\hat{U} + \Psi)^{-1} \geq \vec{0}$. Then, the regression problem,

$$\tilde{Y} = \tilde{A}_0 + \beta_1 \odot \tilde{X}_1 + \cdots + \beta_m \odot \tilde{X}_m,\ \tilde{A}_0 \in V,\ \beta_i \in \mathbb{R},$$

can be solved by the following formulas:

$$(\beta_1, \ldots, \beta_m) = (\vec{c}\hat{U} + \vec{r})(\hat{U}\Phi\hat{U} + \Psi)^{-1}\hat{U} \text{ and } \tilde{A}_0 = P_V(E(\vec{\tilde{Y}})) - \sum_{i=1}^{m} \beta_i \odot P_V(E(\vec{\tilde{X}}_i)).$$

3. Symmetric Triangular Approximations. The symmetric triangular approximation of a fuzzy number $\tilde{A}$ is the symmetric triangular fuzzy number $\Delta(\tilde{A})$ such that $\mathrm{d}(\tilde{A}, \Delta(\tilde{A})) \leq \mathrm{d}(\tilde{A}, \tilde{X})$ for any symmetric triangular fuzzy numbers $\tilde{X}$. In Yeh (2009c), Yeh showed that $\Delta(\tilde{A}) = [\tau - \sigma(1-t), \tau + \sigma(1-t)]$, where τ and σ can be computed by

$$\tau = \tau(\tilde{A}) := \int_0^1 A^c(t)\ dt \quad \text{and} \quad \sigma = \sigma(\tilde{A}) := 3\int_0^1 A^r(t)(1-t)\ dt. \tag{4}$$

Further, he extended the results to the case of weighted distance and proposed symmetric trapezoidal approximation. More general approximations are referred to Grzegorzewski and

Mrowka (2008), Yeh (2008), Yeh (2009a), Zeng and Li (2007).

For any vector $\tilde{A} \in L_2[0,1] \times L_2[0,1]$, in fact we can also find a symmetric triangular fuzzy number $\Delta(\tilde{A})$ such that $\mathrm{d}(\tilde{A}, \Delta(\tilde{A})) \leq \mathrm{d}(\tilde{A}, \tilde{X})$ for any symmetric triangular fuzzy numbers $\tilde{X}$. Indeed, represent $\tilde{A}$ as CR-representation $[A^c(t), A^r(t)]_{CR}$, then compute τ and σ, by (4). If $\sigma \geq 0$, then $\Delta(\tilde{A}) = [\tau - \sigma(1-t), \tau + \sigma(1-t)]$, otherwise $\Delta(\tilde{A}) = [\tau, \tau]$.

4. Algorithms and Examples. To solve such a regression problem that the constant coefficient $\tilde{A}_0$ is assumed to be symmetric triangular, first let V_Δ be the subspace of $L_2[0,1] \times L_2[0,1]$ spanned by symmetric triangular fuzzy numbers. It is easy to verify that V_Δ is fuzzy symmetric. By applying Main Theorem, we get the possible estimators β_i and $\tilde{A}_0$. Note that, represent $\tilde{A}_0$ as CR-representation, then it must be of the form $[\tau, \sigma(1-t)]_{CR}$ and $\tilde{A}_0 \in F(\mathbb{R})$ if and only if $\sigma \geq 0$. So, if $\tilde{A}_0 \in F(\mathbb{R})$ (or $\sigma \geq 0$), then they are actually the best estimators. Next, if $\tilde{A}_0 \notin F(\mathbb{R})$ it requires solving each regression subproblem, which is corresponding to signs of β_i, by assumption that all regression coefficients are real. Finally, we should compare these observation errors to obtain the best estimators.

Let $\vec{\tilde{A}}, \vec{\tilde{B}} \in F(\mathbb{R})^n$. It is easy to verify that

$$\langle \vec{\tilde{A}} - E(\vec{\tilde{A}})\vec{1}, \vec{\tilde{B}} - E(\vec{\tilde{B}})\vec{1} \rangle = \langle \vec{\tilde{A}}, \vec{\tilde{B}} \rangle - n\langle E(\vec{\tilde{A}}), E(\vec{\tilde{B}}) \rangle.$$

If we can assure that each independent variable $\vec{\tilde{X}}_i$ is effective, i.e. $\beta_i \neq 0$ for all $1 \leq i \leq m$, then the following algorithm is applied.

Algorithm 1. Input fuzzy data $\vec{\tilde{Y}} = (\tilde{Y}_1, \ldots, \tilde{Y}_n)$, $\vec{\tilde{X}}_i = (\tilde{X}_{i1}, \ldots, \tilde{X}_{in}) \in F(\mathbb{R})^n$, $1 \leq i \leq m$.

(1) By (2) compute $E(\vec{\tilde{Y}})$, $E(\vec{\tilde{X}}_i)$, $1 \leq i \leq m$, and by (1) represent $\vec{\tilde{Y}}$ and $\vec{\tilde{X}}_i$ with CR-representations. Hence, obtain $\vec{\tilde{Y}}^c$, $\vec{\tilde{Y}}^r$, $\vec{\tilde{X}}_i^c$, $\vec{\tilde{X}}_i^r$.

(2) By (4), compute $\tau(E(\vec{\tilde{Y}}))$, $\tau(E(\vec{\tilde{X}}_i))$, $\sigma(E(\vec{\tilde{Y}}))$, $\sigma(E(\vec{\tilde{X}}_i))$ and

$$c_i = \langle \vec{\tilde{Y}}^c, \vec{\tilde{X}}_i^c \rangle - n\tau(E(\vec{\tilde{Y}}))\tau(E(\vec{\tilde{X}}_i)),\ \Phi_{ij} = \langle \vec{\tilde{X}}_i^c, \vec{\tilde{X}}_j^c \rangle - n\tau(E(\vec{\tilde{X}}_i))\tau(E(\vec{\tilde{X}}_j)),$$
$$r_i = \langle \vec{\tilde{Y}}^r, \vec{\tilde{X}}_i^r \rangle - \frac{n}{3}\sigma(E(\vec{\tilde{Y}}))\sigma(E(\vec{\tilde{X}}_i)),\ \Psi_{ij} = \langle \vec{\tilde{X}}_i^r, \vec{\tilde{X}}_j^r \rangle - \frac{n}{3}\sigma(E(\vec{\tilde{X}}_i))\sigma(E(\vec{\tilde{X}}_j)),$$

$1 \leq i, j \leq m$, hence obtain $\vec{c} = (c_1, \ldots, c_m)$, $\Phi = [\Phi_{ij}]$, $\vec{r} = (r_1, \ldots, r_m)$, $\Psi = [\Psi_{ij}]$.

(3) Let $\Omega = \{U \in \Im : (\vec{c}U + \vec{r})(U\Phi U + \Psi)^{-1} \geq \vec{0}\}$, where $\Im$ is defined by (3), and

$$\Omega_1 = \{U \in \Omega : (\vec{c}U + \vec{r})(U\Phi U + \Psi)^{-1}\left(\sigma(E(\vec{\tilde{X}}_1)), \ldots, \sigma(E(\vec{\tilde{X}}_m))\right)^T \leq \sigma(E(\vec{\tilde{Y}}))\}.$$

(4) If $\Omega_1 = \varnothing$, then set $\Omega_2 = \Omega$ and go to Step 5, otherwisefind $\hat{U}_1 \in \Omega_1$

which maximizes $g_1(U) = (\vec{c}U + \vec{r})[U\Phi U + \Psi]^{-1}(\vec{c}U + \vec{r})^T$, $U \in \Omega_1$,

compute $(\beta_1^{(1)}, \ldots, \beta_m^{(1)}) = (\vec{c}\hat{U}_1 + \vec{r})(\hat{U}_1\Phi\hat{U}_1 + \Psi)^{-1}\hat{U}_1$

and

$$\tilde{A} = [\tau(E(\vec{\tilde{Y}})), \sigma(E(\vec{\tilde{Y}}))]_{CR} - \sum_{i=1}^{m} \beta_i^{(1)} \odot [\tau(E(\vec{\tilde{X}}_i)), \sigma(E(\vec{\tilde{X}}_i))]_{CR},$$

and set $$\Omega_2 := \{U \in \Omega : g_1(U) > g_1(\hat{U}_1)\}.$$

(5) If $\Omega_2 = \varnothing$, then output the best estimators $(\beta_1^{(1)}, \ldots, \beta_m^{(1)})$, $\tilde{A}$, and stop.

(6) Otherwise, compute $r_i' = \langle \vec{\tilde{Y}}^r, \vec{\tilde{X}}_i^r \rangle$, $\Psi_{ij}' = \langle \vec{\tilde{X}}_i^r, \vec{\tilde{X}}_j^r \rangle$, $\vec{r'} = (r_1', \ldots, r_m')$, $\Psi' = [\Psi_{ij}']$,

and find $\hat{U}_2 \in \Omega_2$ which maximizes
$$g_2(U) = (\vec{c}U + \vec{r'})[U\Phi U + \Psi']^{-1}(\vec{c}U + \vec{r'})^T,\ U \in \Omega_2,$$
subject to $$(\vec{c}U + \vec{r'})(U\Phi U + \Psi')^{-1} \geq \vec{0}.$$

(7) Set $$(\beta_1^{(2)}, \ldots, \beta_m^{(2)}) = (\vec{c}\hat{U}_2 + \vec{r'})(\hat{U}_2\Phi\hat{U}_2 + \Psi')^{-1}\hat{U}_2$$
and
$$a = \tau(E(\vec{\tilde{Y}})) - \sum_{i=1}^{m} \beta_i^{(2)} \tau(E(\vec{\tilde{X}}_i)).$$
Compare the two observation errors,
$$\mathrm{d}^2(\vec{\tilde{Y}}, \tilde{A} \odot \vec{1} + \beta_1^{(1)} \odot \vec{\tilde{X}}_1 + \cdots + \beta_m^{(1)} \odot \vec{\tilde{X}}_m)$$
and
$$\mathrm{d}^2(\vec{\tilde{Y}}, a\vec{1} + \beta_1^{(2)} \odot \vec{\tilde{X}}_1 + \cdots + \beta_m^{(2)} \odot \vec{\tilde{X}}_m).$$
Output the best estimators.

Example 1. For cross referencing to the previous contributions, let us consider the example designed by Sakawa and Yano, as shown in Table 1.

For the case that the parameters (a, β) are assumed to be real, Sakawa and Yano (1992) offered (3.201, 0.579), Kao and Chyu (2003) offered (3.565, 0.522), and Yeh (2009b) offered (3.530, 0.525). And, for the case that $\tilde{A} \in F(\mathbb{R})$ and $\beta \in \mathbb{R}$, Diamond (1988) offered
$$(\tilde{A}, \beta) = ([3.563, 0.3(1-t)]_{CR}, 0.521)$$

TABLE 1. Comparison with the previous contributions

	$\vec{X}_1$	$\vec{Y}$	$\tilde{\mathrm{d}}^2(\tilde{Y}_j, a + \hat{\beta} \odot \tilde{X}_j)$ S.-Y.	K.-C.	Y.	$\tilde{\mathrm{d}}^2(\tilde{Y}_j, \tilde{A} + \beta \odot \tilde{X}_j)$ D.	C.-H.	Alg. 1
1.	$(1.5, 2, 2.5)$	$(3.5, 4, 4.5)$	0.2873	0.7798	0.7104	0.7344	0.7466	0.7417
2.	$(3, 3.5, 4)$	$(5, 5.5, 6)$	0.1781	0.0614	0.0727	0.0282	0.0273	0.0275
3.	$(4.5, 5.5, 6.5)$	$(6.5, 7.5, 8.5)$	2.6024	2.4165	2.4940	2.3177	2.3265	2.3200
4.	$(6.5, 7, 7.5)$	$(6, 6.5, 7)$	1.1666	1.0720	1.0317	1.0106	0.9965	1.0049
5.	$(8, 8.5, 9)$	$(8, 8.5, 9)$	0.3146	0.5341	0.5527	0.5195	0.5359	0.5267
6.	$(9.5, 10.5, 11.5)$	$(7, 8, 9)$	3.3975	2.3406	2.3240	2.1578	2.1086	2.1352
7.	$(10.5, 11, 11.5)$	$(10, 10.5, 11)$	1.7593	2.8846	2.8937	2.9113	2.9743	2.9403
8.	$(12, 12.5, 13)$	$(9, 9.5, 10)$	1.7911	0.7343	0.7397	0.6648	0.6285	0.6476
		Observation errors	11.4969	10.8233	10.8189	10.3443	10.3442	10.3439

and Chen and Hsueh (2009) offered $([3.572, 0.3(1-t)]_{CR}, 0.519)$. By applying Algorithm 1, we obtain $([3.568, 0.3(1-t)]_{CR}, 0.520)$. The corresponding observation errors are listed in Table 1. It can be seen that our estimators are better than the others.

Example 2. Let us consider another example of two-variable model, as follows:

TABLE 2. An example of two-variable model

	$\vec{\tilde{X}}_1$	$\vec{\tilde{X}}_2$	$\vec{\tilde{Y}}$	$\tilde{A} \in \mathbb{R}$ Yeh	$\tilde{A} \in F(\mathbb{R})$ Alg. 1
1.	$(1.5, 2, 2.5)$	$(12, 12.5, 13)$	$(3.5, 4, 4.5)$	0.5717	0.7908
2.	$(3, 3.5, 4)$	$(10.5, 11, 11.5)$	$(5, 5.5, 6)$	0.0810	0.0190
3.	$(4.5, 5.5, 6.5)$	$(9.5, 10.5, 11.5)$	$(6.5, 7.5, 8.5)$	1.8968	2.4729
4.	$(6.5, 7, 7.5)$	$(8, 8.5, 9)$	$(6, 6.5, 7)$	1.1455	0.9625
5.	$(8, 8.5, 9)$	$(6.5, 7, 7.5)$	$(8, 8.5, 9)$	0.4437	0.5562
6.	$(9.5, 10.5, 11.5)$	$(4.5, 5.5, 6.5)$	$(7, 8, 9)$	2.6150	2.0056
7.	$(10.5, 11, 11.5)$	$(3, 3.5, 4)$	$(10, 10.5, 11)$	3.3352	2.8183
8.	$(12, 12.5, 13)$	$(1.5, 2, 2.5)$	$(9, 9.5, 10)$	0.4900	0.7089
			Observation errors	10.5789	10.3342

Yeh (2009b) assumed that the parameters are all real and offered $(1.7011, 0.6434, 0.1234)$. By applying Algorithm 1, we obtain

$$(\tilde{A}, \beta_1, \beta_2) = ([4.1389, 0.2996(1-t)]_{CR}, 0.4825, -0.0381).$$

Notice that, β_2 is negative (very different from Yeh's estimators). The corresponding observation errors are listed in Table 1. Our estimators are better than Yeh's.

Note that, in the aforementioned examples each independent variable is effective. In a general situation, it may happen to be ineffective. Such a case, a simple way is to solve all regression subproblems by deleting $\vec{\tilde{X}}_i$ for each i, and then compare all observation errors of these possible estimators. A more efficient method can be obtained from (Yeh, 2009b) , analogously. We omit it.

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STABILITY ANALYSIS OF EXPONENTIAL TYPE STOCHASTIC SWARMS WITH TIME-DELAY

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Abstract. *In the first part of this paper, based on the inspiration from biology, a novel Lagrangian "individual-based" isotropic/anisotropic continuous time exponential type stochastic swarming model in an n-dimensional Euclidean space with a family of attraction/repulsion function is proposed. The stability of aggregating behavior of the swarms system are verified by stability theoretical analysis and numerical simulation. Stability analysis and numerical simulations result further indicate that the individual members living in group during the course of coordinative motion can realize the mutual aggregating behavior, the motion of each individual member is a combination of the inter-individual interactions, which are also presented to demonstrate the effectiveness of our model at the same time. The attraction/repulsion function is odd, so the attractive force and repulsion force taking effect in opposite direction that leads to aggregation behavior. Numerical simulation results further indicate that the individual members of controlled intelligent agent systems living in group during the course of coordinative motion can realize the collision-eluding obstacles. Moreover, the effect of noise on collective dynamics of the swarm is also examined with a white Gaussian noise model; Meanwhile, in the second part of this paper, the stability analysis of exponential type stochastic swarms with time-delay are discussed, we can derive some relatively new valuable and significant conclusions.*
Keywords: Stochastic swarms, Stability, Aggregation, Collision avoidance, Isotropic/anisotropic, Time-delay, Lyapunov functional

1. **Introduction.** In the natural world, population appears in patterns of aggregation such as schools of fish, flocks of birds, and herds of ungulates. The details of such aggregations are important because they influence numerous fundamental processes like predator avoidance, foraging success and so on. Recently, to study the phenomena of aggregation is

an interesting topic in biology, physics and control engineering. Meanwhile, modelling and exploring the collective dynamics of swarms aggregating behavior has become an important issue in biomimicry of foraging and swarming for using in engineering applications, such as the coordinated control of multi-agent systems. However, most available results in the literature are on the isotropic non-exponential swarming model, convincing results on the exponential type swarms model are relatively few. Based on the analysis of various biological swarms of dynamic aggregation mechanism, an isotropic/anisotropic exponential type swarming dynamic model with time-delay is proposed in this paper. Dynamic change of the environment, local observation and nonlinear characteristics are ubiquitous phenomena in nature, but the study is very difficult and it has profound engineering significance.

In the individual-based (or Lagrangian) frameworks models, the basis rule is that the swarming behavior is a result of an interplay between a short-ranged repulsion and a long-ranged attraction between the individuals and interplay with environment (Gazi and Passion, 2004). Models which use forces between individuals that are analogous to physical forces, have a long history. Parr (1927) proposed the idea of mutual interactions between individuals that are composed of attractions and repulsion, designed to maintain the group as a stable mass. Breder (1951) developed this idea further by discussing the possibility of modelling attraction forces between individual fish upon classical gravitation and electromagnetism. In a later paper, Breder (1954) considered inverse power laws to model the repulsions and attractions between individuals, with repulsion stronger at short inter-individual distances. Breder compared this model to actual fish schools, to obtain realistic values for model parameters. This article is one of the very first instances of the use of attraction and repulsion biological forces, Breder proposed a simple model composed of a constant attraction and a repulsion inversely proportional to the square of the inter-individual distance. In this paper, a family of attraction/repulsion-distance functions is used to construct exponential type swarming model and stability analysis is given. Numerical simulation was used to examine the effects of each function on group cohesion, as reflected by foraging behavior. There has been a strong effort both on computational and mathematical front to model animal group behavior. The implications for aggregating animal behavior extend far beyond an understanding of animal behavior. The same laws governing animal behavior can be generalized to guide artificial machines or robots to carry out complex routines by relying only on local interactions. So this article is able to provide some results on this topic.

The paper is organized as follows. Firstly, In Section 2, we consider the stability analysis of exponential type stochastic swarms without time-delay. The main contents include following: In Section 2.1, we establish a new individual-based continuous-time isotropic exponential type aggregating swarm model. Aggregation behavior analysis of the isotropic swarms system is given in Section 2.2, and the stability in isotropic swarms system is discussed in Section 2.3. We also provide numerical simulations to verify our approach and theories in Section 2.4. Numerical results about the collision-eluding obstacles in isotropic swarms and effect of noise are given in Sections 2.5 and 2.6, respectively. In Section 2.7, we consider the influence of the random noise on the anisotropic swarms under a standard white Gaussian noise perturbation in plan social potential field profile environment. Secondly, In Section 3, we consider the stability analysis of exponential type stochastic swarms with time-delay. Finally, Concluding remarks given in Section 4.

2. Stability analysis of exponential type stochastic swarm systems without time-delay.

2.1. Model of an isotropic exponential type aggregating swarms. Mogilner, Edelstein-Keshet, Bent & Spiros (2003) propose a Lagrangian model based on attractive and repulsive potentials, to investigate the spacing of individuals in social aggregate. This is a different approach to an earlier paper, which uses an Eulerian approach. Their attractive and repulsive potential functions are formed using both exponential and power laws. The authors show (analytically and numerically) that repulsio terms must dominate attraction potentials at a short range for a well spaced biologically plausible group to form. Lyapunov function are used to evaluate equilibrium position resulting from their models.

Swarm model with isotropic exponential forces property can adapt well to environment and follow the principles of short-ranged repulsion and long-ranged attraction which are needed for realistic spacing behavior and cohesion in a group. Referring to the known results in literatures Edelstein-Keshet et al. (2003), Chen and Xu (2006), Pan et al. (2006) and Pan et al. (2008), we consider a swarm of M individuals (members) in an n-dimensional Euclidean space, assume synchronous motion and no time delays, and model the individuals as points and ignore their dimensions. The equation of collective motion of individual i is given as follows

$$\dot{x}^i = -\nabla_{x^i}\sigma(x^i) + \sum_{j=1,j\neq i}^{M} g(x^i - x^j), i = 1, \cdots, M\ . \tag{1}$$

For the convenience of discussion, where let $\nabla_{x^i}\sigma(x^i) = 0$. Then,

$$\dot{x}^i = \sum_{j=1,j\neq i}^{M} g(x^i - x^j), i = 1, \cdots, M\ . \tag{2}$$

Where $x^i \in R^n$ represents the position of individual i, $-\nabla_{x^i}\sigma(x^i)$ stands for the collective motion's direction resting with the different social attractant/repellent potential fields environment profile around individual i, $g(\cdot)$ represents the function of attraction and repulsion between the individuals members. The attraction/repulsion function that we consider is

$$g(\mathrm{y}) = \mathrm{sign(y)}[\mathrm{g_a}(\|\mathrm{y}\|) - \mathrm{g_r}(\|\mathrm{y}\|)] \tag{3}$$

$$g_a(\|\mathrm{y}\|) = \mathrm{A}\exp(-\frac{\|\mathrm{y}\|}{\mathrm{a}}) \tag{4}$$

$$g_r(\|\mathrm{y}\|) = \mathrm{R}\exp(-\frac{\|\mathrm{y}\|}{\mathrm{r}}) \tag{5}$$

Where $\|\mathrm{y}\| = \sqrt{\mathrm{y^T y}}$, y>o is distance between an interacting pair. The functions are extended to negative values of y as odd functions.

The parameters R,A>0 are magnitudes (positive constants) and r, a>0 (positive constants) are the spatial ranges of the repulsion and attraction.

Note that, in Edelstein-Keshet et al. (2003), Case (4), R>A and a>r. This is the short-ranged repulsion and long-ranged attraction case, and is the most interesting and biologically relevant: In this case, for a pair of individuals in isolation, there is a comfortable distance, s:

$$s = \frac{a}{((\frac{a}{r}) - 1)}\ln(\frac{R}{A}) \tag{6}$$

Where, $Rr^2 > Aa^2$. This condition quantifies explicitly what is meant by the assertion that repulsion has to be strong enough to prevent collapse of the group.

2.2. **Aggregation behavior analysis of the isotropic swarms system.** Discriminant analysis of the parity of the functions g(y).

Since, the sign function as follows

$$\mathrm{sign(y)} = \begin{cases} -1, & \text{if y} < 0; \\ 0, & \text{if y} = 0; \\ 1, & \text{if y} > 0. \end{cases} \tag{7}$$

Therefore, one issue to note here is that for the attraction/repulsion functions g(·) defined as above we have g(y)=-g(-y). In other words, the above g(·) functions are odd (and therefore symmetric with respect to the origin). This is an important feature of the g(·) functions that leads to aggregation behavior (Gazi and Passion, 2004). Note also that the combined term $\mathrm{sign(y)}g_a(\|\mathrm{y}\|)$ represents the actual attraction, whereas the combined term $-\mathrm{sign(y)}g_r(\|\mathrm{y}\|)$ represents the actual repulsion, and they both act on the line connecting the two interacting individuals, but in opposite directions. The vector y determines the alignment (i.e. it guarantees that the interaction vector is along the line on which y is located), the terms $g_a(\|\mathrm{y}\|)$ and $g_a(\|\mathrm{y}\|)$ affect only the magnitude, whereas their difference determines the direction (along vector y). The exponential type attraction/repulsion function g(·) as Fig.1 shows.

2.3. **The stability analysis in the isotropic swarms system.** Based on the same method and process in reference Pan et al. (2008), in this paper, we studied stability in exponential type swarms system, which is no viewed before. It's significant in the swarms to deal with practical stability.

For readers' convenience, we first introduce the practical stability of equilibrium points of swarms systems.

In spite of the stochastic noise in environment, the biological swarm is still able to harmonize the individual behavior inside the swarm to accomplish the collective task, which a single individual fails to accomplish (Grunbaum, 1998). However, most available analysis results in the literature are on the stability of the swarm system flocking behavior are all based on the determinate system model, but do not give consideration to the effect of random disturbance caused by factors such as environmental noise on the flocking behavior of the swarm system. However as far as modeling of real systems, factors like random noise must be considered (Yang and Fang, 2007). It is, in fact, convincing results on the effect of random disturbance on the dynamic behavior control of the swarm system are relatively few.

However, in reality, the motion of the swarms is inevitable subjected to noise in the environment. Hence, here we consider practical stability of the swarms with the effect of noise, which has few been studied before (Pan et al., 2008).

Consider the motion equation of individual i in the stochastic swarm system described by (Pan et al., 2006)

$$dx^i = \sum_{j=1, j\neq i}^{M} g(x^i - x^j)dt + f(x^i - \bar{x})\omega^i(t)dt \tag{8}$$

Thereupon,the formula (3) is written as

$$\begin{aligned} g(\mathrm{x^i} - \mathrm{x^j}) \quad = \quad & \mathrm{sign}(\mathrm{x^i} - \mathrm{x^j}) \\ & [A\exp(-\tfrac{\|\mathrm{x^i}-\mathrm{x^j}\|}{a}) \\ & -R\exp(-\tfrac{\|\mathrm{x^i}-\mathrm{x^j}\|}{r})] \end{aligned} \tag{9}$$

Where, g(0)=0, $\omega^i(t) \in R^n$ is the n-dimensional standard Brown motion. Define the center of the swarm members as $\bar{x} = \frac{1}{M}\sum_{j=1}^{M} x^i$.Define agent i's error vector with respect

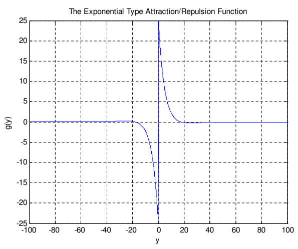

FIGURE 1. The exponential type attraction/repulsion function g(·).

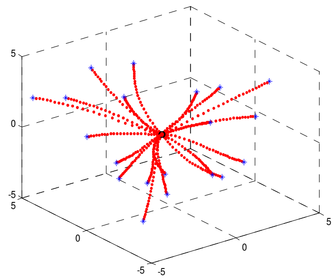

FIGURE 2. Convergent trajectories of individuals in isotropic exponential type swarm model and we used the tanh(·) function instead of the sign(·) function to smooth the motion trajectories.

to $\bar{x}$ as $e_i = x^i - \bar{x}$. It is obvious that $\bar{x} \in R^n$ and $e_i \in R^n$ (Yang and Fang, 2007). Thereupon,

$$\begin{aligned} \dot{x}^i \; = \; & \sum_{j=1, j\neq i}^{M} \{\mathrm{sign}(\mathrm{x^i - x^j}) \\ & [A\exp(-\tfrac{\|\mathrm{x^i - x^j}\|}{a}) \\ & -R\exp(-\tfrac{\|\mathrm{x^i - x^j}\|}{r})]\} \end{aligned} \tag{10}$$

Suppose that the swarm system (8) is under the influence of a permanently acting perturbation $p(x^i)$ with its bound $\|p(x^i)\| \leq \delta$, $\delta > 0$, so that the swarms system can be rewritten as

$$\begin{aligned} dx^i \; = \; & \sum_{j=1, j\neq i}^{M} g(x^i - x^j)dt + p(x^i)dt \\ & + f(x^i - \bar{x})\omega^i(t)dt \end{aligned} \tag{11}$$

Where,i=1,2,$\cdots$, M.

Now, using the stochastic swarms model, we obtain the following results as follows

Definition 2.1. *A stochastic swarm system is called practically stable, for a given positive constant estimation pair (λ, s) and some $t_0 \in R_r$, if $\|x^i(0) - \bar{x}| < \lambda$, then $\|x^i(t) - \bar{x}| < \; s$ is achieved for all $t \geq t_0$.*

Definition 2.2. *We call $Q_0 = \{x^i \| x^i(0) - \bar{x}\| < \lambda\}$ is the initial state set and $Q = \{x^i \| x^i(t) - \bar{x}\| < \; s\}$ is the permissible state set.*

Theorem 2.1. *$f^i(x^i - \bar{x}) = \lambda_i(x^i - \bar{x})$,$(0 \leq \lambda_i < 2\sqrt{\;s})$ is satisfied, swarm system (8) is practically stable with respect to t_0, Q and Q_0, where $Q = \{x^i \| x^i - \bar{x}\| < \; s\}$, $\varepsilon \simeq \sqrt{12\frac{Rr^2 - Aa^2}{R-A}} \ll s$, $t_0 = \max_i\{\, -\frac{1}{2(R-A)} \ln \frac{s^2}{2V_i(0)}\}$, where as Q_0 is unrestrained.*

2.4. **Numerical simulation results about the isotropic swarms system.** By use of the swarm dynamical model, based on artifical potential field (APF) function and Newton-Raphson iteration method, we perform simulations, numerical simulation results is as Fig.2 shows

Since,

$$\tanh(\mathrm{y}) = \frac{\mathrm{shy}}{\mathrm{chy}} = \frac{\mathrm{e^y - e^{-y}}}{\mathrm{e^y + e^{-y}}} \tag{12}$$

So, tanh(y) is odd.

One issue to note about the algorithm is that the sign function which is used in the calculation of the control inputs works well in theory. However, in practice it creates numerical problems and also cause high frequency chattering because of its discontinuous characteristic during simulations. Instead of the sign function, we used the function tanh(γ y), where γ is a smoothness parameter which determines the slope of the function around y=0 and therefore the similarity between the sign and tanh functions. The smoothness parameter in our case is chosen as γ=1 (Koksal et al., 2008).

In Fig.2, blue "*" represents original position, black "$\circ$" represents final position, red "." represents convergent trajectories of individuals.

2.5. **Effect of noise in the isotropic swarms.** So far we have not considered the effect of any external disturbances on the collective motion of the swarms. In real cases, however, the motion of a swarm is inevitably under the influence of noises or disturbances from the environment.So it is of practical interest to examine such influence on the motion of swarms. In this section we present numerical results on the effect of Gaussian white noises on the collective dynamics of the swarms considered in previous sections. So it is of practical interest to examine such influence on the motion of swarms. In this section we present numerical results on the effect of Gaussian white noises on the collective dynamics of the swarms considered in previous sections (Liu et al., 2009).

Let us add an independent random disturbance to the eqnarray of motion of each individual described by Eq.(2). The disturbed model is then described as

$$\dot{x}^i = \sum_{j=1, j\neq i}^{M} g(x^i - x^j) + \zeta^i(t), i = 1, \cdots, M \ . \tag{13}$$

Where $\zeta^i(t) \in R^n$ is the noise vector having effect on individual i.
Figs.3 shows the simulations of the swarms with Gaussian white noises perturbation. The simulations results verify that the collective motion of the disturbed swarms can withstand white noises.

2.6. **The collision-eluding obstacles in the isotropic swarms.** Based on the same simulation method, and process in reference Chen and Fang (2006), by using the isotropic exponential type swarm model, we obtain the following simulation results as shown in Fig.4 are for 100 individuals to traverse through an environment with five obstacles. Where the red balls center represent the global object position is at (78 cm, 78cm) and the simulation region is 80 cm $\times$ 80 cm in the space. The five black balls center is respectively : (35 cm, 45 cm), (48 cm, 35 cm), (52 cm, 50 cm), (50 cm, 45 cm) and (65 cm, 65 cm). The five black balls represents the obstacles in the environment. The yellow dots represent the convergent trajectories of individuals in swarm.

The results shown in Fig.4 reify our theories, in multi-obstacle environment, the individuals in the isotropic swarm during the course of coordinative motion can realizes the collision-eluding obstacles, mutual aggregating behavior and arrive at object position finally.

2.7. **The anisotropic swarms system with white Gaussian noise perturbation in plan social potential field profile environment.** The equation of motion of each individual i for different attractant/repellent profiles of artificial potential fields are given by

$$\begin{aligned} \dot{x}^i &= -\nabla_{x^i}\sigma(x^i) + \sum_{j=1, j\neq i}^{M} \omega_{ij} g(x^i - x^j) \\ &\quad + \zeta^i(t), i = 1, \cdots, M \ . \end{aligned} \tag{14}$$

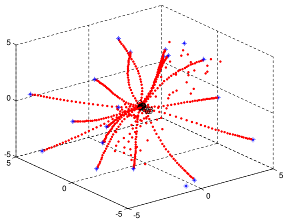

FIGURE 3. Convergent trajectories of individuals in isotropic exponential type swarm model and we used the tanh(·) function instead of the sign(·) function to smooth the motion trajectories with Gaussian white noises perturbation.

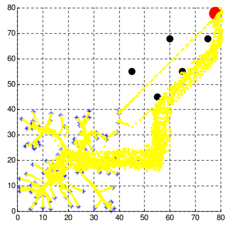

FIGURE 4. The track of the swarm in multi-obstacle environment.

Where ω_{ij} expresses the anisotropic factor affected by the positions of individual i and j in reference Gazi and Passion (2004). For the convenience of discussion, where let $-\nabla_{x^i}\sigma(x^i) \neq 0$ stands for the collective motion's direction resting with the plan social attractant/repellent potential fields environment profile around individual i, and let $\zeta^i(t) = 0$.
The simulation result in Fig.5 shows that such an anisotropic swarms model it can realize the social foraging swarms aggregation in plane social potential field environment.

3. Stability analysis of exponential type stochastic swarms with time-delay.

3.1. **The theoretical analysis.** Based on the same form theoretical deducing process in reference Li (2005), the corresponding results are obtained as follows:

3.1.1. *Model of a class of isotropic exponential type aggregating swarms with time-delay.* Let $T = \{1, 2, \cdots\}$; $T^i \subseteq T$, $i = 1, 2, \cdots, M$; $t^i \in T^i$. Which $T^i, i = 1, 2, \cdots, M$ are mutually independent, and $T^i \cap T^j = \Phi$ if $i \neq j$; $\tau^i \in T$ is the time-delay index set of individual i.

Then for individual i,

$$\begin{aligned}\dot{x}^i(t) \;=\; & \sum_{j=1, j\neq i}^{M} \{sign(x^i(t) - x^j(t-\tau_t^j)) \\ & [A\exp(-\tfrac{\|(x^i(t)-x^j(t-\tau_t^j))\|}{a}) \\ & -R\exp(-\tfrac{\|(x^i(t)-x^j(t-\tau_t^j))\|}{r})]\}, \\ & i = 1, \cdots, M \;.\end{aligned} \tag{15}$$

$$x^i(t+1) = x^i(t) + \dot{x}^i(t) \tag{16}$$

Where, $x^i(t) \in R^n$ is the position vector of individual i at time t, $x^j(t-\tau_t^j) \in R^n$ is the position vector of individual j at time t, τ_t^j is the time-delay of individual j at time t. It is due to the time-delay existing, so the actual position of individual j at time t can be written as $x^j(t-\tau_t^j)$.

Definition 3.1. *If put $x^j(t-\tau_t^j) = x^j(t) + d_t^j$, then d_t^j is called delay time step.*

Thereupon,the formula (16) is written as

$$
\begin{aligned}
\dot{x}^i(t) = & \sum_{j=1,j\neq i}^{M} \{sign(x^i(t)-x^j(t)-d_t^j) \\
& [A\exp(-\tfrac{\|(\mathrm{x^i(t)-x^j(t)-d_t^j})\|}{a}) \\
& -R\exp(-\tfrac{\|(\mathrm{x^i(t)-x^j(t)-d_t^j})\|}{r})]\}, \\
& i=1,\cdots,M\ .
\end{aligned} \tag{17}
$$

Definition 3.2. *We call* $\bar{x} = \frac{1}{M}\sum_{j=1}^{M} x^i(t-\tau_t^j)$ *is the center of the swarm systems which have time-delay.*

Theorem 3.1. *The center* $\bar{x} = \frac{1}{M}\sum_{j=1}^{M} x^i(t-\tau_t^j)$ *of the swarm is stabilized in anytime* t.

Proof: Omit.

Hereinafter $\bar{x}(t)$ abbrevd $\bar{x}$, and define agent i's error vector with respect to $\bar{x}$ as $e_i(t) = x^i(t) - \bar{x}$.

3.1.2. *Motion situation analysis of one-dimensional isotropic exponential type aggregating swarms with time-delay.*

Theorem 3.2. *On the basis of the formula (17) and formula (18), the resulting system which satisfies condition* $\|x^i(t)-x^j(t)\| > s$ *and* $\|e_i(t)\| > s$ *(Note: s is balance distance), if the delay time step* d_t^j *satisfy the requirement of* $(M-\frac{2}{u}) < \frac{\sum_{j=1}^{M} d_t^j}{e^i(t)} < M$, *in which* $u = A\exp(-\frac{\|\mathrm{s}\|}{a}) - R\exp(-\frac{\|\mathrm{s}\|}{r})$. *Then, the individual member i will move to the center of the swarm.*

3.1.3. *Motion stability analysis of n-dimensional isotropic exponential type aggregating swarms with time-delay.*

Theorem 3.3. *On the basis of the formula (17) and formula (18), the resulting system of n-dimensional aggregating swarms which satisfies condition* $\|x^i(t)-x^j(t)\| > s$ *and* $\|e_i(t)\| > s$ *(Note: s is balance distance), also* $MA\exp(-\frac{\|\mathrm{s}\|}{a}) < 1$, *if the delay time step* d_t^j *satisfy the requirement of* $\sum_{j=1}^{M} |d_t^j| < \frac{Mu}{A\exp(-\frac{\|\mathrm{s}\|}{a})}|e_i(t)|$, *in which* $u = A\exp(-\frac{\|\mathrm{s}\|}{a}) - R\exp(-\frac{\|\mathrm{s}\|}{r})$. *Then, the individual member i will move to the center of the swarm.*

Theorem 3.4. *On the basis of the formula (17) and formula (18), the resulting system of n-dimensional aggregating swarms which satisfies condition of the theorem 3.3., as far as all the* $t^i \in T^i$ *is concerned, which has the corresponding result* $\lim_{t\to\infty} |e^i(t)| = s$.

Proof: Omit.

Special case If all the individual members of the swarm has the same delay time step at time t, namely, $\tau_t^i = \tau_t$, then, according to the above-mentioned theorem 3.3., we can deduce the following conclusion.

Corollary 3.1. *On the basis of the formula (17) and formula (18), as far as all the* $t^i \in T^i$ *is concerned, the resulting system of n-dimensional aggregating swarms which satisfies condition* $\|x^i(t)-x^j(t)\| > s$ *and* $\|e_i(t)\| > s$ *(Note: s is balance distance), also* $MA\exp(-\frac{\|\mathrm{s}\|}{a}) < 1$, *if the delay time step* d_t^j *satisfy the requirement of* $|d_t^j| < \frac{A\exp(-\frac{\|\mathrm{s}\|}{a}) - R\exp(-\frac{\|\mathrm{s}\|}{r})}{A\exp(-\frac{\|\mathrm{s}\|}{a})}|e_i(t)|$. *Then, the individual member i will move to the center of the swarm.*

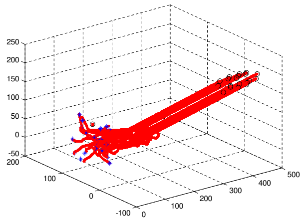

FIGURE 5. Convergent trajectories of anisotropic swarms of considering individuals' dimensions in plane social potential field.

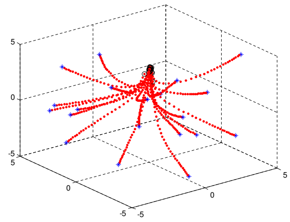

FIGURE 6. Convergent trajectories of individuals in isotropic exponential type stochastic swarms with time-delay and we used the $\tanh(\cdot)$ function instead of the $\text{sign}(\cdot)$ function to smooth the motion trajectories.

Proof: Omit.

Theorem 3.5. *On the basis of the formula (17) and formula (18), as time progresses all the individual members of the swarm will converge to a hyperball $B_\varepsilon(\overline{x})$ in finite time bounded by t_0.*
Where
$B_\varepsilon(\overline{x}) = \{x : \|x - \overline{x}\|\} \leq \varepsilon,$
$t_0 = \max_i\{ -\frac{1}{2(R-A)} \ln \frac{s^2}{2V_i(0)}\},$
$\varepsilon = \frac{r_2+r_3}{r_1},$
$r_1 = MA\exp(-\frac{\|s\|}{a}),$
$r_2 = R(M-1)\exp(-\frac{\|s\|}{r}),$
$r_3 = A\exp(-\frac{\|s\|}{a}) \sum_{j=1,j\neq i}^{M} sign(d_t^j).$

3.2. **Simulation examples.** Simulation examples are provided in this section in order to illustrate the operation of the model of exponential type stochastic swarms with time-delay. We chose either $n = 2$ or $n = 3$ for the simulation for easy visualization. However, note that the result hold for any n-dimensional Euclidean space.

In Fig.6, blue "*" represents original position, black "$\circ$" represents final position, red "." represents convergent trajectories of individuals. Numerical results for the swarms model with time-delay show that it has a very good convergence and a high precision.

As one can see, the individual form a cohesive cluster (around the center) as predicted by the theory. Our theorems and its the beneficial conclusions improve and generalize the corresponding results in reference Li (2005).

4. **Conclusion.** In the first part(namely, section 2: from section 2.1 to section 2.7) of this paper, based on the inspiration from biology, we consider an isotropic/anisotropic exponential type swarm model of aggregating for multi-agent system. The model is a kinematic model, meanwhile, it is fit for individuals which move basing on the Newton's law in an environment can capture the basic convergence properties of biological populations in nature. Therefore, the final behavior of the isotropic/anisotropic swarms described by the model may be in harmony with real biological swarms well. The simulation results in this paper confirm that the stability of aggregating behavior of the isotropic/anisotropic exponential type swarm systems. Furthermore, the aggregating results obtained in the isotropic/anisotropic exponential type model which has a definite reference value in the multi-agent coordination and control literature. Numerical simulation experiments show

that the model can guarantee collision avoidance in the isotropic/anisotropic swarms in stochastic noise environment. We also analyze the isotropic swarms which global asymptotic stability properties for without or with Gaussian white noises perturbations, and analyze the anisotropic swarms which social foraging aggregation behavior in plane social potential field environment. The study to practical stability in the swarms system is a practical significant topic. The isotropic/anisotropic exponential type swarm model proposed here is simple and possible for future extensions, which can be further extensions for different perturbations under the different social attractant/repellent potential field profile environment. Numerical simulations experiments also reify the capabilities of the proposed models, approach and relevant theories. In the second part(namely, section 3)of this paper, we mainly discuss the Stability analysis of exponential type stochastic swarms with time-delay, based on the theoretical analysis and simulation results in this section, some relatively new valuable and significant conclusions are obtained.

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RESEARCH ON SOLVING PROFIT PROBLEM IN SMALL AND MEDIUM SIZED PROPERTY INSURANCE COMPANY

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ABSTRACT. *In this pap er, property and casua lty insura nce companies' profit are from the four main areas as a starting point, in-depth analysis of the small and medium sized property and casua lty insur ance co mpany making profits in t he thre e m ajor steps. Combined w ith cases, po inted out : 1 .Underwriting ma nagement by t arget market segments is th e first key step; 2.The establ ishment of "E QC" (efficiency, qual ity, co st) claims m anagement mo del i s the seco nd key step ; 3 .The es tablishment of a " quarter" method of budget management system is the third key step. Further more, this paper also present some institutional recommendations to make the small and medium sized property and casualty insurance companies in a sustainable development.*

Keywords: Property and Casualty Insurance; Losses; Profit; Underwriting Components; Claims Components; Cost Components

1. The Whole Property and Casualty Insurance Industry Has Been into Losses. From 1999 to 2009 is the Golden Decade for the great development of property and casualty insurance. In 1999, the insurance industry realized a total income of 52.112 billion Yuan of property and casual ty insurance premiums, in 2009 this figure reached 287.583 billion Yuan. However, in the recent years, the whole industry has been into losses. How to make profit, especially the small and medium sized property and casualty insurance companies, is an important issue facing the insurance industry. For a long time, there was a "three year odd cycle" in property and casualty insurance industry, that is prosper in first year, rich in second year and loss in third year. This cycle, also led the industry to form such a mindset, a new property and casualty insurance company must be in loss for the first three years. Opening of the new property insurance companies are basically small scale, this also means that small and medium sized property and casualty insurance campanies are the bulk of losses of the property insurance industry. First half of 2009, property insurance industry as a whole loss of 540 million Yuan, of which over 7.8 billion is underwriting loss.

2. Chinese Small and Medium Sized Property Insurance Company Profit Model.

2.1. Analysis on the "Three Year Odd Cycle". First, it is attributed to the unreasonable development strategy. Many companies who paid more attention to scale than benefit, taking scale as markers, misleading front-line agencies do not attach importance to quality of business, resulting in rapid expansion of institutions, over-development, risks continue to accumulate during this process and there is no time and means to resolve, eventually lead to crisis, the case China United Property Insurance Company Limited be inadequate solvency is just a good lesson to the new small and medium sized property insurance company.

Secondly, are the homogeneous products. According to statistics, motor vehicle insurance premiums is accounting for 70% of insurance premium income. However, motor vehicle insurance product is awarded re unification provisions, there was not much competition in individual terms, and then the competition focused on rates, now the auto insurance is a field of over-competition, there is no benefit at all, the same problems is also spreads to the other major traditional property insurance products, such as business property insurance and cargo insurance and so on.

Thirdly, is to ignore the main business operators, underwriting profit turned to investors profit. Previous years, based on the explosive growth of capital markets, the cash flow underwriting philosophy began to be respected, in the past, the companies is emphasis on underwriting profit and now they rely on investment returns, However, capital market downturn in recent years, making a significant decline in investment income, investment income can not cover an underwriting loss.

2.2. The Main Profit Links of Property Insurance Companies. Proved, small and medium sized property insurance company that is in line with previous thinking, "to scale for efficiency", will be impossible to achieve sustainable development. We must change the past, relying solely on profit return on investment model, and strengthen the management of insurance business and lower operating costs to improve business performance. This is the realistic choice for property insurance company.

The profits of insurance companies are mainly from four areas: investment income areas, underwriting areas, claims link and cost control link.

For investment income areas, because of its high dependence on capital markets, can not guarantee a stable and effective high yield. I think: insurance companies should return to core business operations, and make a good control in three links of underwriting, claims and cost control to achieve an underwriting profit.

3. Three Key Steps for Small and Medium Sized Property and Casualty Insurance Companies to Make Profit.

3.1. The First Key Step-Underwriting Management by Target Market Segments. Underwriting is the first pass，in this first pass, to shut out the potential loss business, underwriting business of good quality, which needs around managing the development and target market segments, establishing different customers types of risk underwriting management. This can be divided into internal and external two aspects:

3.1.1. The External Aspect-According to the Probability of Dangerous Condition to Classify Different Customers, and Adopt Different Customers with Different Risk Underwriting Management. For example, Sunshine Property and Casualty Insurance issued a set of underwrite management mode called “Red, Yellow & Blue”. Blue stands for VIP client, Yellow is elementary clients, Red is risk clients. This mode is mainly used to subdivide the existing clients, on the basis of “from vehicle, from people, from region” and according to the different claim probability in the classified to the clients as “Red & Yellow & Blu e” three lev els. Sun shine In surance analyzed two sets of date acc ording to a l arge number o f statistics, “claim p robability o f th e ta rget market is 4 .61%, an d the no n-target market is 10.59%; loss ration of the target market is 39.86%, while the non-target market is 66.81%; t here’s the m aximum 50% on a verage loss ra tion between ta rget m arket a nd non-target market. Centering on the de velopment a nd s ubdivide target m arket, S unshine Insurance divided Car insurance into red, blue and yellow. Red car insurance is high claim probability, high loss ration, it’s a kind of loss service. Yellow car insurance is high claim probability, loss ration can be controlled, and it’s a kind of service between profit and loss. While blue ca r insura nce is low cla im p robability, l ow loss ra tion, it’ s a kind of cost-effective service. Com panies ce ntre o n resource allocation to pr omote positively develop blue ser vice a nd restrict red s ervice. In 2 007, S unshine Pro perty a nd Ca sualty Insurance real ized accoun ting profits t wo years in adv ance, b roke th e “three y ear odd c y c l e ” o n p r o p e r t y i n s u r a n c e c o m p a n y .

3.1.2. The Ins ide Aspect- the Company Should Build up a Se t of Standard Ac cept Insurance Management Pr ocedure, to Insure the Authe nticity and Accuracy o f the Insurance Data. We still take the Sunshine Property and Casualty Insurance example. The company built a se t of sta ndard underwriting m anagement procedures. If clie nts wa nt to underwrite, we should do it on the basis of standard and specification, or it’ll be no use. On the check insurance management system, it should adopt cascade decision-making authority, based on d ifferentiation management, strengthen e nforcement ef forts in departments a nd staff at all levels. Sunshine Insurance Henan Branch based on developing and subdividing target m arket m anagement t o set up the i nsurance m anagement m ode of different clients and r isk types. Sunshine I nsurance He nan Branch e arned premium income a s m uch as 321.85 million in 200 7 an d 356 .95 m illion in 2008. Wh ile the administration cost rate i s 100.16% and 94 .80% respectiv ely. Using th is method, Hen an Bran ch got sign ificant benefits in the first 2 years.

3.2. The Seco nd Key Step-"EQC" (Efficiency, Quality and Cost) Claims Management Mode. Claims cost are the largest cost for companies operating in the property and casualty companies. The key step is ho w to m anage compensate? Property companies should build "EQC" (efficiency, quality and cost) claims management mode to compensate. Mainly the mode is divided into two aspects:

3.2.1. Comprehensive E valuation Syst em. The evaluation of cl aims e ffect sho uld be a comprehensive evaluation system, this m eans the bad o r good ef fect evaluation claims management should be changed to “EQC” these three aspects to comprehensive evaluation instead of the previous single hand (such as efficiency or quality or cost);

3.2.2. Qu antified Standards. According t o EQC , setti ng standard for the clai ms jo b, setting formulate specific r equirements, the qu antitative evalua tion o f the job ro le play controls; Recently, such as its "link in the claims EQC" claims management mo de, mainly from three aspects of t he e valuation re sult c laims management. A nd each position t o formulating relevant standards, specific requirements and performance quantification, very good control effect plays. By December 2009, restores the property division, 17 claims range in AB insurance, 12 interval fluctuated.

3.3. The Third Key Step--Establishment of Budget Management, "Four Quarter" Method Management System. From the point of view of the cost link in property insurance company, one of the most important financial indicators are combined ratio in insurance companies, the indicator can be objectively reflect the company's operating costs of the integrated control capability, management and professional level of fine important performance reflected. The current general insurance industry, "two half" cost accounting system, making the "change fee" of a gray area for a long time, the industry has become "the cost of promoting the development of path dependence," This accounting treatment is the cost of packaging concept insurance companies is difficult to achieve a fair cost. For the cost of property insurance sectors, we have to establish budget management, "four quarter" method management.

Many international property insurance companies uses a quarter of the cost of budget management control mechanisms, which are cost of sales, management costs, operating costs and compensation cost of the "four quarter ". For example, Ping An Property & Casualty leads in establishing a quarter of the cost management and control mechanism, which are cost of sales, management costs, operating costs and compensation cost, through the right insurance, market, institutional differentiation inputs to play into the cost of leverage. But now the world's largest medical insurance and finance companies: CIGNA Group (Cigna) using in-house "four quarter ", is the market cost in classified acquisition costs will be divided into the cost of acquisition costs, compensation costs, operating costs and management costs four categories, from risk control and financial point of view, this kind of "four quarter " is more scientific.

For example, in January 2009 the Sunshine Property & Casualty company also draws on CIGNA Property & Casualty Group (Cigna) "4 quarter ", also experimented with "criss and cross," but which is different from Ping An company is that their marketing costs will be included in acquisition cost where the cost is divided into acquisition costs, compensation costs, operating costs and management costs four categories, "through the detailed management on the fine cost, it will be clearly ensuring the responsibility and facilitating the centers to examine and implement dual control process. It is reported that the whole process through the implementation of all aspects of budget management, property insurance comparable caliber of Sun Property & Casualty Company is under a 30% decline in fixed costs. As of the first quarter of 2009, the combined ratio remained at less than 100%, combined ratio can be shoulder to shoulder along good control property and casualty insurance peers like the Pacific.

4. More opinions. In addition to these have been discussed several aspects, small and medium sized property insurance company should do more to make profit. Such as involving insurance products to meet market demand, providing a full range insurance services. At the same time, insurance regulators is also facing the difficult task that to promote market more market-oriented.

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SOLVING A SINGLE-MACHINE SCHEDULING WITH THE SUM-OF PROCESSING- TIMES-BASED LEARNING AND RELEASE TIMES BY SIMULATED ANNEALING ALGORITHMS

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ABSTRACT. *Scheduling with learning effect has received considerable attention recently. However, research with learning and release times is relatively unexplored. Motivated by this limitation, in this paper we address a single-machine problem with the sum-of processing-times-based learning and release times where the objective is to minimize the makespan. Since the same problem without learning consideration has been shown as NP-hard one in the strong sense, thus we attempt to propose three simulated annealing heuristic algorithms for near-optimal solutions. The computational experiments show that the performance of the simulated annealing algorithm is good.*

Keywords: Scheduling; Learning Effect; Release Time; Simulated Annealing; Makespan; Single-Machine

1. Introduction. Scheduling with learning effect has received considerable attention recently. Biskup (1999), Cheng and Wang (2000) are among the pioneers that brought the learning effect into the scheduling field. Since then, many researchers have devoted attention on the relatively young but vivid area. Biskup (2008) further provided a comprehensive survey of scheduling problems with learning effects. In particular, he emphasized that as there is a significant involvement of humans in scheduling environments, the amount of learning activities is high. Hence it seems to be reasonable to consider learning in scheduling environments.

Recently, Cheng et al. (2008) introduced a new scheduling model in which both job deterioration and learning exist simultaneously. The actual processing time of a job depends not only on the processing times of the jobs already processed but also on its scheduled position. Janiak and Rudek (2008) brought a new model of the learning effect into the scheduling field that relaxed the rigorous constraints of the position-dependent approach by assuming that each job can provide different experiences to the processor. Xu et al. (2008) developed heuristic algorithms with tight worst-case bound for the flow shop scheduling with a learning effect and regular objective functions, such as the total weighted completion time, the discounted total weighted completion time, and the sum of the quadratic job completion times. Eren and Guner (2008) considered a two-machine flowshop learning scheduling problem where the objective is to minimize a weighted sum of total completion time and makespan. They used an integer programming model for the optimal solution, and a heuristic algorithm and a tabu search based heuristic algorithm to solve large size problems. Wang and Liu (2009) studied a two-machine total completion time flow shop scheduling problem with the effects of deterioration and learning. They gave some polynomially solvable special cases, and developed an exact and a heuristic algorithm for the problem. Yin et al. (2009) developed a general model with learning effects where the actual processing time of a job is not only a function of the total normal processing times of the jobs already processed, but also a function of the job’s scheduled position. In addition, Toksari and Guner (2009) addressed earliness/tardiness (ET) scheduling problem on a parallel machine environment with common due-date under the effects of time-dependent learning and linear and nonlinear deterioration. By the effects of learning and deterioration, they assumed that the processing time of a job is defined by increasing function of its execution start time and position in the sequence.

More recently, Wang et al. (2010) considered the single machine scheduling problems with exponential sum of logarithm processing times based learning effect. Xingong and Guangle (2010) proposed a new group scheduling with deteriorated and learning model where the learning effect not only depends on job position, but also depends on the group position; the deteriorated effect depends on its starting time of the job. Cheng et al. (2010) introduced a new scheduling model in which job deterioration and learning, and setup times are considered simultaneously. Yin et al. (2010) brought into the scheduling field a general learning effect model where the actual processing time of a job is not only a general function of the total actual processing times of the jobs already processed, but also a general function of the job’s scheduled position. Toksari et al. (2010) investigated several single machine scheduling problems under the joint effects of nonlinear job deterioration and time-dependent learning.

However, research with learning and release times is limited. To the best of our knowledge, Bachman and Janiak (2002) proved the makespan single-machine job position-based learning problem is NP hard in the strong sense, and Lee et al. (2009) further provided exact and heuristic algorithms for the problem. Eren (2009) considered a single machine scheduling problem with unequal release dates and a position-based learning where the objective is to minimize the total weighted completion time. He developed a non-linear mathematical programming model for the problem. Moreover, Monch et al. (2005) claimed that in Wafer fabrication, the first step in semiconductor manufacturing was characterized by hundreds of steps, re-entrant flows, sequence- dependent setups, diversity of product mix and batch processing. This complexity combined with meeting customer due dates with different priorities—an important criterion for customer satisfaction—is a difficult challenge. In addition, the jobs to be processed have different priorities/weights, due dates and ready times. In the presence of unequal ready times, it is sometimes advantageous to form a non-full batch, while in other situations it is a better strategy to wait for future job arrivals in order to increase the fullness of the batch. In addition, the studies which are mentioned above focus on position-based learning. Motivated by this observation, in this paper we consider the single-machine makespan problem with sum of processing times-based learning and release times.

The rest of the paper is organized as follows. In the next section, the description of the problem formulation is given. In Section 3, the simulated annealing heuristic algorithm is provided. The results of a computational experiment are given in Section 4. Conclusions are given in the last section.

2. Notation and Problem Formulation. The formulation of the proposed problem is as follows. There are n jobs to be scheduled. Preemption is not allowed and the machine is only able to process one job at a time. Each job j has a normal processing time p_j, and a release time r_j. The actual processing time of job j is $p_{jr} = p_j(1-\sum_{l=1}^{r-1} p_{[l]}/\sum_{l=1}^{n} p_l)^a$ if it is scheduled in the rth position where $a \geq 1$ is a learning ratio common for all jobs, where the original model is proposed by Koulamas and Kyparisis (2007), but it does not involve release times. The main objective of this paper is to find an optimal schedule S^* to minimize the makespan, i.e.

$$C_n(S^*) \leq C_n(S) \tag{1}$$

for any schedule S.

3. Simulated Annealing Algorithm. Lenstra et al. (1977) pointed out that this problem is strongly NP-Hard even without learning consideration. Thus, we will develop a beta-heuristic algorithm for the near-optimal solution--Simulated annealing. Simulated annealing (*SA*) , proposed by Kirkpatrick et al. (1983), is one of the most popular meta-heuristic methods widely applied to solve combinatorial optimization problems. This approach has the advantage of avoiding getting trapped in a local optimum. This is due to the hill climbing moves, which are governed by a control parameter. In the following we utilize the *SA* approach to derive near-optimal solutions for our problem. We apply three *SA* algorithms as follows:

Step 1: Initial sequence. We use three initial sequences for the four *SA* algorithms. In SA_1, jobs are arranged in the SPT order of processing times, while in SA_2, jobs are arranged in a non-decreasing order of ready times. In SA_3, jobs are arranged in non-decreasing order on the values of the sum of processing times and ready times of the jobs, i.e., $p_i + r_i$.

Step 2: Neighborhood generation. Neighborhood generation plays an important role in the efficiency of *SA*. We use the pairwise interchange (PI) neighborhood generation method in the algorithms.

Step 3: Acceptance probability. When a new sequence is generated, it is accepted that its objective value is smaller than that of the original sequence; otherwise, it is accepted that some probability decreases as the process evolves. The probability of acceptance is generated from an exponential distribution,

$$P\left(accept\right) = \exp\left(-\alpha \times \Delta C_{\max}\right),$$

where α is a control parameter and $\Delta C_{\max}$ is the change in the objective value. In addition, we use the method suggested by Ben-Arieh and Maimon (1992) to change α in the kth iteration as follows:

$$\alpha = \frac{k}{\beta},$$

where β is an experimental constant. After preliminary trials, we used $\beta = 5$ in our experiments. If the makespan increases as a result of a random pairwise interchange, the new sequence is accepted when $P(accept) > r$, where r is randomly sampled from the uniform distribution U(0, 1).

Step 4: Stopping condition. Our preliminary trials indicated that the quality of the schedule is stable after 200*n* iterations, where n is the number of jobs.

4. Computational Experiment. A computational experiment was conducted to evaluate the accuracy of the simulated-annealing algorithms. The algorithms were coded in Fortran and run on Compaq Visual Fortran version 6.6 on a Intel(R) Core(TM)2 Quad CPU 2.66GHz with 4GB RAM on Windows Vista. The experimental design followed Reeves (1995) design. The job processing times were generated from a uniform distribution over the integers between 1 and 20 in every case, while the release times were generated from a uniform distribution over the integers on $(0,\ 20n\lambda)$ where n is the number of jobs

For the three simulated annealing algorithms, the mean and the maximum error percentages were recorded, where the error percentage was calculated as

$$(SA_i - C^*_{\max}) / C^*_{\max} * 100\%,$$

where SA_i is the makespan obtained from the ith simulated-annealing algorithm and $C^*_{\max}$ is the makespan of the optimal schedule. The computational times of the heuristic algorithms were not recorded since they were finished within a second.

The computational experiment consisted of four parts. In the first part of the experiment, we want to explore the values of cooling control variable and the number of trials by using 100 instances. The number of jobs (n = 15) and $\lambda = 0.5$ were tested in the heuristic algorithms. The learning effect, denoted by a, took the values of 1.001, 1.01 and 1.1. (If the learning effect took values greater than 1.1, then the job processing time would approach zero very fast. Therefore, it was set to take values no more than 1.1.) As shown in Figure 1 and Figure 2, the performance of SA is better when the values of β and repeated number were fixed at 5 and 200n.

In the second part of the experiment, we want to explore the performance of SA over changing the values of λ. The number of jobs (n = 15) and $\lambda = 1/15$, 2/15,…,1 were tested in the heuristic algorithms. 100 instances for each case were tested. Thus, 1500 instances were tested in this part. As shown in Figure 3, we observed that the performance of SA is getting better as the value of λ becomes larger. As the effect of learning, the performance of SA is better at a=1.001 and 1.01. However, the situation is declining as the value of λ is getting larger.

In the third part of the experiment, fixed at a=1.1, we want to investigate the differences between the performances of all three SAs over changing the values of λ. The number of jobs (n = 15) and $\lambda = 1/15$, 2/15,…,1 were tested in the heuristic algorithms. 100 instances for each case were tested. Thus, 1500 instances were tested in this part. As shown in Figure 4 and Table 1, the performance of all SAs with larger ready times is better than those with smaller ones. However, there is no absolute dominance among all three SAs. Thus, we further consider combining them into one.

In the final part of the experiment, we want to test the performance over different job sizes. The number of jobs (n = 15, 20, 25) were tested in the heuristic algorithms. The learning effect, denoted by a, took the values of 1.001, 1.01 and 1.1. Five different sets of problem instances were generated by assigning λ the values of 1/n, 0.25, 0.5, 0.75, and 1. As a consequence, 45 experimental situations were examined. A set of 100 instances were randomly generated for each situation. The results are presented in Table 2. Out of the 45 evaluations, the number of times that each of the objective functions of the SA_1, SA_2, and SA_3 algorithms takes the smallest mean error percentage are 18,14, and 13, respectively. All of the mean error percentages of the SA_1, SA_2, and SA_3 algorithms are less than 0.7367, 0.7713, and 0.7301. In addition, their performances are not affected as the values of learning rate or release times vary. The worst cases of the algorithms were 7.5788%, 7.8371%, and 9.0985%, respectively. The combination of the first three heuristics brings down the mean error percentage and the worst case error by more than 0.2386% and 5.5636%, respectively. Thus, the combined algorithm is recommended.

5. Conclusions. In this paper, we explored a single-machine makespan problem where the job processing times decrease functions of their already processed jobs and each job has its release time. Since the same problem without learning consideration has been shown as NP-hard one in the strong sense, we proposed three SA heuristic algorithms to obtain a near-optimal solution. The computational results showed that the performance of the combined SA algorithm is very accurate.

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Appendix.

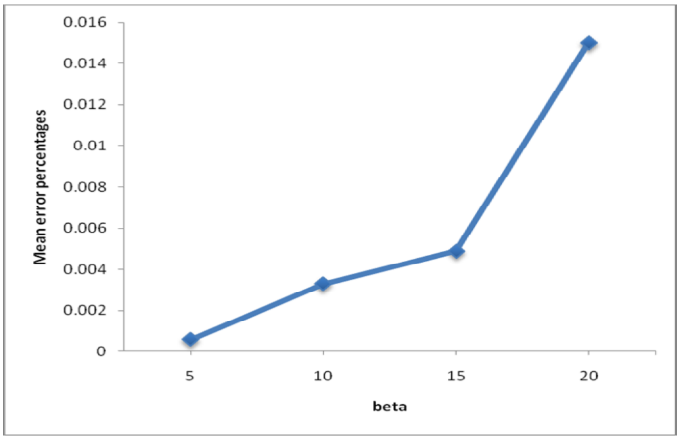

FIGURE 1. The performances of the combined SA over different beta

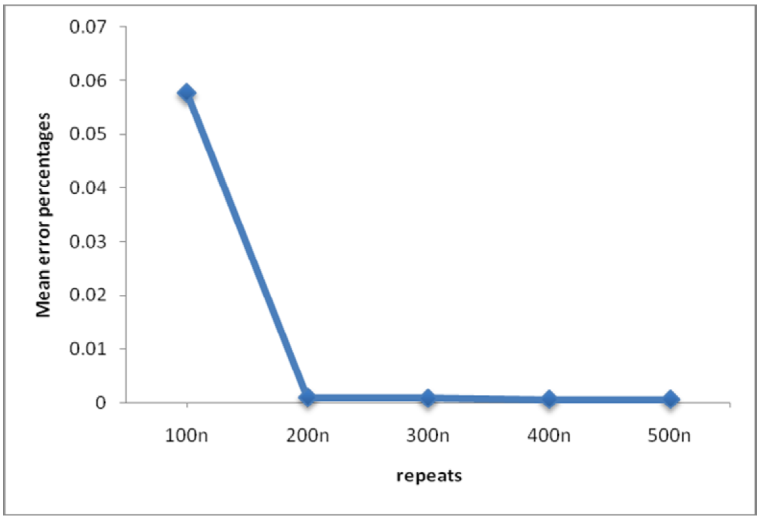

FIGURE 2. The performance of the combined SA over different trials

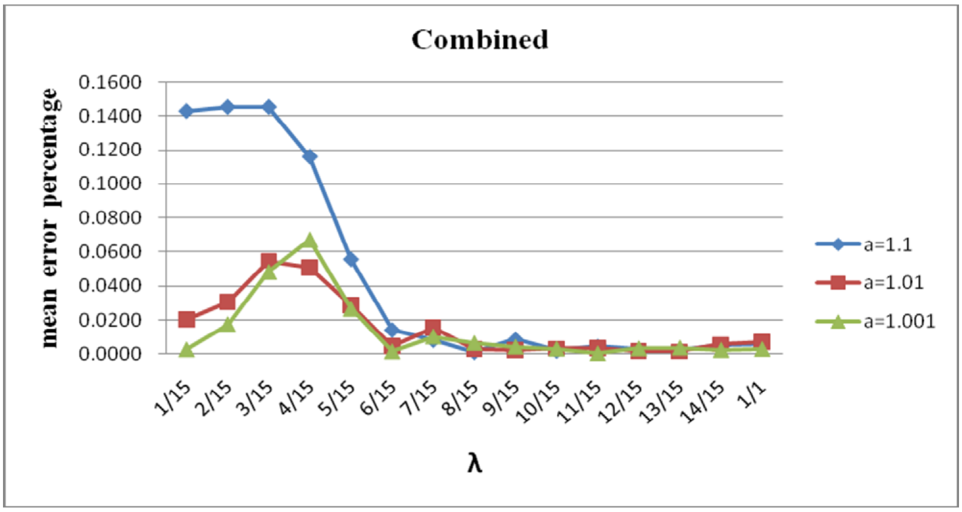

FIGURE 3. The perforamnces of the combined SA over different rates and learning effects

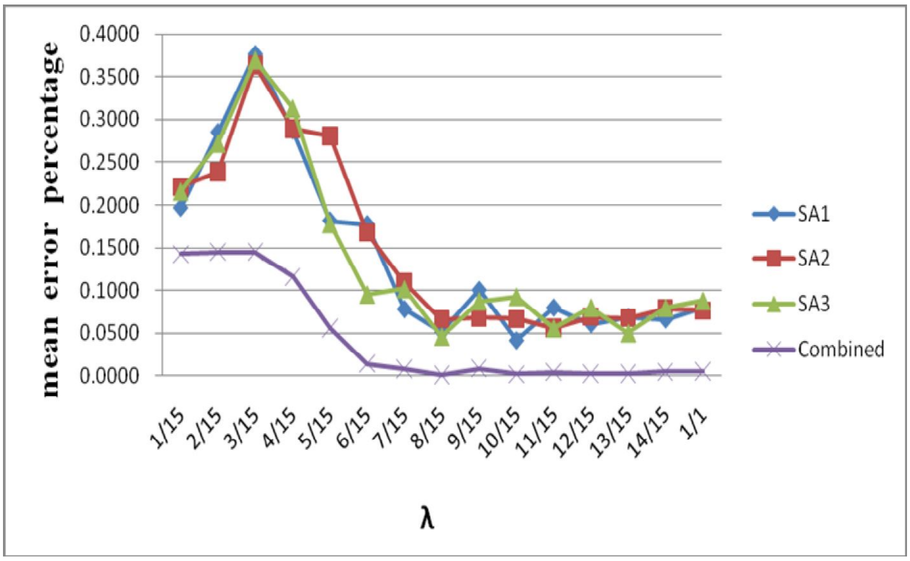

FIGURE 4. The performances of ll proposed Sas over rates of ready times

TABLE 1. The performances of all proposed Sas overdifferent rats of ready times

	SA_1		SA_2		SA_3		Combined	
	Error percentage							
λ	mean	max	mean	max	mean	max	mean	max
1/15	0.1966	0.3884	0.2213	1.3377	0.2158	1.3750	0.1427	0.3090
2/15	0.2850	2.5007	0.2387	3.0694	0.2719	2.5653	0.1451	0.2962
3/15	0.3761	6.2306	0.3637	5.7186	0.3693	5.6421	0.1451	1.2258
4/15	0.2870	5.0988	0.2895	4.8979	0.3128	6.2462	0.1159	2.5412
5/15	0.1817	5.2560	0.2807	5.3314	0.1777	1.8263	0.0558	0.8898
6/15	0.1774	9.2071	0.1675	2.4669	0.0955	1.5111	0.0143	0.4410
7/15	0.0781	1.5471	0.1094	2.7439	0.1017	1.5777	0.0083	0.1758
8/15	0.0515	0.8684	0.0665	0.9805	0.0462	0.5987	0.0012	0.0463
9/15	0.1005	1.6496	0.0684	0.8370	0.0876	1.6165	0.0088	0.4306
10/15	0.0416	0.6384	0.0666	0.7058	0.0929	1.1938	0.0020	0.0894
11/15	0.0799	0.9053	0.0558	0.6435	0.0561	0.8098	0.0046	0.1234
12/15	0.0609	0.7443	0.0693	0.8222	0.0802	1.2290	0.0028	0.0956
13/15	0.0690	0.9746	0.0678	0.8235	0.0504	0.8306	0.0024	0.1104
14/15	0.0660	0.5866	0.0791	0.8580	0.0800	0.8318	0.0050	0.1717
1	0.0802	0.8295	0.0764	0.7320	0.0882	0.8333	0.0058	0.1551

TABLE 2. The performances of all proposed Sas over different job sizes

n	a	λ	SA_1		SA_2		SA_3		Combined	
			Error percentage							
			mean	max	mean	max	mean	max	mean	max
15	1.100	1/n	0.2110	1.4616	0.2186	1.4993	0.2153	1.5528	0.1472	0.3089
		0.25	0.2838	5.4492	0.3016	6.3666	0.2603	3.0659	0.1371	2.6947
		0.50	0.0804	0.7888	0.0776	3.2593	0.0856	2.0687	0.0101	0.5219
		0.75	0.0812	1.7367	0.0523	0.5631	0.0657	1.0715	0.0068	0.2072
		1.00	0.0622	0.5959	0.0676	0.6748	0.067	1.0962	0.0062	0.1468
	1.010	1/n	0.0638	1.5596	0.0767	2.8036	0.0920	3.3125	0.0183	0.0500
		0.25	0.1543	4.7721	0.1226	1.9368	0.1712	3.9740	0.0615	1.9348
		0.50	0.0636	1.7115	0.1179	1.7100	0.0847	1.0727	0.0086	0.3050
		0.75	0.0530	0.9007	0.0797	1.3481	0.0822	0.7956	0.0013	0.1060
		1.00	0.0620	1.0002	0.0933	1.2623	0.0623	0.5815	0.0034	0.1443
	1.001	1/n	0.0147	0.9749	0.0252	1.1578	0.0520	1.5055	0.0029	0.0335
		0.25	0.2241	5.5082	0.2645	4.2840	0.1868	5.0286	0.0315	1.1313
		0.50	0.0810	1.1119	0.0659	1.1124	0.0495	0.4609	0.0009	0.0569
		0.75	0.1357	1.0814	0.0673	0.5222	0.0608	0.8477	0.0113	0.3708
		1.00	0.1003	1.0534	0.0731	1.2859	0.0572	0.6896	0.0070	0.3914
20	1.100	1/n	0.2115	1.2657	0.2127	3.2192	0.1994	1.2982	0.1382	0.2599
		0.25	0.7183	7.5788	0.6758	7.5374	0.5856	6.1727	0.2105	2.3940
		0.50	0.0552	0.4822	0.0357	0.8198	0.0485	0.5615	0.0019	0.1343
		0.75	0.0621	0.5064	0.0465	0.3568	0.0559	0.5026	0.0037	0.1603
		1.00	0.0808	0.4926	0.0766	0.6796	0.0640	0.8607	0.0053	0.1187
	1.010	1/n	0.0358	0.8896	0.0469	0.9117	0.0289	0.8796	0.0170	0.0558
		0.25	0.5720	5.1929	0.4237	5.9738	0.6372	5.1928	0.1943	3.0895
		0.50	0.0475	0.5210	0.0571	1.0334	0.0509	1.0335	0.0004	0.0249
		0.75	0.0527	0.6060	0.0536	0.9343	0.0533	0.6753	0.0055	0.3311
		1.00	0.0650	1.0296	0.0619	0.3855	0.0659	0.7452	0.0083	0.2491
	1.001	1/n	0.1097	2.9256	0.0730	2.9255	0.0847	2.9256	0.0470	2.9255
		0.25	0.4925	6.8433	0.3584	5.6143	0.4410	6.3394	0.1057	3.1487
		0.50	0.0620	1.4938	0.0731	1.0666	0.1109	4.7365	0.0171	1.0666
		0.75	0.0327	0.5594	0.0582	0.7394	0.0580	0.8965	0.0040	0.1684
		1.00	0.0611	0.5794	0.0684	0.7380	0.0528	0.3855	0.0042	0.0943
25	1.100	1/n	0.1998	1.6902	0.1709	1.1134	0.1601	1.0491	0.1300	1.0436
		0.25	0.4418	4.2274	0.6104	7.9790	0.5893	7.9780	0.2386	2.5221
		0.50	0.0677	0.6145	0.0530	0.3984	0.0623	0.5897	0.0053	0.1253
		0.75	0.0873	0.8570	0.0532	0.3616	0.0694	0.7199	0.0079	0.1984
		1.00	0.0668	0.4391	0.0736	0.8976	0.0724	0.5386	0.0117	0.1661
	1.010	1/n	0.0251	0.7060	0.0247	0.7396	0.0406	0.9269	0.0154	0.0240
		0.25	0.7367	9.1029	0.7713	7.4290	0.7301	9.0985	0.2684	5.5636
		0.50	0.0407	0.7071	0.1170	6.3755	0.0590	1.3522	0.0110	0.7071
		0.75	0.0559	0.3736	0.0612	0.5687	0.0620	0.5431	0.0042	0.0669
		1.00	0.0724	0.5868	0.0675	0.6522	0.0704	0.4788	0.0094	0.1609
	1.001	1/n	0.0340	1.6756	0.0457	1.3888	0.0380	0.7697	0.0016	0.0025
		0.25	0.5390	6.2903	0.6271	7.8371	0.5272	8.1553	0.2132	5.2044
		0.50	0.0522	1.2033	0.0432	0.4399	0.0472	0.5373	0.0008	0.0440
		0.75	0.0466	0.5597	0.0591	0.4823	0.0565	0.6202	0.0064	0.1766
		1.00	0.0599	0.4538	0.0611	0.3995	0.0695	0.3974	0.0105	0.2123

INNOVATION IN ECONOMIC GROWTH: EVIDENCE FROM CHINA

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ABSTRACT. *This paper provides the interplay between innovation and economic growth for the case of China over the period 1990–2008. The innovation, fostered by the government fiscal expenditure, is an effective mechanism for increasing economic output. There is an inverse U-curve relationship between the rate of tax and the economic growth. In addition, private capital investment can promote the economic growth. These findings are confirmed in the empirical study. The findings suggest that the government should increase financial support to foster the innovation environment and the ability of independent innovation.*
Keywords: Innovation; Private Investment; Economic Growth

1. Introduction. Since the reform and opening up in 1978, China has achieved seemingly miraculous growth, and changed the living standard of people. With the economic development and the increase of government revenue, government spending has more and more important effect on economy. Literatures (Barro, 1990; Hsieh and Lai, 1994) examined an endogenous growth model that suggested a possible relationship between the share of government spending in GDP and the growth rate of real per capital GDP. One strand of recent researches (Khalifa, 1997; Alexiou, 2009), in particular, compared the effect ways of government expenditure in the growth process. So effective public fiscal policies and institutional arrangements may lead to the high economic growth. We model and identity innovation as an important activities supported by government fiscal policy. The objective of this paper is to show that higher innovation performance is conductive to per capital economic growth.

Fiscal spending has led to significant increases in per capita income over the past several years (Barro, 1990; Shieh, 2006; Turnovsky and Fisher, 1995). Public expenditure is usually divided into productive expenditure and consumption expenditure. Classical growth theory suggests that productive public spending can directly enter the production function, which affects the marginal productivity of capital and labor. Consumer spending directly enters the utility function, which can directly improve people's welfare. Innovation driven technological progress is an important force for economic growth. The government's support to the basic research is the prerequisite of the development and research of new products in the enterprise. The government subsidies for R&D directly stimulate the motivation of private R&D investment. The theory of endogenous growth points out innovation is the engine of long-run growth. Enhancing independent innovative capability of the countries establishes the basic to guide the economic development. Innovative capability accelerates the transformation of economic growth, and promotes the industrial structure. Countries in the world are attention to use fiscal policy to increase their independent innovation capacity, especially those countries such as U.S., Japan, Finland, South Korea etc. Hicks and Lee (1994) found that U.S. federal R&D funding had a statistically significant regional employment effects. A recent study by the OECD (2003), investigating the relationship between R&D and economic growth over the period 1981-1998, revealed a significant effect of R&D activity on the growth process. Innovation depends on public sector intervention. Government finance of R&D expenditure is an important tool of innovation policy (Nevo, 1998). R&D subsidies are an important tool of innovation policy, and they have potential impact on innovation. The theoretical terms the link between innovation and economic growth has long been acknowledged (Agénor and Kyriakos, 2007) in a three-period model of endogenous growth. Traditionally it has been regarded that further public investment in science and technology should be supported from the public science base. Yang (2006) investigates the importance of innovation, both domestic innovative efforts and the discovery of new ideas throughout the world, to promote Taiwan's economic growth. We show government public spending affects economic growth by fostering innovation and deliver the effects of public fiscal policy on innovation and growth in this paper.

The structure of the paper is as follows. Section 2 presents the model of endogenous growth. Section 3 describes the econometric methodology and the empirical results. The final section summarizes out the overall conclusions of the study.

2. Modeling Economic Growth and Innovation. We consider the government decides optimal public expenditure for innovation under given income tax rates, in order to maximize representative households' lifetime utilities. Given the optimal composition, representative households then optimize consumption choices.

Consider the economy is populated by a continuum of infinitely-lived, representative households. They maximize the following utility function:

$$U=\int_0^\infty u(c(t))e^{-\rho t}dt \tag{1}$$

where c(t) is consumption per person in t, and $\rho>0$ is the instantaneous time preference rate. u(c(t)) is a utility function with a constant elasticity of substitution($\sigma > 0$) given by:

$$u(c(t))=\frac{[c(t)]^{1-\sigma}-1}{1-\sigma} \tag{2}$$

We follow Barro(1990) by assigning public service and consumption to enter into the utility function, increasing the households' utility. So the objective is to maximize the following utilities:

$$\text{Max: } U=\int_0^\infty \frac{\{[c(t)]^{\alpha}[g_c(t)]^{1-\alpha}\}^{1-\sigma}-1}{1-\sigma}e^{-\rho t}dt \tag{3}$$

where $g_c(t)$ is public consumption. $0<\alpha<1$ is the share of public service and consumption in households' utility. In general, we can portray economic growth through a standard Cobble-Douglas function:

$$Y(t) = A(t)K(t)^{\beta} L(t)^{1-\beta} \tag{4}$$

where Y(t) is the output, L(t) is the labor input, K(t) is the private capital input in t, and A(t) is the productivity and technology level. If y(t)=Y(t)/L(t) is the output of per capital, Eq.(4) can be written as:

$$y(t) = A(t)k(t)^{\beta} \tag{5}$$

Where k(t) is the private capital stock per capita in t.

If the government implement the balanced budget, government expenditure equal to the revenue: g(t)=τy(t), τ (0<τ<1) is the tax rate for government revenue. The representative household is bound by a flow capital accumulation constraint:

$$\dot{k}(t) = (1-\tau)y(t) - c(t) \tag{6}$$

Part of government expenditure is used to provide public service, goods and services for society, increasing the private utility of the households.

$$g_c(t)=s\tau y(t) \tag{7}$$

where s corresponds to the share of government expenditure on public goods and services for society.

Another part is R&D funding and subsidies for innovation activities, to foster the social innovation. Now assume that the accumulation of public capital generates innovation and new technology progress taking the level of B as given, which benefits the whole economy. The innovation technology is a simple function:

$$A(t) = B[g_a(t)]^{\theta} \tag{8}$$

B represents the level of innovation sector, 0< θ<1 is the parameter.

$$g_a(t)=(1-s)\tau y(t) \tag{9}$$

where (1-s) is the fraction of innovation performance in government revenues. The production of innovation depends on the government spending on R&D and education subsidies etc. The innovation technology is a simple function:

$$A(t) = B[g_a(t)]^{\theta} \tag{10}$$

where B is an innovation parameter. Substituting Eq.(10) into Eq.(5), the output of economy is given by:

$$y(t) = B[g_a(t)]^{\theta} k(t)^{\beta} \tag{11}$$

Let's assume θ+β=1, letting θ and β are co-state variables associated with the technology constrain. So the production function assumes constant returns to scale.

$$y(t) = Bk(t)[g_a(t)/k(t)]^{1-\beta} = B\phi(g_a(t)/k(t)) \tag{12}$$

where $\phi(\cdot)$ satisfies the usual conditions for positive and diminishing marginal products, so that $\phi(\cdot)^{'} > 0$ and $\phi(\cdot)^{''} < 0$. The Hamiltonian to be maximized at each point of time is given by:

$$H = \frac{[c(t)^{\alpha} g_c(t)^{1-\alpha}]^{1-\sigma} - 1}{1-\sigma} + \lambda(t)[(1-\tau)Bk(t)^{\beta} g_a(t)^{1-\beta} - c(t)] \tag{13}$$

Here λ(t) is the co-state variable representing the shadow price of private investment. Maximizing the Hamiltonian with respect to c and assuming an interior solution, that is $\partial H/\partial c = 0$ and we can obtain:

$$\frac{\alpha[c(t)^{\alpha} g_c(t)^{1-\alpha}]^{1-\sigma}}{c(t)} = \lambda(t) \tag{14}$$

Also the optimum time path of λ(t) satisfies $\partial H/\partial \lambda = -\dot{\lambda}(t) + \rho\lambda(t)$, that can be expressed as:

$$\frac{\dot{\lambda}}{\lambda} = \rho - (1-\tau)B\beta k(t)^{\beta-1} g_a(t)^{1-\beta} \tag{15}$$

The transversality condition is:

$$\lim_{t\to\infty} \lambda k(t)e^{-\rho t} = 0 \tag{16}$$

The steady-state growth rate can be readily computed by using Eq.(6), (11), (13), (14), (15). In the equilibrium with a balanced growth path (BGP), the economy is characterized by

$$\dot{k}/k = \dot{g}_c/g_c = \dot{g}_a/g_a = \dot{y}/y = \dot{c}/c = \gamma$$

The steady-state growth rate (γ) can be shown as:

$$\gamma = \frac{\dot{c}}{c} = \frac{1}{\sigma}\left[(1-\tau)\beta B^{1/\beta}\tau^{1/\beta-1}(1-s)^{1/\beta-1} - \rho\right] \tag{17}$$

The variables of τ and β have effects on the growth rate. Now considering the effect of tax policy illustrated by the derivative:

$$\frac{\partial\gamma}{\partial\tau} = \frac{A^{1/\beta}[\tau(1-s)]^{1/\beta-1}(1-\beta-\tau)}{\sigma\tau} \tag{18}$$

The sign of Eq.(18) depends on the sign of variable 1-β-τ. That is, different sizes of governments for τ or g(t)/y(t), have two effects on the growth rate γ. When the tax rate is lower, τ <1-β, then 1-β-τ > 0 and ∂γ/∂τ > 0. That means an increase in τ raises γ. If the tax rate is higher, τ >1-β, then 1-β-τ < 0 and ∂γ/∂τ < 0. So an increase in τ will reduce γ. Therefore the graph shape between economic growth and tax rate is the inverted U-relationship. The peak point of curve, at which τ optimally amounts to 1-β, denotes the optimum share of innovation to economic growth. The direct growth effect of the innovation share can be illustrated by the derivative:

$$\frac{\partial\gamma}{\partial(1-s)} = \frac{(1-\tau)(1-\beta)B^{1/\beta}[\tau(1-s)]^{1/\beta-1}}{\sigma(1-s)} > 0 \tag{19}$$

So the increase of innovation activity is favor to the steady-state growth rate. On the other hand, let i=I(t)/y(t) presents the ratio of private investment to GDP, where private investment I corresponds to the instantaneous change (I=dk(t)/dt). Because all factors grow at the same rate γ in the steady state, the private investment to GDP ratio i=$\dot{k}(t)/y(t)$ is:

$$i = \frac{\dot{k}(t)}{k(t)} \cdot \frac{k(t)}{y(t)} = \frac{\gamma}{B\varphi(g_a(t)/k(t))} \tag{20}$$

which means that the rate of private investment is unambiguously propitious to higher the growth rate.

Now we summarize the above results as following conclusions:

Proposition. In the steady-state growth path, there is an inverse U-curve relation- ship between the rate of tax and economic growth. Government spending is positive to economic growth, and the rate of private capital investment can promote economic growth.

3. Empirical Evidence.

3.1. Indicators Measurements and Data Description. In this section we use the annual time series data over the period 1990-2008 in China. Data are collected from China Statistical Yearbooks published by China Statistics Press. The output growth (PG) is constructed by real per capital GDP. The per capital GDP deflator (1990=100) is used to deflate the variable of GR. The rate of private investment (pir) is the radio of private investment (PI) to GDP. Private investment is deflated by the price index for investment in fixed assets. The rate of tax (τ) is the radio of total taxes to GDP. The innovation performance (PN) is measured by the public expenditures for scientific and technological research funds, which are deflated by the retail price index. All variables are described in TABLE 1.

TABLE 1. Description of variables

Variable	Definition
LPG	Logarithms of real per capital *GDP*
gr	growth rate of real per capital *GDP*
LPI	Logarithms of private investment
pir	the radio of private investment
LPN	Logarithms of innovation performance
τ	radio of total taxes to *GDP*

The curve in FIGURE 1 shows the relation between the growth rate (γ) and the tax rate (τ) for the Cobb- Douglas case. The inverted *U*-curve approves the proposition.

3.2. Unit Roots Test. In order to proceed with the empirical analysis, all data series are first checked for stationary. If the series are non-stationary, standard economic techniques will lead to misleading estimation. So we have to determine the degree to which they are integrated if the null hypothesis of non-stationary cannot be rejected. By using the method of the augmented Dickey-Fuller (ADF) unit root test, as well as of the Phillips-Perron (PP) test, the unit root tests provide the following results (Table 2). According to the testing results, LPG, LPI and LPN variables (log levels) are both level non-stationary almost significant at 5% level. But they are stationary at their second differences. Thus, we can concluded that all series are integrated of order two, or I(2).

3.3. Multivariate VAR Framework. The dynamic relationships among the real per capital GDP, innovation, and the private investment are examined using vector autoregressive (VAR) analysis. Suppose that the level of y_t can be represented as a non-stationary p-th order vector autoregre- ssion equation:

$$y(t)=\alpha+\chi_1 y(t-1)+\chi_2 y(t-2)+\cdots+\chi_{p-1}y(t-p+1)+\chi_p y(t-p)+\varepsilon(t) \quad (21)$$

According to Hamilton (1994), this VAR(p) model can be reparameterised as:

$$\Delta y(t)=\alpha+\psi_1\Delta y(t-1)+\psi_2\Delta y(t-2)+\cdots+\psi_{p-1}\Delta y(t-p+1)+\rho y(t-1)+\varepsilon(t) \quad (22)$$

Where y_t=(LPG, LPI, LPN) is a 3×1 vector of the two-order integrated variables; $\psi_s=-(\chi_{s+1}+\chi_{s+2}+\cdots+\chi_p)$ for s=1,2 ,…, p-1. ψ_s is the 3×3 coefficient matrices; ε_t is a vector of normally and independently distributed error terms. Johansen (1988) and Johansen&Juselius(1992) derive the trace test and maximal eigenvalue test to identify the existence and number of distinct cointegrating vector in the VAR framework. We use their methods to test the existence and number of cointegration vectors through trace test and maximum eigenvalue test. The results are reported in TABLE 3.

The trace test of cointegration rank indicates that there exist only one cointegrating vectors in the VAR model set. So we can find out the long-run equilibrium relationship between economic growth, innovation and private investment is as following:

$$LGP=23.999+\underset{(14.357)}{3.887LPI}+\underset{(3.929)}{0.143LPN} \quad (23)$$

The value in brackets is t-statistics. The coefficients of private investment per capita and innovation are all statistically significant at the 1% level and positive. The results suggest that each additional percentage point increase of private investment and innovation have a positive effect on the economic growth. Therefore, increasing investment in innovation can effectively leverage private investment and promote the economic growth. Table 4 gives each estimated equation in the multivariate VAR system. The lag order p of the vector auto-regression is selected using both the Akaike information criterion (AIC) and the Schwarz information criterion (SIC). Because the presence of cross-equation feedbacks and the tendency for the estimated coefficients on successive lags to oscillate, the VAR parameter estimates are generally hard to interpret. We therefore follow the usual practice and focus on impulse-response functions.

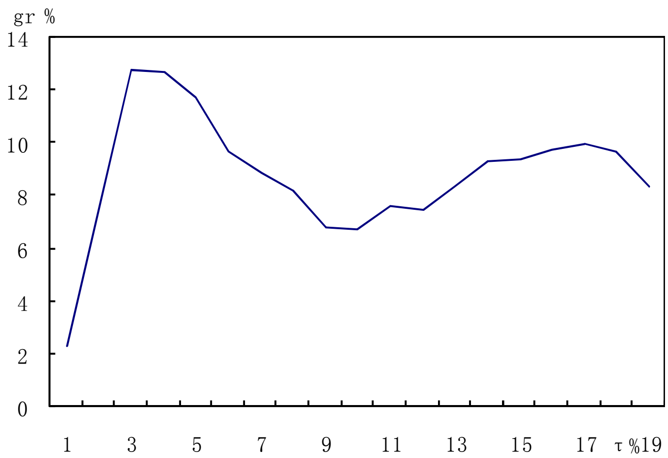

FIGURE 1. Inverted *U*-curve hypothesis between *τ* and *gr*

TABLE 2. Testing for unit roots

Series	The Dickey-Fuller ADF(p) test			The Phillips-Perron(q) test		
	p=0	p =2	p =4	q =0	q =2	q=4
LPG	-1.3847	-4.614**	-2.746	-1.384	-1.712	-1.778
LPI	-2.867	-4.503**	-2.834*	-3.906***	-1.238	-1.158
LPN	-3.349*	1.346	0.411	-3.349**	-3.327**	-3.335**
ΔLPG	-2.105	-2.107	-3.280	-2.105	-2.584	-0.249
ΔLPI	-1.534	-1.318	-1.675	-1.318	-1.238	-1.158
ΔLPN	-5.779**	-0.392	0.494	-5.588***	-0.980	-1.815*
$\Delta^2 LPG$	-3.945***	-4.222***	-3.907**	-4.222***	-4.475***	-4.176***
$\Delta^2 LPI$	-3.819**	-3.931***	-8.808***	-3.931***	-3.957***	-4.813***
$\Delta^2 LPN$	-6.749***	-4.529***	-5.276***	-7.039***	-5.911***	-12.341***

Note: Δ denotes the first differences, and Δ^2 denotes the second differences. *, **, and *** indicate the 10%, 5%, and 1% significance levels respectively. The parameter p gives the lag length employed in the Dickey-Fuller test, and the parameter q indicates the lag length employed in the Phillips-Perron test.

TABLE 3. Cointegration rank test

Null Hypothesis No. of CE(s)	Alternative	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None*	r =1	0.960	78.385	42.915	0.000
At most 1	r =2	0.656	23.260	25.872	0.102
At most 2	r =3	0.259	5.100	12.517	0.582

TABLE 4. Results of vector error correction estimates

	D(LPG)	D(LPI)	D(LPN)
CointEq	0.009	0.156	-0.218
	(0.036)	(0.028)	(0.230)
	[0.248]	[5.439]	[-0.949]
D(LPG(-1))	0.788	1.409	1.773
	(0.484)	(0.383)	(3.062)
	[1.626]	[3.678]	[0.579]
D(LPG(-2))	-0.243	0.789	-5.597
	(0.862)	(0.681)	(5.450)
	[-0.281]	[1.158]	[-1.027]
D(LPI(-1)	-0.006	-0.152	0.183
	(0.169)	(0.133)	(1.069)
	[-0.040]	[-1.136]	[0.171]
D(LPI(-2))	-0.001	-0.277	0.456
	(0.133)	(0.105)	(0.843)
	[-0.008]	[-2.626]	[0.540]
D(LPN(-1))	-0.004	-0.009	-0.520
	(0.046)	(0.037)	(0.295)
	[-0.099]	[-0.248]	[-1.758]
D(LPN(-2))	0.018	-0.043	-0.495
	(0.042)	(0.033)	(0.267)
	[0.442]	[-1.287]	[-1.851]
Constant	0.036	-0.125	0.650
	(0.046)	(0.036)	(0.295)
	[0.777]	[-3.390]	[2.202]
R-squared	0.644	0.981	0.559
Akaike AIC	-5.385	-5.855	-1.697
Schwarz SIC	-5.683	-1.280	17.724

Note: Standard errors in ( ) and t-statistics in [ ].

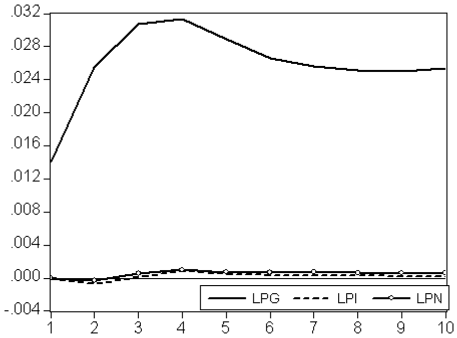

FIGURE 2. Impulse responses of *LPG* to ne-standard-deviation structural shocks

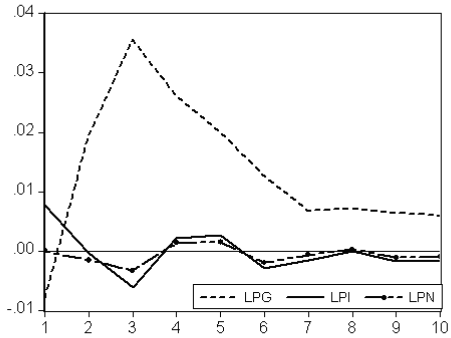

FIGURE 3. Impulse responses of *LPI* to one-standard-deviation structural shocks

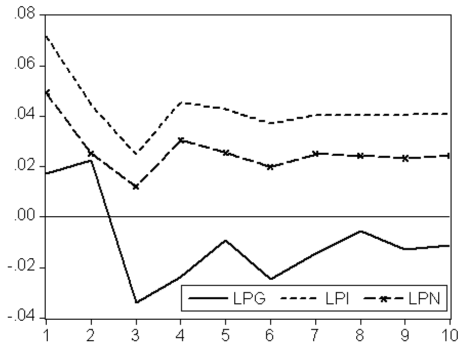

FIGURE 4. Impulse responses of *LPN* to one-standard-deviation structural shocks

TABLE 5. Granger causality tests

	Lag length	F-Statistic	Probability
LPI does not Granger Cause LPG	2	9.449	0.003
LPG does not Granger Cause LPI	2	25.921	4.4E-05
LPN does not Granger Cause LPG	2	8.297	0.005
LPG does not Granger Cause LPN	2	1.590	0.244
LPN does not Granger Cause LPI	2	4.978	0.026
LPI does not Granger Cause LPN	2	3.136	0.080

3.4. Impulse Responses. Impulse responses allow us to trace out the time path and the effects of various shocks on the variables contained in the VAR system. The impulse responses of each variable to one-standard-deviation shocks for the full sample are presented from FIGURE 2 to FIGURE 4, where horizontal axis shows the time of shock effect (unit in year) and the vertical axis shows the size of response.

In FIGURE 2, we examine the impact of GDP per capita responds to one-standard-deviation structural shocks. The shocks generated from GDP per capita have a signifycant positive effect on itself. The maximum impact of shocks appears in the fourth time, and then the shocks weaken. The shocks generated from private investment and innovation have the weak impact on GDP per capita. In FIGURE 3, the shocks generated from GDP per capita have negative effect on the private investment at first two year, then positive impacts are seen in the next year. The results of impulse responses of LPN to shocks generated from GDP per capita are negative in the short run, but positive effect in the long run. The shocks generated from private investment and innovation also have the weak impact on private investment, but have positive effect on the innovation performance. In sum, the shocks generated from GDP per capita have stronger impact on economic variables.

3.5. Causality Tests. Granger causality test is an econometrics method to test the causal relationship between economic variables. Test results of the causality are summarized in TABLE 5. The optimal lag length selected is given in estimating the VAR models. The F-statistic values are provided together with their corresponding p-values, which are the marginal significance level at which the null hypothesis of no causal effect of the corresponding variable on another one can be rejected. According to the table 5, an increasing in the share of innovation is the Granger cause of economic growth in the long-run. Changes in the private investment have significant effect on the economic growth. Of course, the development of economic must be active the increase of private investment and innovation. However, there is no significant evidence to support the proposition of LPG is Granger cause of LPN. The result of causality tests provides support to the view that innovation and private investment is a leading factor in the process of economic growth.

4. Conclusion. This study attempts to identity the role of innovation fostered by public capital in economic growth. Government spending is the driving force and source of innovation, having an important effect on promoting economic growth. The innovation is an effective mechanism that transforms public capital into higher output. There is an inverse U-curve relationship between the rate of tax and economic growth. Innovation performance is positive to economic growth, and the rate of private capital investment can promote economic growth. By implementing a multivariate VAR framework to the annual data of China from 1990–2008 periods, we have empirically examined the long-run relationships among per capital economic growth, innovation and private investment. Together, we find an inverted U-curve relationship between tax rate and the steady-state growth rate, and private investment is significantly positive relate to economic growth.

However, there exists only a unidirectional causality from economic growth to innovation spending. The findings suggest that the government should increase financial support to foster the innovation environment and ability of independent innovation.

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INTERVAL ESTIMATION FOR THE QUANTITLE OF TWO-PARAMETER EXPONENTIAL DISTRIBUTION

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ABSTRACT. *In this paper, we consider the interval estimation for quantile of two-parameter exponential distribution. Based on bootstrap and fiducial inference, two methods for interval estimation of quantile are proposed. To evaluate the coverage probabilities and expected lengths of the two methods, a simulation study is conducted. The results indicate that the fiducial inference method performs well under all examined conditions.*

Keywords: Exponential Distribution; Quantile; Bootstrap; Fiducial Distribution; Coverage Probability

1. Introduction. Two-parameter exponential distribution, which occupies an important position in probability and statistical areas, has been widely used in practice, especially in the area of reliability. During the past few decades, there are many authors considered the statistical inferences for the two-parameter exponential distribution, see Nelson (1982), Lawless (1982), Bain and Engelhardt (1991), Balakrishnan and Basu (1995), and Meeker and Escobar (1998). It is well known that the quantiles of a random sample are the common used indicators to assess the reliability in statistical analysis. However, as the quantiles do not depend on nuisance parameters, there is no exact frequency method for interval estimation of quantiles. Consequently, there has not been much attempt to the study of the inferences on quantiles in recent literatures.

In some complicated situations, Efron (1979) proposed the bootstrap method for statistical inference. Free of population distributions and parameters, the bootstrap theory has been greatly developed and expanded for the last three decades, and now this technique is wildly used in various fields of statistics, see Hall (1988), DiCiccio and Efron (1996), Chen and Tong (2003), etc. Recently, the fiducial inference has attracted a great amount of attention due to its advantage of handling the inference problems under certain complex situations. Fisher proposed and discussed the fiducial inference firstly in 1935. David and Stone (1998) derived a generalized method to conduct the fiducial inference based on the function model. More recently, Li et al. (2005) and Hannig et al. (2006) further discussed the fiducial theory and developed a general method to construct the fiducial intervals.

The main work of this paper is to give the interval estimations for quantiles of two-parameter exponential distribution based on the bootstrap method and the fiducial method. Numerical simulations are conducted to compare the two methods mentioned above.

2. Interval Estimation of the Quantiles.

2.1. The Two-Parameter Exponential Distribution. Let $X_1, X_2, \ldots, X_n$ be a random sample from the two-parameter exponential distribution with its probability density function (pdf) given by

$$p\left(x;\mu,\sigma\right)=\begin{cases}\dfrac{1}{\sigma}\exp\{-\dfrac{x-\mu}{\sigma}\},\ x>\mu\\ 0 \qquad\qquad\qquad\quad , \text{else}\end{cases}$$

where $\mu > 0, \sigma > 0$. By $F(x) = P(X \le x_p) = p$, the pth quantile x_p can be expressed as $x_p = u - \sigma\log(1-p)$ for any $p \in (0,1)$.

Assume the observations are the type II censored data $X_{(1)} \le X_{(2)} \le \cdots \le X_{(r)}$. It is obvious that $W = X_{(1)}$ and $V = \sum_{i=1}^{r} X_{(i)} + (n-r)X_{(r)} - nX_{(1)}$ are the complete sufficient statistics of the distribution and independently distributed. Then, the uniformly minimum-variance unbiased estimators (UMVUE) for μ and σ are

$$\hat{\mu} = X_{(1)} - \frac{1}{n(r-1)}\{\sum_{i=1}^{r} X_{(i)} + (n-r)X_{(r)} - nX_{(1)}\},$$

$$\hat{\sigma} = \frac{1}{r-1}\{\sum_{\text{i}=1}^{r} X_{(i)} + (n-r)X_{(r)} - nX_{(1)}\}.$$

Hence, the UMVUE of the pth quantile x_p is

$$\hat{x}_p = X_{(1)} - \frac{1}{n(r-1)}\{\sum_{i=1}^{r} X_{(i)} + (n-r)X_{(r)} - nX_{(1)}\}$$
$$- \frac{1}{r-1}\{\sum_{\text{i}=1}^{r} X_{(i)} + (n-r)X_{(r)} - nX_{(1)}\}\log(1-p).$$

2.2. The Bootstrap Method. The bootstrap method, proposed by Efron (1979), is often used to construct the confidence intervals for parameters. The main thought of the bootstrapping is to adopt the empirical probability distribution as a replacement of the unknown distribution of underlying population from which the original samples are drawn, and then construct new random variables basing on the independently distributed samples generated from empirical distribution, which is a substitution of the original samples, for further statistical inference. The bootstrap procedure for the calculation of confidence interval of the pth quantile is given as follows:

(1) Calculate the empirical distribution function based on the type II censored data $X_{(1)} \le X_{(2)} \le \cdots \le X_{(r)}$.

(2) By Monte Carlo simulation method, generate a sample $x_1{*} \le x_2{*} \le \cdots \le x_r{*}$ from the empirical distribution with size r randomly.

(3) Based on the random sample, calculate the UMVUE of x_p by $\hat{x}_p = \hat{\mu} - \hat{\sigma}\log(1-p)$.

(4) Repeat step (2)-(3) for N (=5000) times and get N corresponding $\hat{x}_p$.

(5) For the given confidence coefficient $1-\alpha$, sort the $\hat{x}_p$'s in an ascending order, that is, $\hat{x}_{p(1)} \le \hat{x}_{p(2)} \le \cdots \le \hat{x}_{p(N)}$.

Find their $\alpha/2$ and $1-\alpha/2$ percentiles denoted by $\hat{x}_{p,L}$ and $\hat{x}_{p,U}$, respectively. Then the bootstrap confidence interval of the quantile x_p is [$\hat{x}_{p,L}$, $\hat{x}_{p,U}$].

2.3. The Fiducial Method. Let $P_\eta(\cdot)$ denote the pdf of the random variable X with its sample space X, where η is the unknown parameter in the parameter space Ω. $\theta = \theta(\eta)$ is a real-valued parameter function of interest.

Definition 2.1. Suppose that there exist a random variable E with known distribution on space Ξ and a function $h(\eta, e)$ from $\Omega \times \Xi$ to X such that $X = h(\eta, E)$ for all $\eta \in \Omega$. Furthermore, if for any observation $x \in \mathrm{X}$ and $e \in \Xi$, the equation $x = h(\eta, e)$ has a unique solution in Ω, denoted by $\eta_x(e)$, then the distribution of $\theta(\eta_x(E))$ is called the fiducial distribution of $\theta = \theta(\eta)$.

In the following, we will give the confidence interval of the quantile x_p using the fiducial method. Noted that

$$W = X_{(1)},\ V = \sum\nolimits_{i=1}^{r} X_{(i)} + (n-r)X_{(r)} - nX_{(1)}$$

are complete sufficient statistics, and independently distributed. By

$$X = \frac{2n(W-\mu)}{\sigma} \sim \chi^2(2),\ Y = \frac{2V}{\sigma} \sim \chi^2(2r-2)$$

we have

$$(W, V) = (\frac{\sigma X}{2n} + \mu, \frac{\sigma Y}{2})$$

For a given observation (w, v) and (x, y), the equation

$$(w, v) = (\frac{\sigma x}{2n} + \mu, \frac{\sigma y}{2})$$

has a unique solution

$$(\mu, \sigma) = (w - \frac{vx}{ny}, \frac{2v}{y}).$$

Consequently, the fiducial distribution of the pth quantile is

$$F_x(x_p) = P_r(w - \frac{vX}{nY} - \frac{2v}{Y}\log(1-p) < x_p)$$

Hence, for given $\alpha \in (0,1)$, the fiducial confidence interval of x_p is $[x_p(\alpha/2), x_p(1-\alpha/2)]$, where $x_p(\gamma)$ is the 100γ quantile of x_p.

Generally speaking, there exists no explicit expression for the fiducial distribution of x_p, and it is difficult to find a numerical solution. However, the simulation method would be helpful to conduct the calculation of the fiducial intervals.

(1) For given data, set the size of the simulated samples N large enough, say $N = 5000$.

(2) For $i = 1,2,\ldots,N$, generate X_i and Y_i from $\chi^2(2)$ and $\chi^2(2(r-1))$, respectively.

(3) Compute $$x_{p,i} = w - \frac{vX_i}{nY_i} - \frac{2v}{Y_i}\log(1-p).$$

(End N loop)

Denote $x_p(\gamma)$ as the 100γ percentile of $\{x_{p,1}, x_{p,2}, \cdots, x_{p,N}\}$. Then the fiducial confidence interval of x_p is $[x_p(\alpha/2), x_p(1-\alpha/2)]$.

3. Simulation Results. This section is devoted to the comparison of the bootstrap method and fiducial method using numerical simulation. In general, the mutual comparison of the above two methods should take into account the following properties: the coverage probabilities (CP) and the expected lengths (EL) of the intervals. The inference procedures with larger CP are desired firstly, and then a shorter EL would be considered as the indication of more accurate interval estimation.

In order to evaluate the interval estimation of the above two methods, we here apply Monte Carlo simulation to estimate CP and EL. For given μ and σ, generate M samples, compute their bootstrap intervals and fiducial intervals under the nominal level $1-\alpha$ using the related algorithms put forward in section 2, and finally calculate the proportion of the M intervals containing x_p and the average interval lengths. In the simulation procedure, we set $\mu = 2$, $\sigma = 4$, the sample size $n = 12$, the number of observed censored data $r = 8$, the confidence coefficient $1-\alpha = 95\%$ and $M = 3000$. The simulation results are shown in Table 1.

TABLE 1. The simulated CP and EL

p	Bootstrap intervals		Fiducial intervals	
	CP	EL	CP	EL
0.15	0.7723	1.3698	0.9427	1.8392
0.25	0.8833	1.8014	0.9407	2.3308
0.35	0.9217	2.5106	0.9477	3.2295
0.45	0.9300	3.4505	0.9533	4.3433
0.50	0.9410	3.9647	0.9553	5.1475
0.55	0.9447	4.6237	0.9513	5.7954
0.65	0.9457	6.1248	0.9480	7.4689
0.75	0.9477	8.2573	0.9527	10.0852
0.85	0.9447	11.3563	0.9547	14.9056
0.95	0.9583	18.5748	0.9557	24.8511

The numerical results in Table 1 indicate that the CPs of the fiducial intervals are close to $1-\alpha$, and apparently larger than that of the bootstrap intervals for small p. Under this condition, the fiducial method performs more satisfactorily than the bootstrap method. When the value of p is moderately large, the CPs of the two kinds of intervals are close to each other. When it comes to the ELs of the confidence intervals, nevertheless, the bootstrap method performs better. Therefore, we can conclude that the fiducial method would not be affected by the value of p, and the bootstrap method could be well accepted only with moderate to large values of p.

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RESOURCE ALLOCATION BETWEEN HUMAN RESOURCE AND THE DIVISION OF LABOR

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ABSTRACT. *This paper proposes a dynamic model and argues that the relative importance of both the division of labor and human capital accumulation to the increasing returns only depends on the selection of economic parameters. At the same time we show how to maximize the efficiency of resource when we consider resource is allocated between human capital accumulation and increasing specialization and present the corresponding arithmetic.*
Keywords: Resource Allocation; Human Resource; The Division of Labor

1. Introduction. The division of labor, the central to Adam Smith's explanation of growth, is the chief source of productivity gains (Smith, 1776). In Smith's view the division of labor largely took the form of job specialization at the firm level or the development of specialized arts and crafts, but their development is governed by the size of the available market. Building on the Smithian argument, Young (1928) extends the concept of the division of labor to include the specialization that occurs among firms and industries as the market expands and emphasizes these type of specialization are the main source of increasing returns. According to Young, increasing returns at the industry level have been understood in terms of a demand perspective which manifests them through the process of industrial differentiation when the overall size of the market expands and their existence does not necessarily lead to the breakdown of competition since increasing returns do not, in the main, take the form of scale economies (Chandra, 2004).

While the division of labor depends on the size of the market, how does the size of the market depend on the division of labor? Smith did not analyze fully the forces which make growth cumulative and self-reinforcing. Young addresses these issues directly and more fully. He takes the institutions for a competitive system as given and probes the mechanics of the process which made growth self-perpetuating. Young argued that there is a feedback relationship between the division of labor and the extent of the market, that is, the division of labor depends on the extent of the market, which is proportional to the wealth and the population of a country and in turn depends on the division of labor. Thus, there is a mutual dependence between the division of labor and the extent of the market.

Again, in Smith's time industrial capitalism had just begun and the average size of a firm was relatively small for him to worry about the emergence of monopoly. However, increasing returns to scale may lead to the monopolization of an industry. So Smithian division of labor theorem and his “invisible hand” theory are in a dilemma, just as Stigler (1951) observed.

Stigler argues that the different functions performed by a firm have different cost structures. When one function enjoys decreasing costs, another function may be experiencing increasing costs. According to his analysis, the firm starts out vertically integrated. As demand increases, firms vertically disintegrate. They spin off the decreasing cost functions and purchase from new firms entering to meet the demand for the increasing cost activities' products. Thus increasing returns to scale in one function is not enough to lead to the monopolization of an industry (Levy, 1984).

Baumgardner (1988) develops a model to explain differences in the degree of the division of labor across local markets and argues that there is a trade-off between increasing returns to production of each activity for the individual worker and falling marginal revenue with output of an activity. Zhou (2004) examines the mutual dependence between the division of labor and the extent of the market and finds no monotonic relationship between the size of firms and the extent of the market.

One of the benefits of the division of labor is that it increases the skills and dexterity of workers in the process of production which appears akin to "learning by doing". Arrow (1962) built a “learning-by-doing” model that learning effect can lead to technological improvement and cost reduction, hence to generate increasing returns. Romer (1986) applied a complex dynamic mathematical model, with technological change embodied, and got the conclusion that technological change could result in increasing returns and unlimited growth. Lucas’s model (1993) emphasized the effects of human capital, and demonstrated how the process of human capital accumulation resulted in increasing returns. Based on microeconomic mechanisms, Yang and Borland (1991) incorporated the degree of division of labor into their model, which led to the conclusion that the progressive division and specialization of industries can generate economic growth.

Becker et al. (1992) consider specialization and the division of labor and argue that the degree of specialization is more often determined by other considerations. Liso et al. (2001) discuss the returns to scale as a function of the division of labor and learning, which is realized through three main channels, namely a more detailed division of labor, learning-by-doing concerning the individual and learning-by-doing concerning the organization as a whole. They find that, neither the division of labor nor learning, within a given plant or work process, can grow forever.

Obviously, there are significant difference effect between the division of labor, technology progress and human capital on the increasing return, in which they are correlative in reality. This paper proposes a dynamic model and argues that the relative importance of both the division of labor and human capital accumulation to the increasing returns only depends on the selection of economic parameters. At the same time we show how to maximize the efficiency of resource when we consider resource is allocated between human capital accumulation and increasing specialization and present the corresponding arithmetic. The paper is organized as follows: Section 2 considers the dynamic model of increasing scale return; Section 3 contains the analysis of the resource allocation in the economy; Section 4 contains the conclusions.

2. The Dynamic Model of Increasing Scale Return. Dixit and Stiglitz (1977) proposed that the utility function is dependent upon an intermediate product. Ethier (1982) used this utility function and to explore the production function where an intermediate product is present, that is, the endogeneity of the amount of intermediate product. Romer (1987) had a production function that employs labor and the intermediate product, and explained the relationship between increasing scale returns and specialization.

Here we will study the relative importance of specialization and human capital within the framework of the dynamic model. Specifically, we use the number of specialized intermediate products to describe the division of labor. Taking technological change, physical capital and human capital into account, we then have:

$$Y = M^{1-\alpha} N^{\alpha} A K^{\beta} (\mu H)^{\gamma} L^{1-\alpha-\beta-\gamma} \tag{1}$$

where N refers to the total quantity of intermediate inputs and M refers to the length of indirect production chain, i.e., number of specialized intermediate inputs used. Y, L, K and H refer to output, population, physical capital and human capital respectively, and normally technological change is an exogenous variable A. u is the ratio of human capital spent on mass production.

Suppose the savings rate is s,y,k,h and n be the per capita value of output, physical capital, human capital and the amount of intermediate inputs respectively. The production efficiency of human capital is given as δ. There is no depreciation and population increase, and the production of human capital takes place at a uniform rate. We can easily obtain following equations:

$$y = AM^{1-\alpha} n^{\alpha} k^{\beta} (\mu h)^{\gamma} \tag{2}$$

$$\dot{k}(t) = sy(t) \tag{3}$$

$$\dot{h}(t) = \delta(1-\mu)h(t)\,; \tag{4}$$

where $\dot{k}(t)$ is shorthand for dk(t)/dt, so we have the growth rate of a variable which refers to its proportional rate of change. The same fashion is exercised on other variables and yields. We obtain the growth rate of output:

$$\frac{\dot{y}}{y} = \frac{\gamma}{1-\beta}\frac{\dot{h}}{h} + \frac{1-\alpha}{1-\beta}\frac{\dot{M}}{M} \tag{5}$$

Definition: The determinant coefficient is λ=γ/(1-α), which is the ratio between the elasticity of output to the number of intermediate product γ/(1-β) and the elasticity of output to the number of intermediate product (1-α) /(1-β).

The determinant coefficient λ indicates the relative importance of human capital and specialization for increasing return. Human capital is more important than specialization when λ>1, while increasing specialization is more effective than increasing human capital when λ<1. The relative importance of human capital and specialization depends on the parameters of the economic system. Increasing education investment is effective when output is sensitive to human capital while increasing specialization is worth when output is sensitive to the division of labor.

3. The Resource Allocation in the Economy. Now we solve the following problem: how to maximize the efficiency of resource when we consider resource is allocated between human capital accumulation and increasing specialization. Suppose the total resource is 1 in the economy, the portion used for human capital accumulation is *c*, the portion used for increasing specialization is 1-c, and their efficiency are f_1 and f_2 respectively. To seek the optimal *c* so as to get the rapidest growth of output, the description of model as following:

$$Max_c \frac{\dot{y}}{y}$$

$$s.t. \frac{\dot{h}}{h} = f_1(c) \quad ; \quad \frac{\dot{M}}{M} = f_2(1-c); \quad 0 \le c \le 1$$

Denote the object function as $F(c)$ and suppose $f_1(c) = c^{\theta} - \omega_1$, $f_2(c) = c^{\sigma} + \omega_2$, where $\omega_1 > 0, \omega_2 > 0$. ω_1 denotes the depreciation of human capital and ω_2 denotes the natural evolution of the divide of labor without external force which we expect ω_2 is very small. So we have the value of object function:

$$F(0) = \frac{-\gamma\omega_1 + (1-\alpha)(1+\omega_2)}{1-\beta}, \qquad \text{if } c = 0;$$

$$F(1) = \frac{\gamma(1-\omega_1) + (1-\alpha)\omega_2}{1-\beta}, \qquad \text{if } c = 1;$$

$$F(c^*) = \frac{\gamma(c^{*\theta} - \omega_1) + (1-\alpha)\left[(1-c^*)^{\sigma} + \omega_2\right]}{1-\beta}, \qquad \text{if } 0 < c < 1;$$

The optimal solution c^* satisfies $\frac{\sigma(1-c^*)^{\sigma-1}}{\theta(c^*)^{\theta-1}} = \lambda$

Theorem 1. The optimal solution lies on boundary ($c = 0$ or 1) if and only if

$$\left(\frac{(1-c)\theta}{c\sigma} + 1\right)c^{\theta} < 1 \quad \text{or} \quad \left(\frac{c\sigma}{(1-c)\theta} + 1\right)(1-c)^{\sigma} < 1$$

holds.

Theorem 2. The total resource allocated to human capital accumulation is not a optimal scheme if $\lambda > 1$ and the total resource allocated to increasing the divide of labor is also not a optimal scheme if $\lambda < 1$.

We can solve the optimal allocation scheme using theorem 1 and 2 for a given economy. where F_{opti} is the maximum of output growth， c_{opti} is the corresponding optimal solution.

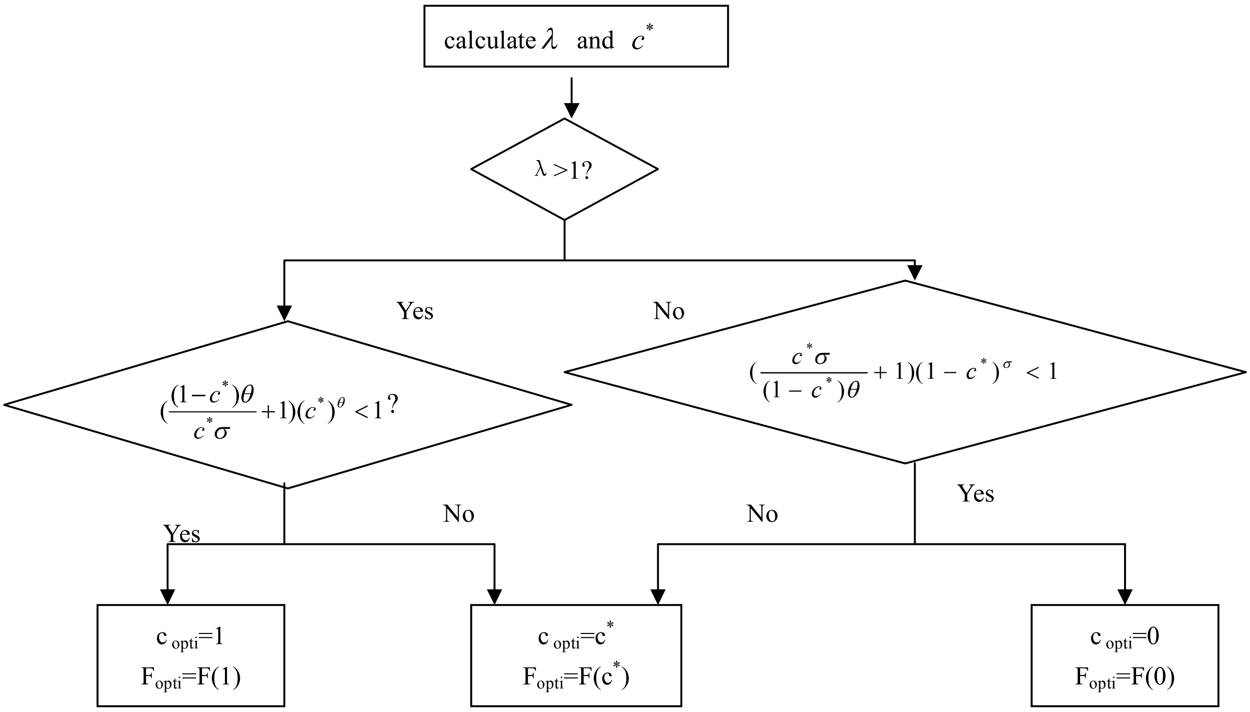

FIGURE 1.

4. Conclusion. The economists have to discriminate what induce increasing return to scale when they construct increasing return model. Some economists argue the division of labor is the dominant factor while others contribute it to technology progress and human capital accumulation. This paper proposes a dynamic model to distinguish such scenarios and show that the relative importance of both the division of labor and human capital accumulation to the increasing returns only depends on the structure of economy, especially the elasticity of output. At the same time we show how to maximize the efficiency of resource when we consider resource is allocated between human capital accumulation and increasing specialization and present the corresponding arithmetic which enables the model calculation is feasible.

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MULTILEVEL MODEL ON THE MATHEMATICS LITERACY ANALYSIS OF PISA 2006

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ABSTRACT. *The purpose of this study is to investigate the multilevel relationship based on PISA2006 database and NRI (networked readiness index). Methodology of multilevel model is Hierarchical Linear Model (HLM). Mathematics literacy and out-of school-time lessons in mathematics per week from PISA2006 are the independent variable and dependent variable of students. Owing to the nested structure of PISA2006, HLM of two levels is used to analyze the database. The unit in level-1 is students and the level-2 is nations. The results show that out-of school-time lessons in mathematics per week will influence mathematics literacy positively. The mean of mathematics literacy among nations differs and the NRI can explain its variance. Finally, based on the findings of this study, some suggestions for future research are provided.*

Keywords: Hierarchical Lineal Model; Mathematics Literacy; Networked Readiness Index; PISA2006

1. Introduction. One major motivation of the international assessment is to investigate the influential factors on students' achievement so that it can improve educational progress, Kotte et al. (2005), Williams (2005). One well-known assessment is TIMSS (Trends in International Mathematics and Science Study). It is an international assessment of the mathematics and science of fourth- and eighth-grade students. Assessment of TIMSS focuses on the knowledge of mathematics and science curriculum, Rodriguez (2004). Another well-known assessment across nations is Programme for International Student Assessment (PISA). PISA is developed by OECD (Organization for Economic Co-operation and Development). PISA is to assess the literacy of 15-year-olds and the literacy includes reading, mathematics and science. One intension of PISA is to build the longitudinal database and the trace of international assessment is a distinguishing feature. The PISA2000 was held in 2000 and it was the first series of triennial assessments. The PISA has been held every three years. One major feature of PISA which differs from TIMSS is the content of assessment. PISA emphasizes the dynamic model of lifelong learning in which new knowledge and skills necessary for successful adaptation throughout life, Goldstein (2004). Assessment of PISA2006 focuses on required daily and life knowledge to be citizen. Therefore, mathematics items of PISA2006 are almost related to non-routine questions.

Issue of technology on education outcome is important. NRI (Networked Readiness Index), built by World Economy Forum, represents the impact of ICT (Information and communication technologies) on the competitiveness of nations. High NRI means it may provide good environment for students to learn mathematics, Schwabet et al. (2004). Therefore, it is prospective to investigate the relationship of NRI and mathematics literacy with out-of school-time lessons in mathematics. However, little is known about their multilevel relationship owing to the nested structure of students and nations, Raudenbush and Bryk (2002). Hierarchical Linear Model (HLM) is adopted in this study to investigate multilevel structure.

2. Literature Review. Features of nested structure and variables for PISA2006 and HLM will be discussed as follows.

2.1. PISA2006 and Its Variables. PISA2006 is not the test on specific knowledge in the textbooks. Mathematics domain of PISA2006 includes include quantity, space and shape, change and relationships, and uncertainly. Most researches indicate there are possible variables needed to clarify the casual relationships in the international database of mathematics literacy. There exist two hierarchies of nested structure in PISA2006. One is nations and the other is students. Statistical analyses of HLM could provide advanced information for casual relationships, Wang (1999).

2.2. Hierarchical Linear Model. When data are collected by cluster sampling method, as is the case in PISA2006, the residuals will violate assumption of independence Boyle and Willms (2001). Therefore, one shortcoming of ordinal least square (OLS) regression is that the standard error will be too small when it is adopted to estimate relationships on nested data, Raudenbush and Willms (1995). The common multilevel model is HLM, Raudenbush et al. (2004), Draper (1995). To take nations and students for example, suppose there be J ($j=1,2,3,\cdots,J$) nations and n_j $(i=1,2,3,\cdots,n_j)$ students within nation j. Nation is the level-2 unit and student is the level-1 unit. A general expression of the two levels is exemplified in (1) and (2).

$$\text{Level-1}: \; Y_{ij} = \beta_{oj} + \beta_{1j} X_{ij} + r_{ij} \tag{1}$$

Y_{ij} is the level-1 criterion variable (e.g. students' mathematics literacy) and X_{ij} is the level-1 predictive variable (e.g. students' out-of school-time lessons in mathematics per week). β_{oj} and β_{1j} are level-1 coefficients and r_{ij} is the level-1 random effects.

$$\text{Level-2}: \; \beta_{0j} = \gamma_{00} + \gamma_{01} W_j + u_{0j} \quad \text{and} \quad \beta_{1j} = \gamma_{10} + \gamma_{11} W_j + u_{1j} \tag{2}$$

W_j is the level-2 predictive variable (e.g. national NRI). γ_{00}, γ_{01}, γ_{10} and γ_{11} are level-2 coefficients. u_{0j} and u_{1j} are level-2 random effects.

3. Methodology and Data Description. Description of variables from PISA2006 and World Economy Forum (WEF) are shown in Table 1, there are 57 nations or areas participating in the PISA2006. Among these nations, one is OECD member and there are 30 nations. The other is non-OECD member and there are 27 nations. There are about 398 thousands of students in PISA2006 data set, OECD (2007).

NRI is the level-1 variable and it comes from the report of 2006 World Economy Forum (WEF). NRI means the propensity for nations to exploit the opportunities offered by information and communications technology. NRI is a composite of three components: (1) environment for ICT offered by a given country or community; (2) readiness of the community's key stakeholders to use ICT; (3) usage of ICT amongst these stakeholders ,WEF (2006). There are two level-2 variables. One is plausible value (PV) of mathematics literacy for each student. The other variable, symbolized by Time, is out-of school-time lessons in mathematics for each student acquired by questionnaire of PISA2006 and it will influence mathematics literacy. Its mean for each nation is depicted in Table 1.

TABLE 1. NRI with mean of mathematics literacy and mathematics studying time

Nations (Areas)	NRI	mean		Nations (Areas)	NRI	mean	
		PV	Time			PV	Time
Argentina	3.59	388.269	1.59	Kyrgyzstan	2.90	315.963	2.12
Australia	5.24	516.233	1.55	Latvia	4.13	491.120	1.91
Austria	5.17	509.340	1.38	Liechtenstein	_	524.967	1.47
Azerbaijan	3.53	476.561	2.17	Lithuania	4.18	485.268	1.61
Belgium	4.93	526.872	1.4	Luxembourg	4.90	490.511	1.63
Brazil	3.84	365.847	1.94	Macao-China	_	523.456	1.85
Bulgaria	3.53	417.206	1.83	Mexico	3.91	420.840	1.81
Canada	5.35	517.446	1.7	Montenegro	_	395.184	1.67
Chile	4.36	417.458	1.77	Netherlands	5.54	537.228	1.55
Chinese Taipei	5.28	563.333	2.08	New Zealand	5.01	523.043	1.53
Colombia	3.59	373.452	1.89	Norway	5.42	489.925	1.84
Croatia	4.00	467.345	1.58	Poland	3.69	500.273	1.64
Czech Republic	4.28	536.017	1.56	Portugal	4.48	470.190	1.64
Denmark	5.71	512.402	2.03	Qatar	4.21	317.934	2.27
Estonia	5.02	517.202	1.76	Romania	3.80	414.972	2.02
Finland	5.59	549.934	1.31	Russian Federation	3.54	478.596	1.89
France	4.99	496.956	1.73	Serbia	_	436.133	1.72
Germany	5.22	503.734	1.61	Slovak Republic	4.15	494.652	1.71
Greece	3.98	461.885	2.5	Slovenia	4.41	482.335	1.83
Hong Kong-China	5.35	551.624	2.01	Spain	4.35	501.435	1.78
Hungary	4.33	496.746	1.98	Sweden	5.66	503.349	1.51
Iceland	5.50	505.151	1.55	Switzerland	5.58	527.781	1.54
Indonesia	3.59	380.726	2.07	Thailand	4.21	425.218	1.75
Ireland	5.01	502.151	1.55	Tunisia	4.24	363.548	2.6
Israel	5.14	443.023	2.48	Turkey	3.86	428.021	2.41
Italy	4.19	473.759	1.59	United Kingdom	5.45	497.461	1.52
Japan	5.27	525.819	1.54	United State	5.54	475.177	1.85
Jordan	3.74	388.894	2.24	Uruguay	3.67	435.204	1.64
Korea	5.14	546.807	2.51				

Note: _ means that WEF does not provide the NRI

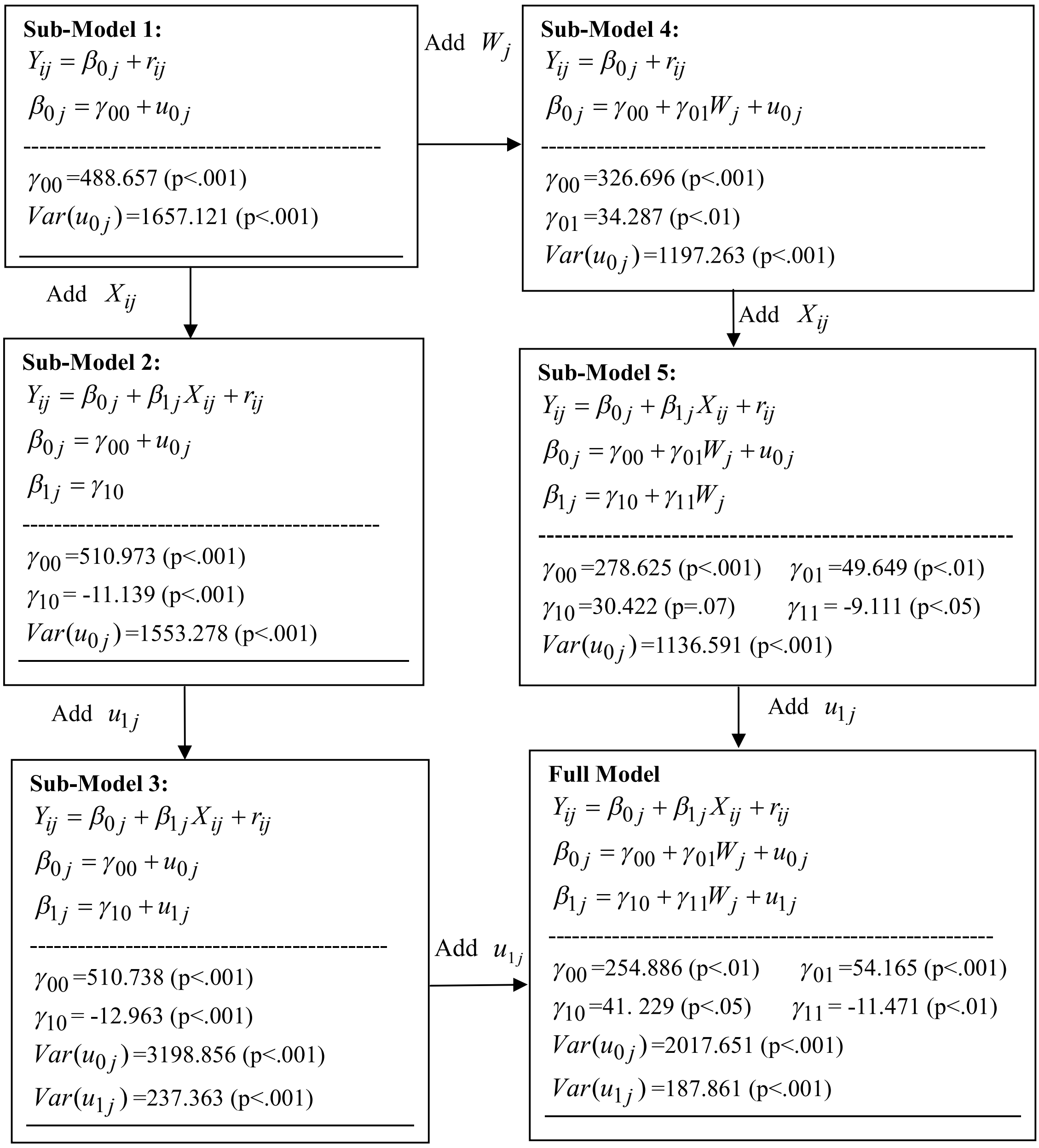

FIGURE 1. Structure relations among sub-models and the full model

4. Main Results. There are five sub-models with one full model to clarify the casual relationship. The structure relations and results are depicted in Figure 1.

HLM 6.02 software is used to analyze data. These models will explain the multilevel information step-by-step. These five sub-models are as follows, Raudenbush and Bryk (2002).

Sub-Model 1: One-way ANOVA model with random effects

Sub-Model 2: One-way ANCOVA model with random effects

Sub-Model 3: Random coefficients regression model

Sub-Model 4: Means-as-Outcomes regression model

Sub-Model 5: Model with nonrandomly varying slopes

Figure 1 shows the structural relation among sub-models and the full models. In level-1, Y_{ij} is mathematics literacy and X_{ij} is out-of school-time lessons in mathematics per week. As to level-2, W_j is the national NRI. As shown in sub-model 1, mean of mathematics literacy for all nations is γ_{00}=488.657 and $Var(u_{0j})$=1657.121 (p<.001) is significant. It means there is difference on mean of mathematics literacy among nations. In sub-model 2, γ_{10}= -11.139 (p<.001) means out-of school-time lessons in mathematics per week influences mathematics literacy with negative effect significantly. As to sub-model 3, it also shows out-of school-time lessons in mathematics per week influence mathematics literacy with negative effect significantly and $Var(u_{0j})$=3198.856 (p<.001) indicates there exists another predictive variables to explain variance of mathematics literacy.

As shown in sub-model 4, γ_{01}=34.287 (p<.01) means NRI influence mathematics literacy with positive effect significantly. $Var(u_{0j})$=1197.263 (p<.001) also shows there are another national variables to explain mathematics literacy. In sub-model 5, γ_{11}= -9.111 (p<.05) shows that NRI will negatively affect the process when out-of school-time lessons in mathematics per week influences mathematics literacy. $Var(u_{0j})$=1136.591 (p<.001) indicates there exist possible variables to explain variance of mathematics literacy in addition to NRI and out-of school-time lessons in mathematics per week. As to full model, in addition to the same results of sub-model 5, it indicates there are another national variables to explain the process for out-of school-time lessons in mathematics per week to influence mathematics literacy because it is $Var(u_{1j})$=187.861 (p<.001).

5. Conclusions. According to the findings, mathematics literacy among nations differs and out-of school-time lessons in mathematics per week will negatively influence mathematics literacy. In addition to out-of school-time lessons in mathematics per week, there exist another predictive variables to explain variance of mathematics literacy. NRI is a positive predictor for mathematics literacy and it will positively intervene between mathematics literacy and out-of school-time lessons in mathematics per week. Moreover, there exist another intervening variables which could explain the influential process for mathematics literacy on out-of school-time lessons in mathematics per week.

The step-by-step procedures in this study show the structural relationship of students and nations. Advanced research could aim at the possible level-2 variables to explain the causal relationship. On the other hand, issues of science literacy or reading literacy for PISA2006 and PISA2009 are also prospective studies, Yildirim and Berberoĝlu (2009), Le (2009).

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RIESZ BASIS GENERATION OF A FLEXIBLE BEAM EQUATION WITH A TIP RIGID BODY WITHOUT DISSIPATIVITY

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Abstract. *In this paper, a flexible beam rotated by a motor in a horizontal plane at one end and a tip body rigidly attached at the free end is considered. By using Guo's conclusion, it is shown that the Riesz basis property can be established for a beam equation with a tip rigid body. Furthermore, we get the conclusions that the system operator* $\mathcal{A}$ *generates a* C_0-*semigroup* $e^{\mathcal{A}t}$ *on the state space and its spectrum-determined growth condition holds.*

Keywords: Flexible Beam, Riesz Basis, Spectrum-determined Growth Condition, Dissipativity.

1. **Introduction.** In this article, we consider a flexible beam rotated by a motor in a horizontal plane at one end and a tip rigidly attached at the free end. The model fits a lot of real applications such as links of robot systems and space-shuttle arms in which high speed manipulation and long and slender geometrical dimensions are the major factors causing mechanical vibration. we consider the beam equation(Guo and Song, 1995)

$$\begin{cases} \rho\tilde{y}_{tt}(x,t) + EI\tilde{y}_{xxxx}(x,t) = 0, 0 < x < l, t \geq 0, \\ \tilde{y}(0,t) = 0, \\ EI\tilde{y}_{xx}(0,t) - \tilde{I}_m\tilde{y}_{xtt}(0,t) + u(t) = 0, \\ EI\tilde{y}_{xxx}(l,t) - \tilde{M}\tilde{y}_{tt}(l,t) = 0, \\ EI\tilde{y}_{xx}(l,t) + \tilde{J}\tilde{y}_{xtt}(l,t) = 0 \end{cases} \tag{1}$$

where l is the length of the beam, ρ is the uniform mass density per unit length, EI is the uniform flexural rigidity, $\tilde{M}$ is the mass of the tip body attached, $\tilde{I}_m$ is the moment of inertia of the motor and $\tilde{J}$ is the moment of inertia associated with the tip body. Suppose the terminal state trajectory is $xv_d(t)$ at position x and time t, $v_d''(t) = 0$, i.e., the traced state would be uniform motion or fixed in some direction of the flexible beam. Let $z(x,t)$ be the total transversal displacement at position x and time t and $\tilde{y} = z(x,t) - xv_d(t)$, $u(t)$ is the torque developed by the motor.

For a linear vibration system, the property that the generalized eigenvectors of the system form a Riesz basis for the state Hilbert space is one of the most important feature from both theoretical and practical points of view. Usually, the property will lead to the establishment of such results as spectrum-determined growth conditions and exponential stability of the system. But unfortunately, it is not easy to establish such a property. Some of the methods on the verification of Riesz basis are the classical Bari' theorem(Guo and Yu, 2001; Guo, 2002a), the residual theorem(Shkalikov, 1986), the technique of non-harmonic exponentials(Xu and Guo, 2003), and the Bessel sequence property for the generalized eigenvectors of the system operators and their adjoint ones. The methods mentioned above have their limitations. In paper(Guo and Wang,2006), the investigators give a new method to verify Riesz basis which use the spectral theory on two-point parameterized ordinary differential operators.

In the paper(Guo, 2002b), the investigators designed a high derivative feedback controller for system (1) and used the Riesz basis approach to prove the closed-loop system exponentially stable. In this paper,we use the regular property of the boundary conditions (Guo,2002a) to study the Riesz basis generation of a beam equation1and give a sufficient condition under which the generalized eigenfunctions of operator form a Riesz basis of the state space. For system (1), we have the same conclusions of Guo (2002b), but our method is easier than Guo (2002b).

The organization of this paper is as follows. In the next section, we give some preliminary notation and known results of ordinary differential operators . In section 3, the main results and their proofs are given.

2. **Preliminary.** The second-order partial differential equation system with one-spacial variable has a general form:

$$\begin{cases} y_{tt}+L(y)=0, & 0<x<1, t>0 \\ U_j(y)=B_{1,j}(y)=0, & j=1,2,...,n_1-1, \\ U_j(y)=B_{1,j}(y)=0, & j=n_1,n_1+1,...,n_2-1, \\ U_j(y,y_t)=B_{1,j}(y)+B_{2,j}(y_t)=0, & j=n_2,n_2+1,...,n_3-1, \\ U_j(y,y_t)=B_{1,j}(y)+B_{2,j}(y_t)=0, & j=n_3,n_3+1,...,n_4-1, \\ U_j(y,y_t,y_{tt})=B_{1,j}(y)+B_{2,j}(y_t)+B_{3,j}(y_{tt})=0, & j=n_4,n_4+1,...,n. \end{cases} \tag{2}$$

Here Here $L(y)$ $B_{1,j}(y), B_{2,j}(y_t), B_{3,j}(y_{tt})$ are same as in Guo and Wang(2006) and we always assume that the boundary conditions of (2) are normalized(Shkalikov,1996).

Consider the system (2) in the state Hilbert space$\mathcal{H}$, we can write (2) into an evolution equation on $\mathcal{H}$:

$$\frac{d}{dt}Y(t)=\mathcal{A}Y(t), \tag{3}$$

where $\mathcal{H}$, $\mathcal{A}$ and $Y(t)$ are same as in Guo and Wang(2006).
If $F=(f,g,\eta_1,\eta_2,...,\eta_{n_0})\neq 0$ such that $\mathcal{A}F=\lambda F$ for some $\lambda\in C$, then $f\neq 0$ and (f,λ) satisfies the following two-point boundary-value problem:

$$\begin{cases} \mathcal{L}(f,\lambda)=L(f)+\lambda^2 f=0, & 0<x<1, \\ U_j(f)=B_{1,j}(y)=0, & j=1,2,...n_2-1, \\ U_j(f,\lambda f)=B_{1,j}(f)+\lambda B_{2,j}(f)=0, & j=n_2,n_2+1,...n_4-1, \\ U_j(f,,\lambda f,\lambda^2 f)=B_{1,j}(f)+\lambda B_{2,j}(f)+\lambda^2 B_{3,j}(f)=0, & j=n_4,n_4+1,...n. \end{cases} \tag{4}$$

Definition 2.1. *Let $\lambda:=\rho^m$, and $V_i(f,\lambda), i=1,2,...,n$, be an arrangement of the boundary conditions of (4) , and let $f_i, i=1,2,...,n$, be a fundamental system of $\mathcal{L}(f,\lambda)$. The determinant*

$$\Delta(\rho)=\begin{vmatrix} V_1(f_1,\lambda) & ... & V_1(f_n,\lambda) \\ ... & ... & ... \\ V_n(f_1,\lambda) & ... & V_n(f_n,\lambda) \end{vmatrix} \tag{5}$$

is called a characteristic determinant of the boundary-value problem (4).

Definition 2.2. *Let*

$$\psi_k:=\{z\in C:\frac{k\pi}{n}\leq \arg z\leq \frac{(k+1)\pi}{n}\}, k=0,1,...,2n-1. \tag{6}$$

Let $l\in N$ be fixed, and let g be a complex valued function on the section ψ_k. If g has an asymptotic expansion $g(\rho)=f(\rho)+\mathcal{O}(\rho^{-l})$, where $f(\rho):=f_0+\frac{f_1}{\rho}+...+\frac{f_l}{\rho^{l-1}}, \forall\rho\in\psi_k$, then we shall write $g(\rho)=[f(\rho)]_l$ for $\rho\in\psi_k$. Here $\mathcal{O}(\rho^{-l})$ means that $|\rho^l\mathcal{O}(\rho^{-l})|$ is bounded as $|\rho|\longrightarrow\infty$.

Definition 2.3. *Let $\lambda = \rho^m$. For $\rho \in \psi_0$, the characteristic determinant $\Delta(\rho)$ of system (4) has an asymptotic expansion of the following form:*

$$\Delta(\rho) = \rho^\gamma e^{\rho\Omega}([\Theta_{-1}(\rho)]_l e^{-\rho\omega_m} + [\Theta_0(\rho)]_l + [\Theta_1(\rho)]_l e^{\rho\omega_m}) \tag{7}$$

where $\Omega := \omega_{m+2} + ... + \omega_n$ and $[\Theta_i(\rho)]_l = \Theta_{i0} + \mathcal{O}(\rho^{-1})$ for some constants Θ_{i0} and $i = -1, 0, 1$. The boundary conditions of (4) is said to be regular if

$$\Theta_{-10} \neq 0 \text{ and } \Theta_{10} \neq 0 \tag{8}$$

It is said to be strongly regular if the zeros $\{\rho_i\}$ of $\Delta(\rho) = 0$ are simple and separable in the sense that $\inf_{i\neq j} |\rho_i - \rho_j| > 0$ for all sufficiently large $|\rho_i|$, or equivalently,

$$\Theta_{00}^2 - 4\Theta_{10}\Theta_{-10} \neq 0 \tag{9}$$

3. **Main Results And Proofs.** In order to adopt the regular property of the boundary conditions to study the Riesz basis property of system (1) as in Guo and Wang(2006), we should first formulate the closed-loop system into a linear evolution equation in an underlying Hilbert state space. As in Guo (2002b), let $y(x,t) = \tilde{y}(lx, \sqrt{l^4/EI\rho t})$, $I_m = \tilde{I}_m l^{-3}\rho^{-1}, M = \tilde{M} l^{-1}\rho^{-1}$, and a feedback controller:

$$l^2 EI^{-1} u(\sqrt{l^4/EI\rho t}) = -\alpha y_x(0,t) - \beta y_{xt}(0,t) + k y_{xxt}(0,t)$$

where $\alpha > 0$ and β and k are real numbers. Then y satisfies

$$\begin{cases} y_{tt}(x,t) + y_{xxxx}(x,t) = 0, \ 0 < x < 1, t > 0, \\ y(0,t) = 0, \\ y_{xx}(0,t) - I_m y_{xtt}(0,t) - \alpha y_x(0,t) + k y_{xxt}(0,t) = 0, \\ y_{xxx}(1,t) - M y_{tt}(1,t) = 0, \\ y_{xx}(1,t) + J y_{xtt}(1,t) = 0. \end{cases} \tag{10}$$

In order to study (1), we define the underlying state Hilbert space $\mathcal{H}$ for the system (10): $\mathcal{H} = H_E^2(0,1) \times L^2(0,1) \times \mathcal{C}^3, H_E^2(0,1) = \{f \in H^2(0,1) : f(0) = 0\}$ with the inner product induced norm

$$\|(f,g,a,b,c)\|^2 = \int_0^1 [|f|^2 + |g|^2]dx + \alpha|f'(0)|^2 + \frac{|a|^2}{I_m} + \frac{|b|^2}{M} + \frac{|c|^2}{J}$$

and the state variable

$$Y(t) = (y(.,t), y_t(.,t), I_m y_{xt}(0,t) - k y_{xx}(0,t), M y_t(1,t), J y_{xt}(1,t)) \tag{11}$$

define the operator $\mathcal{A}$ as follows:

$$\begin{cases} \mathcal{A}\begin{pmatrix} \phi \\ \psi \\ a \\ b \\ c \end{pmatrix} = \begin{pmatrix} \psi \\ -\phi^{(4)} \\ \phi''(0) - \alpha\phi'(0) - \beta\psi'(0) \\ \phi'''(1) \\ -\phi''(1) \end{pmatrix} \\ D(\mathcal{A}) = \{(\phi,\psi,a,b,c) \in (H^4 \cap H_E^2) \times H_E^2 \times C^3 | \\ a = I_m\psi'(0) - k\phi''(0), b = M\psi(1), c = J\psi'(1)\} \end{cases} \tag{12}$$

Then Eq.(10) is formulated to be an evolution equation in $\mathcal{H}$:

$$\frac{d}{dt}Y(t) = \mathcal{A}Y(t) \tag{13}$$

Theorem 3.1. *$\mathcal{A}^{-1}$ exists and is compact on* $\mathbf{H}$. *Hence the spectrum $\sigma(\mathcal{A})$ of $\mathcal{A}$ consists of isolated eigenvalues only.*

Proof. A simple calculation shows that

$$\mathcal{A}^{-1}\begin{pmatrix} \phi, \psi, a, b, c \end{pmatrix}^T = \begin{pmatrix} \phi_1, \psi_1, a_1, b_1, c_1 \end{pmatrix}^T$$

$\phi_1(x) = -[\frac{\alpha+\beta f'(0)}{\alpha} + \frac{c}{\alpha} + \frac{2b+b\alpha}{2\alpha} + \frac{1}{2}\int_0^1 s^2 g(s)ds + \frac{1}{\alpha}\int_0^1 sg(s)ds]x + \frac{b}{6}$
$+ \int_0^1 \frac{1}{6}s^3 g(s)ds - \frac{c}{2}x^2 + \frac{b}{6}(x-1)^3 - \frac{1}{6}\int_1^x (x-s)^3 g(s)ds,$
$\psi_1(x) = \phi, a_1 = \phi_1''(0) - \alpha\phi_1'(0) - \beta\psi_1'(0), b_1 = \phi_1'''(1),\ c_1 = -\phi_1''(1).$

Hence, it follows that

$$\|\mathcal{A}^{-1}\begin{pmatrix} \phi, \psi, a, b, c \end{pmatrix}^T\| \leq M\|\begin{pmatrix} \phi, \psi, a, b, c \end{pmatrix}^T\|$$

for some constant $M > 0$. By the Sobolev embedding theorem, $\mathcal{A}^{-1}$ is compact on $\mathbf{H}$.

Lemma 3.1. *(Guo,2002b) There is a family of eigenvalues* $\{\lambda_n = i\tau_n^2, -i\bar{\tau}_n^2\}$ *of* $\mathcal{A}$ *with the following asymptotic expression* $\lambda_n = i\tau^2 = -kI_m^{-1} + i[M^{-1} + (m\pi)^2] + \mathcal{O}(\frac{1}{n})$ *where* $m = n - 1/2, n$ *is a sufficiently large positive integer.*

Note. In lemma3.1, a family of eigenvalues are indeed asymptotic expression of all eigenpairs of $\mathcal{A}$.

Theorem 3.2. *Let*$\mathcal{A}$ *be defined by (12). Then the eigenvalue problem (1) is strongly regular.*

Proof. Solving the eigenvalue problem

$$\mathcal{A}\begin{pmatrix} \phi \\ \psi \\ a \\ b \\ c \end{pmatrix} = \begin{pmatrix} \psi \\ -\phi^{(4)} \\ \phi''(0) - \alpha\phi'(0) - \beta\psi'(0) \\ \phi'''(1) \\ -\phi''(1) \end{pmatrix} = \lambda\begin{pmatrix} \phi \\ \psi \\ I_m\psi'(0) - k\phi''(0) \\ M\psi(1) \\ J\psi'(1) \end{pmatrix}$$

one has $\psi = \lambda\phi$ and

$$\begin{cases} \phi^{(4)} + \lambda^2\phi = 0, \\ \phi(0) = (I_m\lambda^2 + \beta\lambda + \alpha)\phi'(0) - (k\lambda + 1)\phi''(0) = 0, \\ \phi'''(1) - M\lambda^2\phi(1) = 0, \\ \phi''(1) + J\lambda^2\phi'(1) = 0. \end{cases} \tag{14}$$

Let $f(x) = \phi(1-x)$. Then f satisfies

$$\begin{cases} f^{(4)} + \lambda^2 f = 0, \\ f(1) = 0, \\ (I_m\lambda^2 + \beta\lambda + \alpha)f'(1) + (k\lambda + 1)f''(1) = 0, \\ f'''(0) + M\lambda^2 f(0) = 0, \\ f''(0) - J\lambda^2 f'(0) = 0. \end{cases} \tag{15}$$

Set $\lambda = \rho^2$, and in sector $\phi_0 = \{z \in C | 0 \leq \arg z \leq \frac{\pi}{4}\}$ we arrange the roots of -1 as

$$\omega_1 = -\tfrac{\sqrt{2}}{2} + i\tfrac{\sqrt{2}}{2}, \omega_2 = -\tfrac{\sqrt{2}}{2} - i\tfrac{\sqrt{2}}{2},$$
$$\omega_3 = \tfrac{\sqrt{2}}{2} + i\tfrac{\sqrt{2}}{2}, \omega_4 = \tfrac{\sqrt{2}}{2} - i\tfrac{\sqrt{2}}{2},$$

Such that

$$Re(\rho\omega_1) \leq Re(\rho\omega_2) \leq Re(\rho\omega_3) \leq Re(\rho\omega_4),$$

Note that the equation $f^{(4)}(x) + \rho^4 f(x) = 0$ has four fundamental solutions $f_i(x), i = 1, 2, 3, 4$ which are independent, and have the following expressions:

$$f_k(x) = e^{\rho\omega_k x}, k = 1, 2, 3, 4 \tag{16}$$

Substituting$\lambda := \rho^2$ and (16) into the boundary conditions in (15),for k=1,2,3,4,

$$\begin{aligned}
&U_4(f_k,\rho) = f_k(1) = e^{\rho\omega_k},\\
&U_3(f_k,\rho) = (I_m\rho^4+\beta\rho^2+\alpha)f_k'(1)+(k\rho^2+1)f_k''(1)\\
&= (I_m\rho^4+\beta\rho^2+\alpha)\rho\omega_k e^{\rho\omega_k}+(k\rho^2+1)(\rho\omega_k)^2e^{\rho\omega_k},\\
&U_2(f_k,\rho) = f_k'''(0)+M\rho^4 f_k(0) = (\rho\omega_k)^3+M\rho^4\\
&U_1(f_k,\rho) = f_k''(0)-J\rho^4 f_k'(0) = (\rho\omega_k)^2-J\rho^5\omega_k
\end{aligned}$$

The characteristic determinant $\Delta(\rho)$ of the boundary-value problem (15) has the following form:

$$\Delta(\rho) = \begin{vmatrix}
e^{\rho\omega_1} & e^{\rho\omega_2} & e^{\rho\omega_3} & e^{\rho\omega_4}\\
[I_m\omega_1 e^{\rho\omega_1}+\mathcal{O}(\frac{1}{\rho})]\rho^5 & [I_m\omega_2 e^{\rho\omega_2}+\mathcal{O}(\frac{1}{\rho})]\rho^5 & [I_m\omega_3 e^{\rho\omega_3}+\mathcal{O}(\frac{1}{\rho})]\rho^5 & [I_m\omega_4 e^{\rho\omega_4}+\mathcal{O}(\frac{1}{\rho})]\rho^5\\
[M+\mathcal{O}(\frac{1}{n})]\rho^4 & [M+\mathcal{O}(\frac{1}{\rho})]\rho^4 & [M+\mathcal{O}(\frac{1}{n})]\rho^4 & [M+\mathcal{O}(\frac{1}{\rho})]\rho^4\\
[-J\omega_1+\mathcal{O}(\frac{1}{\rho^3})]\rho^5 & [-J\omega_2+\mathcal{O}(\frac{1}{\rho^3})]\rho^5 & [-J\omega_3+\mathcal{O}(\frac{1}{\rho^3})]\rho^5 & [-J\omega_4+\mathcal{O}(\frac{1}{\rho^3})]\rho^5
\end{vmatrix}$$

$= 2i\rho^{14}e^{\rho\omega_4}MJI_m[-e^{\rho\omega_2}+e^{\rho\omega_3}+\mathcal{O}(\frac{1}{\rho})]$

Since

$$\theta_{-10} = 2i \neq 0, , \theta_{10} = -2i \neq 0,\ \theta_{00} = 0$$

the eigenvalue problem (1) is strongly regular.

By Theorem 3.2 and Lemma3.1 in this paper and theorem2.8 , theorem2.9 in paper Guo and Wang (2006), we have the following corollary:

Corollary 3.1. *Let$\mathcal{A}$ be defined by (12). Then*
(1) the system of generalized eigenfunctions of $\mathcal{A}$ is complete in $\mathcal{H}$: $Sp(\mathcal{A}) = \mathcal{H}$,
(2) the generalized eigenfunctions of $\mathcal{A}$ form a Riesz basis for $\mathcal{H}$,
(3) $\mathcal{A}$ generates a C_0-semigroup $e^{\mathcal{A}t}$ on $\mathcal{H}$,
(4) the spectrum-determined growth condition holds true: $s(\mathcal{A}) = \omega(\mathcal{A})$.
(5) $k > 0$, the C_0-semigroup $e^{\mathcal{A}t}$ generated by $\mathcal{A}$ is exponentially stable:

$$\|e^{\mathcal{A}t}\Phi\| \leq Me^{-\omega t\|\Phi\|}, for\ any\ \Phi \in \mathcal{H}$$

where $M > 0$ is a constant independent of Φ, $Re\lambda < -\omega$ for all $\lambda \in \sigma(\mathcal{A})$.

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NEW APPROACH TO REALIZE OPTIMAL HEDGE RATIO BASED ON TAIL RISK

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ABSTRACT. *Combining expected shortfall (ES) and tail variance (TV), comprehensive hedging degree (CHD) is constructed and maximized to realize optimal strategy of stock index futures hedging. Nonparametric methods and grid search technique are employed. The maximum CHD hedging model can be regarded as the generalization of the minimum-variance hedging model and the hedging models under risk-return analysis framework. Empirical studies show that the CHD model outperforms the minimum-variance hedging model in both in-sample and out-of-sample results. The new approach is helpful to reduce the hedging cost by provide more delicate hedge ratio.*
Keywords: Tail Risk; Optimal Strategy; Hedging; Stock Index Futures

1. Introduction. In recent years, as crisis in the financial markets happens frequently, tail risk management has gained more and more attention from investors and has become an important part of risk management. As Bhansali (2009) points out, well-positioned portfolios are not only those that outperform others in periods of normalcy, but those that can weather storms. Tail insurance is an offensive strategy for the long term, even though it may appear to be a defensive strategy in the short term. Tail risk plays an important impact on the emerging stock markets. Early studies find that there exist excess-kurtosis and fat-tail features in A-share market in China. It implies that tail risk can't be ignored in A-share market. It is not only the demand of market but also the need of investors for risk hedging that motivate the research of tail risk management. In practice, investors with different risk tolerance may be concerned with different risk. They are inclined to hedge the sort of risk that will cause greater loss on them when it occurs. The sort of risk always means the tail risk. The inclination of risk hedging can be explained in two aspects. First, transaction cost for hedging normal risk may offset the hedged loss. Second, due to the objective conditions, risk can't be hedged completely. So, investors should use their resources where they are needed most. In the past years, investors in China have little choice but to hold diversified portfolios to manage risk. Today, as the launch of CSI 300 stock index futures in China at 16 April 2010, investors can use the stock index futures to hedge the systematic risk of stock market. The paper mainly discusses the hedging theory for tail risk.

In previous literatures, hedging is viewed as an application of basic portfolio theory. Under the theory framework, risk avoidance and profits maximization are integrated and one buys or sells futures for the same risk-return reasons that one buys any other security. Fu and Tan (2009) studied the application of portfolio theory in stock index futures hedging and found good effectiveness.

There are many kinds of hedging models under portfolio theory. One of the main theoretical issues in hedging is to determine the optimal hedge ratio. However, the optimal hedge ratio depends on the particular objective function to be optimized. Different objective function brings different model. For example, one of the most widely-used hedging models is based on the minimization of the variance of the hedged portfolio. The model is simple to understand and estimate. However, it ignores the expected return of the hedged portfolio. Therefore, it is not consistent with the risk-return framework. Other hedging models involve different objective functions, such as Sharpe ratio, expected utility, mean extended-Gini coefficient (MEG), generalized semivariance (GSV) (see Chen et al (2003)). One weakness of the models is about the risk selection. Most models are specified to hedge the overall risk including both positive return volatility and negative return volatility. In fact, investors always expect to reduce the loss and keep the profit. Although the GSV model for hedging considers the downside risk, it can't easily provide effective strategy for hedging tail risk at different level. It is worthy to point out that hedging strategies based on the overall risk minimization may enhance the tail risk. Another weakness of the models is about the risk preference of investors. Some models doesn't consider the difference of risk preference, supposing that all investors have the same risk preference, such as the minimum-variance model and the Sharpe hedging model. In the MEG hedging model, parameters of risk preference are always given subjectively. Because different investors may have different utility function, hedging models based on maximum-utility don't have practical application. In addition, the models don't consider the market efficiency on the implement of hedging strategies. Due to the objective conditions of the stock index futures market and the stock market, it may be favorable for risk avoidance or profit maximization. The paper argues that the inclination of market on risk hedging should be introduced in the hedging model in order to obtain effective hedging strategy. It is remarkable that the optimal hedge ratios based on the different models are different and there is no single optimal hedge ratio that is distinctly superior to the remaining ones. In practice, it is difficult for investors to select proper hedging model to get optimal hedging strategy.

Landsman (2010) proposed the tail mean-variance (TMV) approach based on expected shortfall and tail variance as a measure for the optimal portfolio selection, which is enlightening for the establishment of hedging model for tail risk. But the TMV model is based on the assumption of multivariate normal distribution which is always violated in practice. So, it is limited in application.

In the paper, we follow the idea of Landsman and try to establish an effective model that can provide optimal hedge ratio for tail risk at different level and investors with different risk preference. Firstly, we introduce expected shortfall (ES) and tail variance (TV) as measurements of tail risk and construct comprehensive hedging degree (CHD) from the perspective of hedging performance evaluation. Then, according to the hedging principles, the paper establishes the maximum-CHD model with nonparametric method and grid search technique. In the maximum-CHD model, risk preference of investors is divide into two parts. One part is embodied in the choice of tail risk for hedging, which can be implemented in the model by determining the confidence level. The other part is represented by the tradeoff between ES and TV, which reflects investors preference in ES hedging and TV hedging. The hedging efficiency of market is also discussed in the maximum-CHD model by introduced market hedging inclination index, which reflects the market capacity in hedging ES and TV due to the features of stock index futures market and the stock market. We demonstrate that the maximum-CHD model is a generalization of the hedging models under minimum-variance framework and risk-return tradeoff framework. With nonparametric estimator, the new model will have a broad application prospect. Finally, with the simulated data of CSI 300 stock index futures, empirical study is carried out by comparing the maximum-CHD model with the minimum-variance model.

The remainder of the paper is organized as follows. Section 2 introduces the measurements of tail risk. Nonparametric estimators of ES and TV is given in section 3. The maximum-CHD model for hedging is established in section 4. The empirical findings are presented in section 5. The summary and conclusions are provided in section 6.

2. Measurements for Tail Risk. Value at risk (VaR) and expected shortfall (ES) are two popular risk measures based on the tail of distribution, which have been rapidly developed as analytic tools to assess market risk. VaR is simple and easy to estimate and has been chosen by Basel Committee on Banking Supervision as the benchmark of risk measurement for capital requirements. In terms of the formal definition, VaR is simply a quantile of the loss distribution over a prescribed holding period at a given confidence level. But, VaR is not coherent risk measure, because it does not satisfy the subadditivity. ES is proposed based on VaR by Artzner et al. (1999) and is defined as the expected loss, given that the loss is at least as large as some given VaR. ES is a coherent risk measure satisfying homogeneity, monotonicity, translation invariance and subadditivity. As advocated by Artzner et al. (1999), ES is preferred in practice due to its better properties, although VaR is widely used in applications.

Let $\{P_t\}_{t=1}^{T}$ be the market values of an asset or a portfolio of assets over n periods of a time unit. Let $X_t = -\ln(P_t / P_{t-1})$ be the negative log return (log loss) over the t-th period. $\{X_t\}_{t=1}^{T}$ has the marginal distribution function $F(\bullet)$. Given a positive value α close to zero, the VaR at a confidence level $1-\alpha$ is denoted as υ_α, that is

$$\upsilon_\alpha(X) = \inf\{u : F(u) \geq 1-\alpha\}$$

The ES associated with confidence level $1-\alpha$, denoted as μ_α, is the conditional expectation of a loss given that the loss is larger than υ_α, that is

$$\mu_\alpha(X) = E(X \mid X > \upsilon_\alpha).$$

It is easily known from the definition that, the VaR specifies a level of excessive losses such that the probability of a loss larger than υ_α is less than α. So VaR can be used to define the tail risk. A major shortcoming of VaR is that it provides no information on the amount of the excessive losses apart from specifying a level that defines the excessive losses. In contrast, ES is a risk measure which can reflect the extreme loss larger than υ_α. However, the ES isn't informative on the volatility of the extreme loss, which is an important proxy for tail risk. In Furman and Landsman (2006), a tail variance risk measure (TV) was proposed. The TV at a confidence level $1-\alpha$ is denoted as ω_α, that is

$$\omega_\alpha(X) = E\left((X-\mu_\alpha)^2 \mid X > \upsilon_\alpha\right)$$

The TV estimates the deviation of the extreme loss greater than υ_α from μ_α, reflecting the volatility of the extreme loss. So, we can use ES and TV to measure the tail risk comprehensively. The ES represents the expected level of the extreme loss and the TV represents the volatility of the extreme loss.

By choosing the confidence level $1-\alpha$, investors can determine the tail risk that they expect to hedge according to their risk tolerance. We propose the following procedure to choose the value of parameter α.

Let r_s be the return of the spot one holds. Let R be the minimum return that one can tolerate. $-R$ means the expected maximum loss. The parameter α can be obtained by solving the equation $ES_\alpha(-r_s) = -R$. So, if the investors know the minimum return they can tolerate, they can easily determine the confidence level.

3. Nonparametric Estimation of ES and TV. Early estimators of VaR and ES are based on parametric models, which are easy to interpret. However, the parametric approaches are model dependent and are subject to errors of model misspecification. In recent years, nonparametric methods are proposed to estimate VaR and ES (see Scaillet, 2004), Chen and Tang (2005), Chen (2008), Cai and Wang (2008). These nonparametric estimators have the advantages of (i) being model-free and avoiding potential model misspecification; and (ii) being free of distributional assumptions and able to capture fat-tail and asymmetry distribution of returns automatically; and (iii) imposing much weaker assumptions on the dynamics of the return process and allowing data "speak for themselves". In the paper, we consider the nonparametric estimator of ω_α based on the nonparametric kernel estimators of υ_α and μ_α.

Let X be the negative log return of asset or portfolio of assets. Let $\{X_t\}_{t=1}^n$ be the observed data of X over n periods.

VaR υ_α can be expressed as $\upsilon_\alpha(x) = S^{-1}(\alpha)$, where $S(x) = 1-F(x)$ and $F(x)$ is the CDF of X_t. The nonparametric estimation of υ_α can be constructed as $\hat{\upsilon}_\alpha(x) = \hat{S}^{-1}(\alpha)$, where $\hat{S}^{-1}(\alpha)$ is a nonparametric estimator of $S^{-1}(\alpha)$.

Let f be the PDF of X_t. The nonparametric kernel density estimator of f is

$\hat{f}_h(x) = n^{-1}\sum_{t=1}^{n} K_h(x - X_t)$, where $K_h(x - X_t) = h^{-1}K((x - X_t)/h)$, K is a kernel function and h is the smoothing bandwidth which controls the smoothness of the estimate. In the empirical studies of the paper, Gaussian kernel function is used and the h is selected by the cross-validation method.

The nonparametric estimator of F is given by

$$\hat{F}_h(x) = \int_{-\infty}^{x} \hat{f}_h(x)dx = \int_{-\infty}^{x} n^{-1}\sum_{t=1}^{n} K_h(x - X_t)dx = 1 - n^{-1}\sum_{t=1}^{n} G_h(x - X_t),$$

where $G_h(v) = \int_{v/h}^{\infty} K(u)du$ and $G(v) = \int_{v}^{\infty} K(u)du$.

Using the plug-in method, the nonparametric estimators of υ_α, μ_α and ω_α are obtained as follows, respectively denoted as $\hat{\upsilon}_\alpha$, $\hat{\mu}_\alpha$ and $\hat{\omega}_\alpha$.

$$\hat{\upsilon}_\alpha = \hat{S}^{-1}(\alpha)$$

where $$\hat{S}(x) = 1 - \hat{F}(x) = n^{-1}\sum_{t=1}^{n} G_h(x - X_t)$$

$$\hat{\mu}_{\alpha,h} = \alpha^{-1}\int_{\hat{\upsilon}_{\alpha,h}}^{\infty} x\hat{f}(x)dx = \alpha^{-1}\int_{\hat{\upsilon}_{\alpha,h}}^{\infty} xn^{-1}\sum_{t=1}^{n} K_h(x - X_t)dx = (\alpha n)^{-1}\sum_{t=1}^{n}\left[hG_{1h}(\hat{\upsilon}_{\alpha,h} - X_t) + X_t G_h(\hat{\upsilon}_{\alpha,h} - X_t)\right]$$

where $$G_{1h}(v) = \int_{v/h}^{\infty} uK(u)du.$$

$$\begin{aligned}
\hat{\omega}_{\alpha,h} &= \alpha^{-1}\int_{\hat{\upsilon}_{\alpha,h}}^{\infty} (x - \hat{\mu}_{\alpha,h})^2 \hat{f}(x)dx \\
&= (\alpha n)^{-1}\sum_{t=1}^{n}\int_{\hat{\upsilon}_{\alpha,h}}^{\infty} (x - \hat{\mu}_{\alpha,h})^2 K_h(x - X_t)dx \\
&= (\alpha n)^{-1}\sum_{t=1}^{n}\left[h^2 G_{2h}(\hat{\upsilon}_{\alpha,h} - X_t) + 2(X_t - \hat{\mu}_{\alpha,h})hG_{1h}(\hat{\upsilon}_{\alpha,h} - X_t) + (X_t - \hat{\mu}_{\alpha,h})^2 G_h(\hat{\upsilon}_{\alpha,h} - X_t)\right]
\end{aligned}$$

where $$G_{2h}(v) = \int_{v/h}^{\infty} u^2 K(u)du.$$

4. The Maximum-CHD Model. When the tail risk for hedging is determined, the following work is to select the proper hedging strategies, the key issue of which is the determination of the optimal hedge ratio. The optimal hedge ratio is always obtained by optimizing particular function which measures risk, return or utility. With the purpose of reducing tail risk, minimization of ES or TV is a natural approach to calculate the optimal hedge ratio. However, the optimal hedge ratios obtained by minimizing ES and TV separately are always different. The minimum-ES hedge ratio may be ineffective in minimizing TV, and so is the minimum-TV hedge ratio for minimizing ES. In order to hedge tail risk comprehensively, the ES and the TV should be integrated. The paper considers the hedging performance for tail risk and constructs the comprehensive hedging degree which can evaluate the overall hedging performance on both ES and TV. By maximizing the CHD, the optimal hedge ratio is obtained.

4.1. Hedging Performance. Ederington (1979) proposed the measure of hedging effectiveness defined as the percent reduction in the variance. The measure is denoted as

HE^{var} and formulated as

$$HE^{\mathrm{var}}(H)=\frac{\mathrm{var}(r_s)-\mathrm{var}(r_p)}{\mathrm{var}(r_s)}$$

where H denote the optimal hedge ratio and $r_p = r_s - Hr_f$, r_s and r_f represent the return of the spot investors holding and the future used for hedging respectively.

HE^{var} can evaluate the hedging performance for overall risk measured by variance. But, it is not suitable for the performance of tail risk hedging. We construct the measures of hedging effectiveness based on ES and TV, formulated respectively as

$$HE_{\alpha}^{ES}(H)=\frac{ES_{\alpha}(-r_s)-ES_{\alpha}(-r_p)}{ES_{\alpha}(-r_s)}$$

$$HE_{\alpha}^{TV}(H)=\frac{TV_{\alpha}(-r_s)-TV_{\alpha}(-r_p)}{TV_{\alpha}(-r_s)}$$

where α is associated with the tail risk.

HE_{α}^{ES} and HE_{α}^{TV} reflect the percent reduction in ES and TV respectively. It is worthy to note that, due to the intrinsic features of markets, the reduction degree of ES and TV through hedging is limited. The maximum limitations of hedging effectiveness in terms of ES and TV embodies the hedging capacity of the futures market and the spot market, denoted by $HE_{\alpha,opt}^{ES}\left(H_{opt}^{ES}\right)$ and $HE_{\alpha,opt}^{TV}\left(H_{opt}^{TV}\right)$, where $HE_{\alpha,opt}^{ES}$ and $HE_{\alpha,opt}^{TV}$ represent the optimal hedge ratios when the maximum limitations are achieved. Because HE_{α}^{ES} and HE_{α}^{TV} can't reflect the comprehensive hedging performance for tail risk, it needs to construct other measure from the perspective of comprehensive evaluation.

4.2. Comprehensive Hedging Degree. In order to measure the hedging performance for tail risk in terms of both ES and TV, we use the comprehensive evaluation method and construct the comprehensive hedging degree.

Firstly, individual index is defined as

$$k_{ES}=\frac{HE_{\alpha}^{ES}(H)}{HE_{\alpha,opt}^{ES}\left(H_{opt}^{ES}\right)},\quad k_{TV}=\frac{HE_{\alpha}^{TV}(H)}{HE_{\alpha,opt}^{TV}\left(H_{opt}^{TV}\right)}.$$

k_{ES} and k_{TV} reflect respectively the realization extent of hedging in reduction of ES and TV.

Based on the individual index, the comprehensive hedging degree (CHD) is constructed as

$$CHD_{\alpha}(H)=\lambda k_{ES}+(1-\lambda)k_{TV}$$

where $\lambda \in [0,1]$ is the weight parameter, reflecting the tradeoff between ES and TV as well as the risk preference of investors. When α is close to 1, λ also reflects the preference of investors to return.

The comprehensive hedging degree evaluates the performance of tail risk hedging comprehensively by integrated the measures of hedging effectiveness based on ES and TV. It can be decomposed as

$$CHD_\alpha(H) = \lambda \frac{HE_\alpha^{ES}(H)}{HE_{\alpha,opt}^{ES}\left(H_{opt}^{ES}\right)} + (1-\lambda)\frac{HE_\alpha^{TV}(H)}{HE_{\alpha,opt}^{TV}\left(H_{opt}^{TV}\right)}$$

$$= \frac{\lambda}{A} + \frac{1-\lambda}{B} - \frac{\lambda}{Aa}\left[ES_\alpha\left(-r_p\right) + \frac{Aa}{Bb}\left(\frac{1}{\lambda}-1\right)TV_\alpha\left(-r_p\right)\right]$$

$$= \frac{\lambda}{A} + \frac{1-\lambda}{B} - \frac{\lambda}{Aa}\left[ES_\alpha\left(-r_p\right) + \eta_1\eta_2 TV_\alpha\left(-r_p\right)\right]$$

where

$$A = HE_{\alpha,opt}^{ES}\left(H_{opt}^{ES}\right)、B = HE_{\alpha,opt}^{TV}\left(H_{opt}^{TV}\right)、a = ES_\alpha\left(-r_s\right)、b = TV_\alpha\left(-r_s\right)、\lambda \in [0,1]、\eta_1 = \frac{Aa}{Bb}、\eta_2 = \left(\frac{1}{\lambda}-1\right)$$

The decomposition indicates that the maximization of CHD coincides with the classical mean-variance framework when $\alpha \to 1$, and reduces to the minimum-variance framework when $\alpha \to 1$ and $\lambda \to 0$. By adjusting the values of α and λ, CHD can evaluate the effectiveness for hedging tail risk at different level by investors with different risk preference.

In the paper, η_1 is called “the market hedging inclination parameter”, which reflects the difference of efficiency on hedging ES and TV due to the intrinsic features of futures market and spot market. The greater the η_1 is, the lower the efficiency on hedging TV is, so the risk represented by TV should be emphasized and weighted in the risk measurement. η_2 is called “the investor hedging inclination parameter”, which reflects the difference of inclination investors show on hedging ES and TV. Higher η_2 implies greater inclination of investors on hedging TV and the risk represented by TV should be weighted in the risk measurement.

In the construction of CHD, the selection of parameter λ is very important. There are many methods to determine the weight parameter in the studies of comprehensive evaluation. We recommend the Delphi method which is always used in practice. The procedure is as follows:

First, select one from ES and TV as the prior risk indicator that the investors prefer to hedge. Second, give the range of the individual index k_{ES} or k_{TV} associated with the prior risk indicator that investors expect to achieve by hedging. Third, adjust the value of λ and calculate the optimal hedge ratio by maximizing CHD. Finally, select the value of λ that makes the individual index reach the demanded range.

4.3. Optimal Hedge Ratio. In the paper, the optimal hedge ratio is derived by maximizing CHD. Because of the complexity of CHD function and the nonparametric estimators, we recommend the grid search technique to seek for the optimal hedge ratio. The procedure is as follows.

Let ε be the minimum precision of the optimal hedge ratio demanded by investors. We take $\varepsilon = 0.001$ in the empirical study.

Let $H = \varepsilon,\ 2\varepsilon, 3\varepsilon,\ \ldots\ldots,\ \frac{1}{\varepsilon}\varepsilon$ and calculate $CHD_{\alpha}(H)$ respectively. Select the optimal hedge ratio that has the maximum CHD.

Grid search technique can be implemented easily with the assistance of computer and has a practical application.

5. Empirical Study.

5.1. Data. The futures data corresponds to daily settlement prices for the nearby contracts of CSI 300 stock index future. The futures data are obtained from the CFFEX (China Financial Futures Exchange) website which provides simulation trading of CSI 300 stock index futures.

The spot portfolio is construct with 50 stocks heavily held by security investment funds. The 50 stocks are those that have the largest current market value. The weight of individual stock in the spot portfolio is the ratio of the individual current market value to the total current market value of the 50 stocks. The stocks data are daily closing prices from the website of hexun.com.

Returns are calculated by computing the differences in the natural logarithm of price. The return of the spot portfolio is the weighted average of the return of individual stock. The sample period is from 26 December 2007 to 30 June 2009. In total, we get 367 daily observations of which the first 345 (from 26 December 2007 to 27 May 2009) observations are used for in-sample estimation and the remaining 22 (from 1 June 2009 to 30 June 2009) observations are used for out-of-sample forecasting.

5.2. Model for Comparison. The paper compares the proposed maximum-CHD hedging model with the traditional minimum-variance hedging model. We use the GARCH model to calculate the minimum-variance hedge ratio because it can capture the time-varying second moment effects in the joint distribution of spot and futures, Fu and Tan (2009). The estimation results of the GARCH model are as follows.

The mean equation is

$$r_{s,t} = \underset{(0.0000)}{0.6887} r_{f,t} - \underset{(0.0064)}{0.1054} r_{s,t-1} + \varepsilon_t$$

The variance equation is

$$\sigma_t^2 = \underset{(0.6595)}{7.4561\times 10^{-5}} + \underset{(0.0743)}{0.8033}\sigma_{t-1}^2$$

The minimum-variance hedge ratio is equal to the coefficient of $r_{f,t}$ in the mean equation, that is 0.6887. The hedging effectiveness of the minimum-variance model based on variance criteria is $HE_{in-sample}^{\mathrm{var}} = 0.5242$ and $HE_{out-of-sample}^{\mathrm{var}} = 0.3399$, indicating that variance is reduced by 52.42% in the in-sample period and by 33.99% in the out-sample period. The hedging effectiveness of the minimum-variance model based on ES and TV criteria is shown in table 1. It can be found that the effectiveness of hedging tail risk based on the minimum-variance hedging model is not good.

TABLE 1. Hedging effectiveness of the minimum-variance model

HE	Sample	α					
		0.01	0.05	0.1	0.5	0.95	1
HE_{α}^{ES}	In-sample	-0.067	0.176	0.272	0.385	0.511	0.648
	Out-of-sample	-0.008	-0.066	-0.109	-0.581	-1.066	-0.832
HE_{α}^{TV}	In-sample	-3.062	-2.143	-1.305	0.239	0.485	0.530
	Out-of-sample	0.341	0.306	0.261	0.188	0.313	0.340

5.3. Results Based on Maximum-CHD Model. The optimal hedge ratios based on the maximum-CHD hedging model are calculated with different α and λ (see table 2). The paper also compares the comprehensive hedging degree of the maximum-CHD hedging model and the minimum-variance hedging model (see table 3 and table 4).

Table 2 shows that, the optimal hedge ratio is different when the values of α and λ are changed. The optimal hedge ratios with $\alpha < 0.5$ are smaller than that with $\alpha > 0.5$, indicating that the hedging cost for hedging overall risk is greater than that for hedging extreme risk. When $\alpha = 1$ and $\lambda = 0$, the optimal hedge ratio is 0.69 which is close to the optimal hedge ratio of the GARCH model. It is implied that the maximum-CHD hedging model can reduce to the minimum-variance hedging model. In addition, the optimal hedge ratio increases with the increase of λ, indicating that the hedging cost will increase when investors are inclined to hedge the risk represented by ES.

TABLE 2. The optimal hedge ratio based on the maximum-chd model

α \ λ	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
0.01	0.238	0.238	0.238	0.238	0.238	0.238	0.238	0.238	0.238	0.242	0.250
0.05	0.166	0.169	0.173	0.179	0.185	0.193	0.212	0.231	0.264	0.359	0.519
0.1	0.145	0.148	0.151	0.152	0.158	0.167	0.183	0.212	0.245	0.328	0.692
0.5	0.474	0.479	0.488	0.495	0.544	0.548	0.591	0.619	0.692	0.775	0.839
0.95	0.660	0.692	0.700	0.714	0.744	0.776	0.838	0.871	0.935	1.000	1.000
1	0.690	0.714	0.744	0.776	0.839	0.930	1.000	1.000	1.000	1.000	1.000

Table 3 shows that, the hedging performance of the maximum-CHD hedging model with different α and λ is satisfactory in the in-sample period. When α takes the value of 0.01, 0.05 and 0.1, the corresponding CHD of the GARCH model is negative, implying that hedging strategies based on the GARCH model can enhance the tail risk. In this case, the CHD of the GARCH model increases with the increase of λ. It implies that the GARCH model is more effective in hedging the risk represented by ES than the risk represented by TV. When α takes the value of 0.95 and 1, the corresponding CHD of the GARCH model is close to that of the maximum-CHD model. It indicates that the GARCH model is more effective in hedging the overall risk than the tail risk, while the maximum-CHD model is effective in hedging different risk including the overall risk and the tail risk by adjusting the values of α and λ.

TABLE 3. The in-sample chd of the maximum-chd model and the garch model

λ / α	Model	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
0.01	Max-CHD	1.000	1.000	1.000	0.999	0.999	0.999	0.998	0.998	0.998	0.998	1.000
	GARCH	-7.952	-7.206	-6.460	-5.714	-4.967	-4.221	-3.475	-2.729	-1.982	-1.236	-0.490
0.05	Max-CHD	1.000	0.945	0.891	0.838	0.787	0.738	0.696	0.666	0.653	0.710	1.000
	GARCH	-8.245	-7.334	-6.424	-5.513	-4.603	-3.693	-2.782	-1.872	-0.961	-0.051	0.860
0.1	Max-CHD	1.000	0.936	0.873	0.811	0.750	0.691	0.638	0.596	0.579	0.619	1.000
	GARCH	-13.903	-12.413	-10.923	-9.432	-7.942	-6.452	-4.961	-3.471	-1.981	-0.491	1.000
0.5	Max-CHD	1.000	0.976	0.953	0.932	0.915	0.903	0.895	0.893	0.906	0.939	1.000
	GARCH	0.718	0.741	0.765	0.788	0.812	0.835	0.859	0.882	0.906	0.929	0.953
0.95	Max-CHD	1.000	0.982	0.965	0.951	0.939	0.932	0.929	0.931	0.945	0.970	1.000
	GARCH	0.998	0.982	0.965	0.948	0.932	0.915	0.898	0.882	0.865	0.849	0.832
1	Max-CHD	1.000	0.970	0.944	0.922	0.907	0.901	0.913	0.935	0.956	0.978	1.000
	GARCH	1.000	0.969	0.938	0.907	0.876	0.845	0.813	0.782	0.751	0.720	0.689

TABLE 4. The out-of-sample chd of the maximum-chd model and the garch model

λ / α	Model	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
0.01	Max-CHD	0.613	0.591	0.569	0.548	0.526	0.504	0.483	0.461	0.439	0.424	0.413
	GARCH	0.398	0.357	0.315	0.274	0.232	0.191	0.149	0.108	0.066	0.025	-0.017
0.05	Max-CHD	0.482	0.466	0.452	0.441	0.428	0.417	0.423	0.423	0.435	0.368	0.181
	GARCH	0.358	0.308	0.258	0.207	0.157	0.107	0.057	0.007	-0.044	-0.094	-0.144
0.1	Max-CHD	0.430	0.413	0.395	0.372	0.358	0.348	0.346	0.356	0.359	0.311	-0.254
	GARCH	0.313	0.257	0.201	0.145	0.089	0.032	-0.024	-0.080	-0.136	-0.192	-0.248
0.5	Max-CHD	0.420	0.266	0.106	-0.055	-0.272	-0.451	-0.796	-1.126	-1.730	-2.408	-2.990
	GARCH	0.246	0.001	-0.245	-0.490	-0.735	-0.980	-1.225	-1.471	-1.716	-1.961	-2.206
0.95	Max-CHD	0.499	0.442	0.391	0.339	0.284	0.232	0.184	0.139	0.081	0.030	0.001
	GARCH	0.492	0.443	0.394	0.345	0.296	0.247	0.198	0.149	0.099	0.050	0.001
1	Max-CHD	0.546	0.491	0.434	0.379	0.333	0.266	0.175	0.132	0.088	0.045	0.001
	GARCH	0.546	0.492	0.437	0.383	0.329	0.274	0.220	0.165	0.111	0.056	0.02

In table 4, the out-of-sample prediction results show that the hedging performance of both the GARCH model and the maximum-CHD model is not satisfactory. When α takes the values of 0.01, 0.05, 0.1 and 0.5, the CHD of the maximum-CHD model is larger than that of the GARCH model, implying that the maximum-CHD model is more effective than the GARCH model in hedging the tail risk. When α takes the values of 0.95 and 1, the CHD of the GARCH model is close to that of the maximum-CHD model, implying that the two models performs closely in hedging the overall risk.

Overall, we obtain the conclusion that the maximum-CHD hedging model outperforms the minimum-variance model in both the in-sample results and the out-of-sample results and is more effective in the in-sample period than the out-of-sample period. The minimum-variance model may enhance the tail risk while it reduce the overall risk.

6. Conclusions. In most previous studies, the hedging model is based on the minimization of variance and aims to reduce the overall volatility of asset price. However, in practice, investors need to hedge the risk that have important influence on them according to their risk preference and risk tolerance. The paper considers the individualized risk and pays attention to the management of tail risk, for which the hedging with stock index futures is a good approach.

The paper proposes the maximum-CHD hedging model, which can be used to hedge tail risk at different level for investors with different risk preference and risk tolerance. When α takes small values close to zero, the new model embodies the tradeoff between the expected level and the volatility of the extreme loss; when α takes large values close to 1, the new model is consistent with the risk-return analysis framework. When α is equal to 1 and λ is equal to zero, the CHD model reduces to the minimum-variance hedging model. When α and λ are both equal to 1, the CHD model reduces to the maximum-return hedging model. Therefore, the maximum-CHD hedging model can be regarded as the generalization of the minimum-variance hedging model and the hedging models under risk-return analysis framework. In addition, the new model embodies the market hedging inclination and the investors hedging inclination, which is important in understanding the hedging motivation and analyzing the hedging performance.

The empirical studies show that, the maximum-CHD hedging model can provide optimal hedge ratios for hedging tail risk at different level for investor with different risk preference and risk tolerance by adjusting the parameters α and λ. So, the proposed model is more delicate. By taking the individualized optimal hedge ratio, the hedging cost can be reduced. In addition, the maximum-CHD hedging model outperforms the minimum-variance model in both the in-sample results and the out-of-sample results and is more effective in the in-sample period than the out-of-sample period. The minimum-variance model may increase the tail risk while it reduces the overall risk.

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CONSTRUCTING THE MONITORING SYSTEM OF EPIDEMIC DISEASE – A CASE STUDY OF ENTEROVIRUS INFECTION WITH SEVERE COMPLICATIONS

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ABSTRACT. *This study presents a set of infectious disease epidemical monitoring system.By using the c control chart, the Poisson Exponentially Weighted Moving Average (Poisson EWMA) control chart and Geometric (g) control chart, this study identifies the epidemical trend of enterovirus infection with severe complications. Moreover, by combining with a Geographic Information System (GIS), this study shows the epidemical condition status and geographic distribution of enterovirus infection with severe complications in Taiwan. Finally, study results indicate that this proposed monitoring system can improve the quality of infectious disease surveillance in Taiwan, and will provide government officials with a valuable reference for predicting and monitoring epidemics in the future.*
Keywords: C Control Chart; Poisson EWMA; Geometric Control Chart; Geographical Information System; Enterovirus Infection with Severe Complications

1. Introduction. Enteroviruses are prevalent once every few years in Taiwan. To handle enterovirus epidemics, Taiwan's Centers for Disease Control (CDC) established a team for dealing with enterovirus contingency. At the same time, the Taiwan Pediatric Association and 65 of Taiwan's referral hospitals that deal with critical cases of enteroviruses prepared thoroughly to against the enterovirus epidemic episodes together as well. The mode of transmission of enteroviruses is through contact with respiratory secretions of infected persons or by contact with contaminated objects. Hand, foot and mouth disease and Herpangina are caused by enteroviruses. Patients typically fully recover in 7–10 days, and only a few have severe complications. The main cause of enterovirus infection with severe complications is enterovirus type-71 virus. Some symptoms associate with enterovirus type-71 are sleepiness, weakness, muscle contraction, rapid breathing and a rapid heartbeat. Based on 1998–2007 data in relation to the development of enterovirus infection in Taiwan, children are a high risk group for enterovirus infection, severe complications and death. The enterovirus mortality rate is roughly 10–25.7%; the most susceptible group is children whose age are under 5 years old. As enteroviruses prefer wet and hot environments, infections occur in Taiwan all year. Thus, enterovirus is a local epidemic disease in Taiwan (Taiwan Centers for Disease Control, 2010).

This study utilized a count (c) control chart, Poisson exponentially weighted moving average (EWMA) and geometric (g) control chart to monitor enterovirus infections with severe complications. By applying these control charts, one can accurately monitor variations and trends in epidemic episodes. The main functions of control charts are (1) identifying process variance; (2) process improvement; (3) determining whether processes remain under control; and (4) employing quality improvement tools. The traditional c control chart hypothesizes that a data distribution is a Poisson distribution. The c control chart is the simplest attribute chart, and the chart is used to monitor the defect count (Hsieh et al., 2007). Every point in this chart has a c value, which is the number of occurrences of that subgroup (Hart and Hart, 2002). As Taiwan's urban and county populations have not changed in recent years, the primary use limitation of the c control chart is that the denominator must be the data form of a small variation. The c control chart is commonly applied to monitor the number of patient falls, number of needle punctures and number of infections in a hospital (Benneyan, 1998) Moreover, through the use of Poisson EWMA control chart, this study is able to aim at the tiny shift of enterovirus infection with severe complications and the data monitoring of fitful distribution, and get very good results (Montgomery, 2007). In terms of the g control chart, the assumed data pattern of the chart is a geometric distribution which is mainly for detecting the distribution of qualified events that is between two unqualified events (Benneyan, 2001). Furthermore, the use of the chart in rare events would have a better monitoring sensitivity.

Additionally, the infection level and distribution of epidemic episode vary from location to location. Thus, this study used the Geographic Information System (GIS) to be the control chart in order to show the result of monitoring epidemic. Notably, GIS is a computer-based system that stores and connects non-graphic attribute data or geographically-referenced data with a graphic map. Additionally, GIS can execute a wide range of information procedures and operations to input, storage, retrieval, produce a map, and analyze and model (Antenucci et al., 1991; Malpica, 2007). Geographic Information Systems are widely applied in to monitor the distribution of medical resources and in epidemiological studies. Gatrell and Loytonen (1998) noted that many developed countries utilize GIS in planning the location selection of medical health care and the distribution of medical resources. Kumar (2004) applied GIS to determine the distribution of health services locations and generated a demand distribution map for two Indian districts between 1981 and 1996. Kumar then analyzed and compared the two districts with actual and simulated locations of primary health care centers. In an epidemiological application, Chie et al. Chie et al. (1995) applied GIS Macros orders to draw a geographical distribution map of breast cancer cases in Taiwan. Lai et al. (2004) applied geostatistical methods and cartography to analyze the patterns of disease spreading during the 2003 outbreak of severe acute respiratory syndrome (SARS) in Hong Kong. Jacquez (2000) indicated that GIS can support disease mapping, location analysis, characterization of populations, and spatial statistics and modeling. Disease maps can, using spatial disease distributions, dot maps, diagram maps, choropleth maps and flow maps, describe and explain the geographical distribution of a disease (Kistemann et al., 2002). Kistemann et al. (2000) applied GIS to identify the incidence of tuberculosis (TB) in Germany where huge regional differences exist.

This study constructed an epidemic monitoring system for infectious diseases. Utilizing the conventional c control chart, Poisson EWMA control chart, g control chart and GIS, this study monitored the trends and development of epidemics of enterovirus infections with severe complications. These three control charts are used to determine that status of an epidemic and the future trend. Finally, the drawing function of the GIS is used to determine immediately the different infection levels of an epidemic in various regions.

Taiwan's CDC has applied GIS to determine the geographical distribution of enterovirus infections with severe complications. However, the CDC only addressed the number of people with severe cases. This study used density (number of people with severe cases / population) to determine the county and city distributions of epidemics. Because the urban and county populations differ, using "density" to examine the development of epidemics development is the best. Study results will provide government officials the way in preventing the enteroviruses epidemic, and achieve the efficacy of preventing and controlling epidemics.

2. Methodology.

2.1. Population Research. This study adopted epidemics of enterovirus infections with severe complications as its study object. From the numbers of nearly nine years' epidemic cases, one can see the epidemic mainly prevails over the period from April to September. This study utilized the data in which the case numbers of epidemic were collected by Taiwan's CDC for the past few years to do the analysis (Table 1). Because the original data of the past few years were based on fifty-three weeks per year, the manifestation of the study was, however, based on a two-week period of representation. Therefore, the data of the 53rd week multiplied by two and the result was used as the data of the 54th week. Table 1 lists the epidemic cases for every two weeks for 1999–2008.

2.2. Research Process. Application of the control chart has two stages. Montgomery (2007) indicated that with no known target values, the first stage (stage I) and second stage (stage II) need to find proper target values for a control chart. Stage I assisted operators to bring the process to an applicable statistical control condition, and collected stable and clean data (including the target value). Stage II emphasized the monitoring process, one can compare the data between sample statistics and process control limits in this way.

Therefore, this study constructed the system for monitoring epidemics of infectious diseases. The system combined cluster analysis, the c control chart, Poisson EWMA control chart, g control chart and GIS. There are four steps of this system's process and framework as followed:

TABLE 1. Enterovirus infections with severe complications during 1999–2008

week / year	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	Total
1999	0	0	1	4	2	0	0	0	1	2	4	4	4	0	1	0	1	0	4	0	3	0	0	2	2	0	0	35
2000	0	2	2	0	0	0	0	1	5	8	25	16	27	23	15	16	15	12	12	11	23	20	15	20	7	7	10	292
2001	10	6	5	3	3	2	7	4	12	25	30	32	33	24	22	19	20	21	22	21	19	17	11	9	5	11	0	393
2002	4	1	3	2	3	7	8	8	9	12	6	6	5	7	8	4	5	5	9	8	9	10	7	5	5	4	2	162
2003	9	6	4	2	2	3	2	5	12	4	2	3	0	3	1	2	1	3	0	3	2	0	0	4	0	0	0	73
2004	1	0	0	0	0	0	2	2	3	2	3	2	1	1	1	3	1	5	2	1	6	3	5	2	1	1	4	52
2005	2	1	4	1	2	2	1	3	5	6	22	29	22	14	10	11	2	3	1	1	0	1	0	0	0	0	0	143
2006	0	0	0	0	0	0	0	0	1	1	1	2	1	2	0	0	0	1	0	0	0	0	1	0	1	0	0	11
2007	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2	2	0	0	0	2	0	0	2	1	0	2	0	12
2008	3	8	5	2	2	9	8	19	26	34	57	70	60	26	9	7	6	3	4	5	0	2	1	0	3	1	6	376

TABLE 2. The epidemics via K-means cluster analysis

Clusters	2-week an average of cases	Standard deviation	2-week numbers of cases	Number of subgroups	Level rating	Number of events between weeks
1	2	1.76	295	186	Stable	2/2=1
2	11	2.95	379	36	Middle	2/11=0.1818
3	24	4.18	499	21	Severe	2/24=0.0833

Step I: Cluster module (using K-means cluster analysis to construct different severe clusters of epidemic)

First, cases of enterovirus infections with severe complications during 1999–2007 in Taiwan were used for observations. Through the K-means cluster analysis, it not only can analyze the severe clusters of epidemic, it can also apply to the concepts of stages I and II of the control chart. Table 2 lists cluster results and proper target monitoring values.

The purpose of stage I is to collect stable and clear data, and stage II is to monitor epidemic process. Therefore, this study applied clusters 1 (stable) and 2 (middle) in order to determine when enterovirus epidemics will be severe on the second stage. Additionally, this study's primary analytical variable was 2-week, not a year. This is because enterovirus infections with severe complications mainly happen in a certain period and not a whole year. Thus, this study used 2 weeks as an analytical variable.

Step II: The monitoring module of epidemic occurrence (c control chart and Poisson EWMA control chart)

In stage II, the monitoring system automatically identified enterovirus infections with severe complications for in 2-week periods in 2008 and by the module, the conventional monitoring process c control chart and Poisson EWMA control chart were used to detect epidemics at the same time. The target values obtained from stage I were applied to determine whether the epidemic exceeds the upper control limit (UCL) .Furthermore, this study compared the ability of the c control chart and Poisson EWMA control chart to monitor.

Step III: The module of geographic analysis (GIS analysis). When one of the c control chart or Poisson EWMA control chart detected epidemic signals that exceeded the UCL, any one of them, through GIS, can show every city's infection numbers among the population distribution immediately. One can then identify the numbers of episodes of enterovirus infections with severe complications in each city or medical area, in order to aim at the area which is contaminated more seriously and improve its hygienic knowledge and preventative measures.

Step IV: The judgement module of epidemic ending (g control chart). This final stage of the monitoring system is to proceed the judgment module of epidemic ending. Through the g control chart, this module observes when will epidemics break out of the dangerous stage and become stabilized. This module uses the opposite direction of stage I and II's concepts to monitor the final stage of enterovirus infections with severe complications. Therefore, this study applied the monitoring system of infectious disease epidemics to provide government officials with accurate data and the ability to predict epidemics in the future. Figure 1 shows the structure of the epidemic monitoring system for infectious diseases.

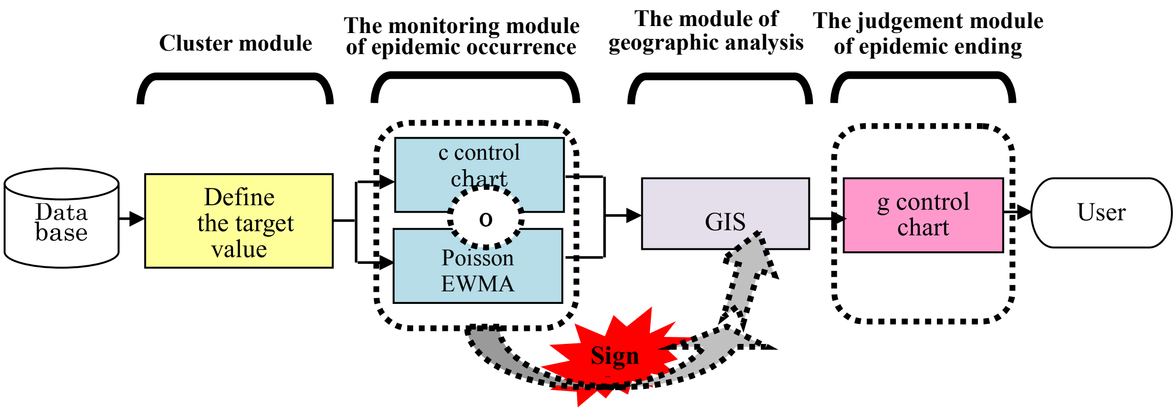

FIGURE 1. The structure of the monitoring system of epidemic disease

3. Results. This study utilized the c, Poisson EWMA and the g control charts of the epidemic monitoring system to monitor epidemics in 2008 and got different epidemic results of the enterovirus infection with severe complications from the three charts (Figures. 2–5, 8 and 9).

3.1. The C Control Chart.

(1) Stage I is used to analyze clusters 1 and 2 as the target values of stage II of enterovirus infections with severe complications for 2008. Therefore, stage I can be divided into stage Ia (cluster 1) and stage Ib (cluster 2) to help identify the severity of epidemics.

(2) Calculated $\bar{c}$, namely, the centerline (CL) of the control chart. During each 2-week period in stage Ia (cluster 1), the total number of subgroups was 186, and the total number of infectious cases was 295. Stage Ib can use the same procedure to calculate its outcome (Table 2).

$\bar{c}$ is the estimated average count (per subgroup) for the population.

$\bar{c}$ = sum of the errors / number of subgroups = 295 / 186 = 2

(3) Calculate the control limits, namely estimate the population 3-sigma of c.

$$3\sigma_c = 3\sqrt{\bar{c}} = 3\sqrt{2} = 3(1.41) = 4.24$$

(4) Calculate the upper (UCL) and lower (LCL) control limits of the c chart.

$$\text{(a)}\, UCL(c) = \bar{c} + 3\sigma_c = 2 + 4.24 = 6.24$$

$$\text{(b)}\, LCL(c) = \bar{c} - 3\sigma_c = 2 - 4.24 = -2.24 = 0$$

Note: according to this study, the lower control limit (LCL(X)) cannot be negative because the number of cases cannot be less than zero.

(5) Design the individual observations (centerline and control limits). According to the above calculated results of formulas, one can obtain the CL of stage Ia (CL = 2), the UCL is 6.24 and lower control limit (LCL) is 0. For stage Ib, CL = 11, the UCL is 20.95 and LCL is 1.

(6) Using the target values to monitor the development of epidemic in 2008 in order to draw the c control chart (Figs. 2 and 3).The target values (CL, UCL and LCL) from stages Ia and Ib of the c control chart are used as epidemic target values for stage II of the c control chart for 2008.

Through Figs. 2 and 3, one understands that the target values of stage Ia can be utilized to monitor the c control chart for 2008. The duration of enterovirus prevalence was from the 12nd–34th week. This is because the main prevalent duration exceeded the UCL; thus, from the 12nd week on, the epidemic slowly became an alert status in which the condition should prepare to set the alert as soon as possible and continue to monitor. Consequently, when the UCL reached 6.24, it's able to set the signal of epidemic episodes as middle severe level after the UCL exceeds the early mark; likewise, when the UCL reached 20.95, it's able to set the signal of epidemic episodes as high level after the UCL exceeds the early mark.

3.2. Poisson EWMA Control Chart.

(1) Same as the procedure of item (1) in the c control chart, one is able to observe the further level of epidemics.

(2) Assuming x_i is a count value and, based on the original EWMA definition (Roberts , 1966; Chou et al. , 2008):

$$z_i = \lambda x_i + (1-\lambda) z_{i-1} \quad \text{and} \quad z_0 = \mu_0$$

According to the above calculated results of formulas, one can obtain CL=2 as the target value of the Poisson EWMA chart. Hunter (1989) indicated that λ in the original EWMA control chart should equal 0.4; thus, this study set the value of λ as 0.4. Additionally, Testik et al. (2006) said when the control chart's $ARL_0 \cong 500$ and sample size is ∞, the upper and lower of the control limit factor (A) would be 3.163. Therefore, this study set the upper and lower of the control limit factor (A) to 3.163 (Fig. 4).

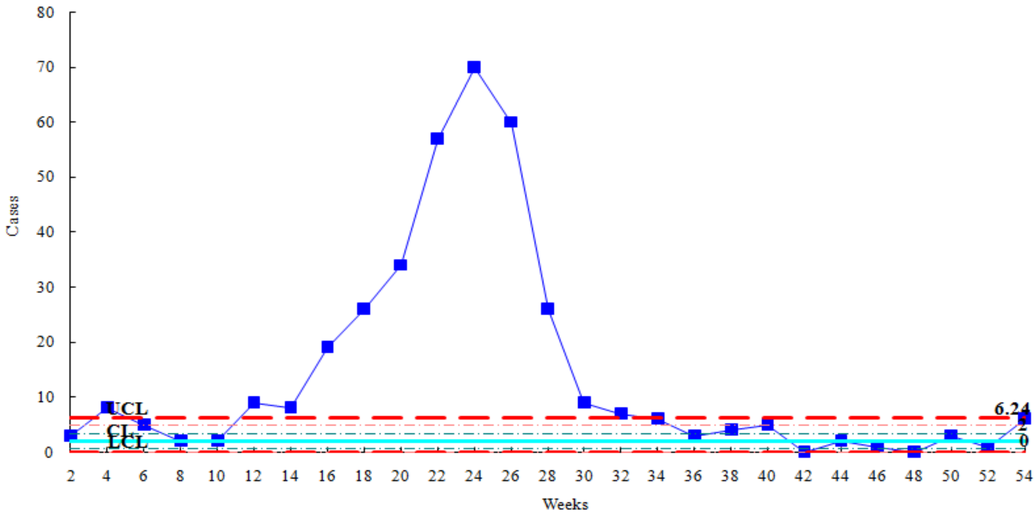

FIGURE 2. The c control chart for stage Ia epidemic monitoring results for 2008

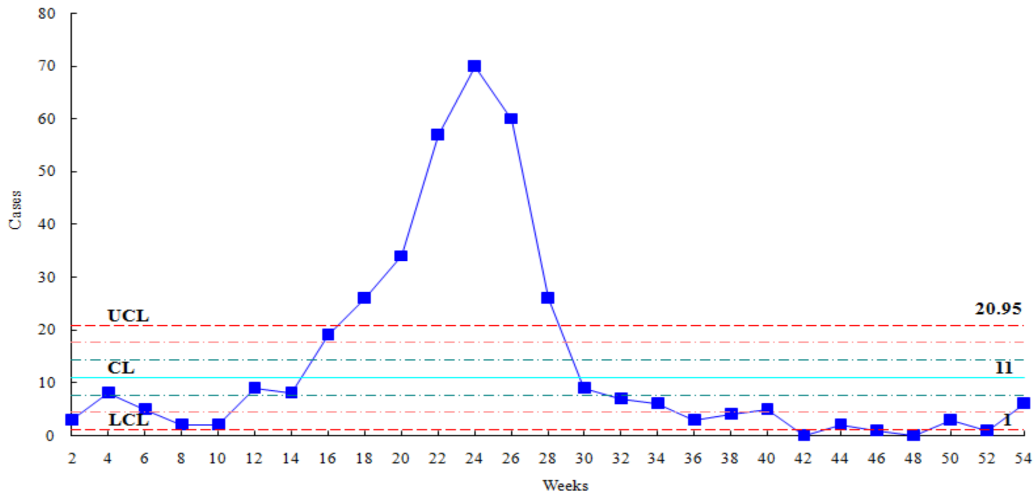

FIGURE 3. The c control chart for stage Ib epidemic monitoring results for 2008

(3) Calculate the UCL and LCL of the Poisson EWMA control chart:

$$h_U = \mu_0 + A_U\sqrt{\frac{\lambda\mu_0}{2-\lambda}} = 2 + 3.163\sqrt{\frac{0.4(2)}{2-0.4}} = 4.24$$

$$CL = \mu_0 = 2$$

$$h_L = \mu_0 - A_L\sqrt{\frac{\lambda\mu_0}{2-\lambda}} = 2 - 3.163\sqrt{\frac{0.4(2)}{2-0.4}} = -0.24 = 0$$

and

$$A = A_U = A_L$$

(4) Using the target value (CL), weight value (λ) and control limit factor (A) settings for monitoring stage II for 2008, and draw the Poisson EWMA control chart (Figs. 4 and 5).

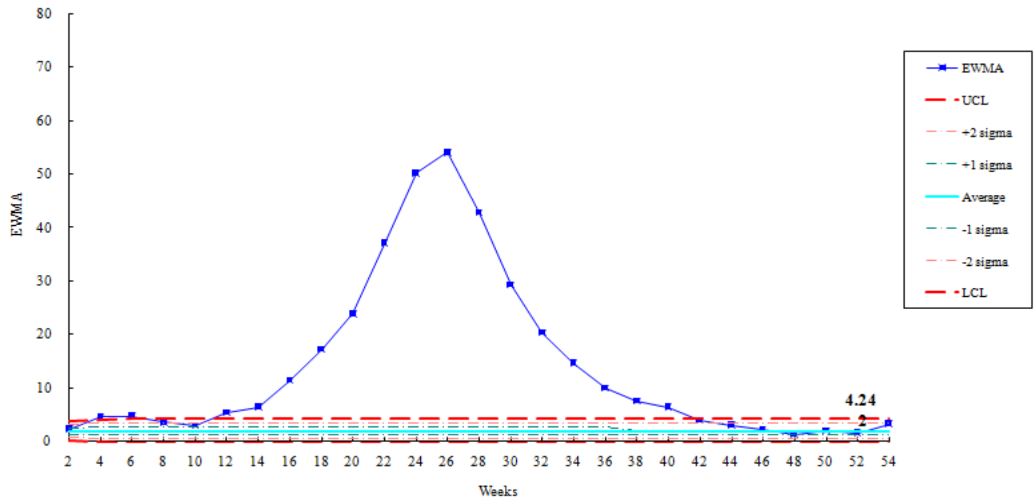

FIGURE 4. Poisson EWMA control chart epidemic monitoring results for Stage Ia for 2008

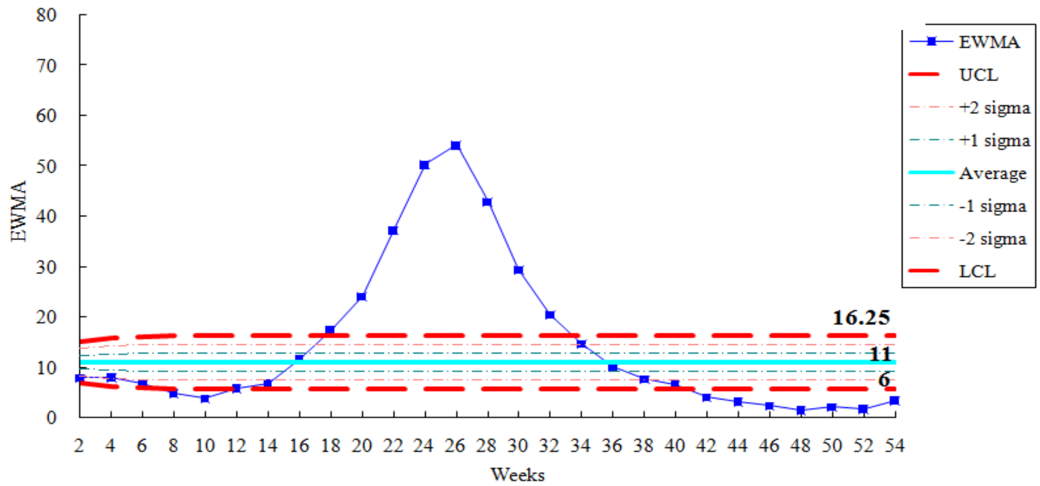

FIGURE 5. Poisson EWMA control chart epidemic monitoring results for stage Ib for 2008

Through Figs. 4 and 5, one can see the result of utilizing the target values of stage Ia to monitor the Poisson EWMA control chart of 2008. The enterovirus prevalence was the same as the c control chart which increased from the 12nd week, but then it declined from the 40th week. Additionally, when the UCL reached 4.24, it's able to set the signal of epidemic episodes as middle severe level after the UCL exceeds the early mark; likewise, when the UCL reached 16.25, it's able to set the signal of epidemic episodes as high level after the UCL exceeds the early mark.

3.3. Geographic Information System Analysis. Using the monitoring results of the c control chart and Poisson EWMA control chart for 2008, this study combined the results with GIS MapInfo 9.0 software to draw the density distribution map for week 16 (formula: total number of people with severe condition / population $\times$ 100000) of enterovirus infections with severe complications in the city and country in 2008, and 1–16 week accumulated density distribution map (formula: accumulated total number of people with severe condition/ population × 100000) for cities and counties. Finally, every city and county in Taiwan that had enterovirus infections with severe complications are shown on the map (Figs. 6 and 7).

Therefore, through the GIS geographic drawing function, one can monitor and forecast epidemic changes before epidemics occur, and observe the distribution of episodes in every city and county. For example, from observing the condition of epidemic of the 1^{st} week to the 16^{th} week (the accumulated density of epidemics before the occurrence), one can understand every city's infectious density in every ten-thousand population in which Kaohsiung County and Pingtung County had the highest density (1.2 people), Tainan City had the second highest density (0.9 people), Nantou County and Hsinchu County had 0.6 people and Kaohsiung City had 0.4 people; additionally, by observing the 16^{th} week, one can also discover every city's infectious density in every ten-thousand population in which Kaohsiung County had the highest density (0.5 people), Tainan City had the second highest density (0.4 people).

3.4. The G Control Chart.

(1) The g control chart must through the concept of opposite control charts, which mean when the epidemic signals passed the UCL, it represents the epidemic condition is stable and under control, to use stage I for analyzing cluster 2 and cluster 3 as monitoring target values in stage II for 2008. Thus, stage I can be divided into stages Ia (cluster 2) and Ib (cluster 3) for determining when episodes will stabilize.

(2) Calculate the $\bar{x}$, namely the centerline (CL) of the g control chart.

$$\begin{aligned}\bar{x} &= \text{average number of weeks between events}\\ &= \text{two weeks/average cases in two-week periods}\\ &= \frac{2}{11} = 0.1818\end{aligned}$$

(3) Calculate the upper (UCL) and lower (LCL) control limits of the g control chart:

k = namely estimate the population 3-sigma of g

(a) $UCL(g) = \bar{x} + k\sqrt{\bar{x}(\bar{x}+1)}$ $= 0.1818 + 3\sqrt{0.1818(0.1818+1)} = 1.57$

(b) $LCL(g) = \bar{x} - k\sqrt{\bar{x}(\bar{x}+1)}$ $= 0.1818 - 3\sqrt{0.1818(0.1818+1)} = -1.21 \approx 0$

(4) According to above calculated results of formulas, one can obtain the target values of the g control chart—CL=0.1818 and UCL=1.57.

(5) The target value (CL) and UCL are used in monitoring stage II for 2008, the g control chart is drawn (Figs. 8 and 9).

The monitoring goal of the g control chart is to determine when will the episodes be stabilized. Through viewing Figs. 8, 9 and Table 3, one can understand that by utilizing stage Ia and Ib target values of the g control chart for 2008, it's able to determine the enterovirus epidemic will be completely stable after the 43^{rd} week.

Based on the results of the researches above (Figs. 2–5), one can see the compared results of stage Ia and Ib between the c control chart and the Poisson EWMA control chart. The results are presented in table 4:

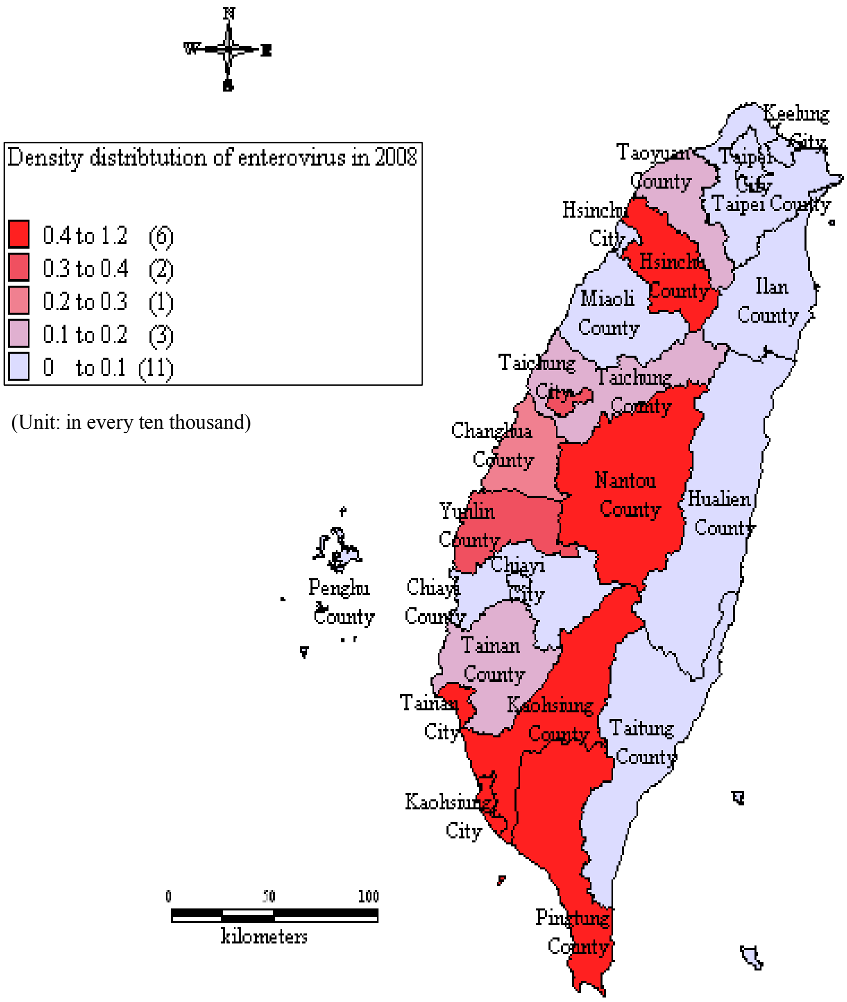

FIGURE 6. Accumulated density distribution of enterovirus infections with severe complications during week 1–16 per city in 2008

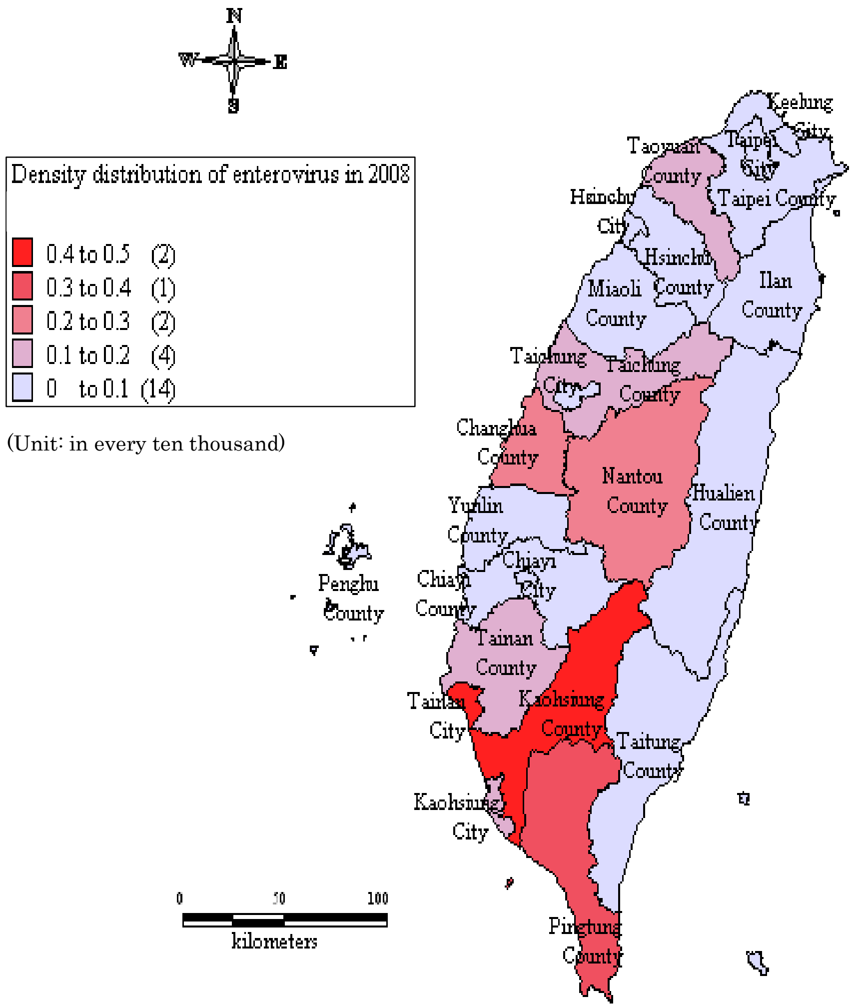

FIGURE 7. Density distribution of enterovirus infections with severe complications during week 16 per city in 2008

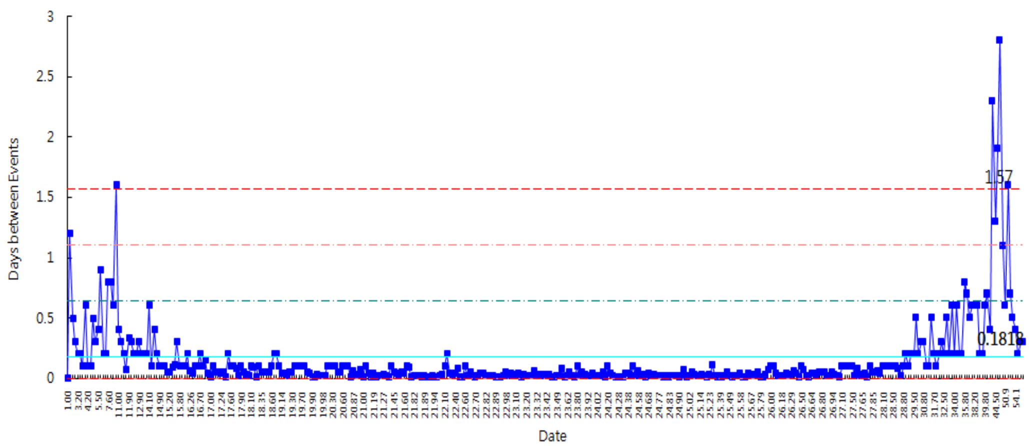

FIGURE 8. The g control chart of stage Ia monitoring results for 2008

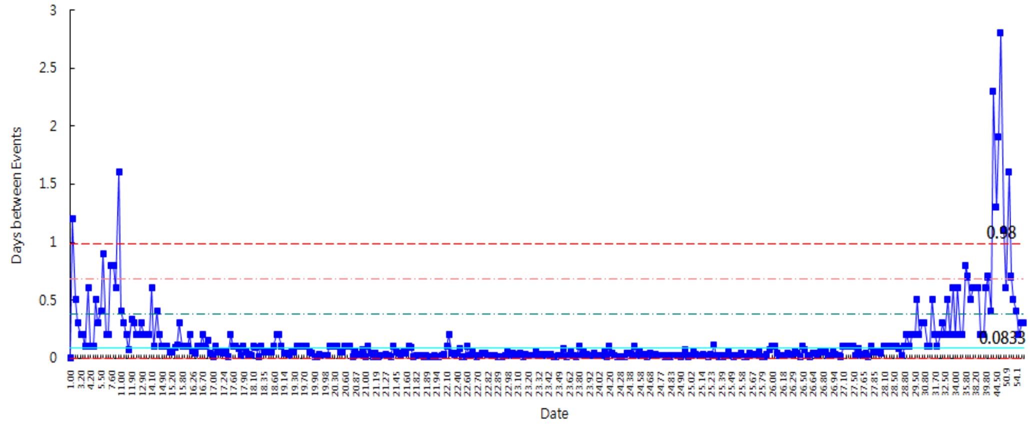

FIGURE 9. The g control chart of stage Ib monitoring results for 2008

TABLE 3. The monitoring results of enterovirus infections with severe complications by using the g control chart

Chart / Year	g control chart	
	Stage Ⅰa	Stage Ⅰb
2008	weeks 43.2-52,5	weeks 43.2-52,5

TABLE 4. The comparison of monitoring results of enterovirus infections with severe complications obtained between the c control chart and poisson EWMA control chart

chart / Year	c control chart		Poisson EWMA control chart	
2008	Stage Ⅰa	Stage Ⅰb	Stage Ⅰa	Stage Ⅰb
	4 weeks, weeks 12–34	weeks 18–28	weeks 4–6 weeks 12–40	weeks 18–32

Generally, the comparison between the c control chart and the Poisson EWMA control chart indicates that the Poisson EWMA control chart detects episodes earlier and better than the c control chart. Additionally, the Poisson EWMA control chart is more sensitive than the c control chart. The first example, one is able to see the small fluctuation through the Poisson EWMA chart before the first twelve weeks in 2008. Although the episode fluctuations were not as big and serious as big and serious as they were after the middle to the later period, there were many weeks of episodes that were almost reaching the UCL; in other words, it reached the condition that needed to be alarmed. The second example, the epidemic episodes all passed the UCL in the middle period. Although it showed the sign of total number of cases decreasing in the later period, the Poisson EWMA control chart could still detect the epidemics as the UCL. It’s because the chart can detect a tiny shift, and prevent the risk of increasing the case numbers of epidemic during an off season or period. Further, the Taiwan CDC indicates that the enterovirus season is from April to September. Thus, the monitoring results of the Poisson EWMA control chart are similar to the Taiwan CDC’s statistics.

4. Discussion. Through the concept of clusters, the study assisted the use of control charts' stage I and stage II, and combined control charts with GIS to develop an epidemic monitoring system for infectious disease. This system can monitor epidemic information effectively, and increase monitoring sensitivity. It does not matter that the epidemic variation and shift big or small, the system can still detect the changes. Additionally, the geographic drawing function of GIS can map the episode density and infected cities over time to elucidate the distribution of infected cities. Finally, the charts can judge whether the epidemic condition is stable or not, or when will it end. Because the differences of epidemic durations, the system used different functions of charts to gain effective monitoring and judgement. Therefore, before the epidemics occur, one can know the total numbers of enterovirus infection with severe complications in every ten-thousand population of every city in Taiwan. The highest accumulated density of epidemic is concentrated in central and southern Taiwan.

The contribution of this study is to set a complete infectious disease monitoring system that can provide government officials with the information to prevent epidemics, and an understanding of which areas or cities must receive attention before an epidemic develops. By using the different control charts, one can accurately predict and monitor the epidemics, and prevent the episodes being delayed and controlled. To control an enterovirus, government officials should improve monitoring techniques and systems, in order to construct ways for providing accurate information about an epidemic in a timely manner. Such information should be able to prevent the epidemics, to control and to terminate the epidemic as well, in order to achieve the goal of public health.

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KNOWLEDGE MANAGEMENT OF MATHEMATICS CONCEPTS BASED ON CONCEPT STRUCTURE AND CLUSTERING WITH MAHALANOBIS DISTANCES

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ABSTRACT. *Knowledge management of mathematics concepts is essential in educational environment. The purpose of this study is to provide an integrated method of fuzzy theory basis for individualized concept structure analysis. This method integrates Fuzzy Logic Model of Perception (FLMP) and Interpretive Structural Modeling (ISM). The combined algorithm could analyze individualized concepts structure based on the comparisons with concept structure of expert. A new improved Fuzzy C-Means algorithm based on a Common Mahalanobis distance (FCM-CM) is proposed. Use the best performance of clustering Algorithm FCM-CM in data analysis and interpretation. Each cluster of data can easily describe features of knowledge structures. To sum up, this integrated algorithm could improve the assessment methodology of cognition diagnosis and manage the knowledge structures of Mathematics Concepts easily.*

Keywords: FCM-M Algorithm; FCM-CM Algorithm; FLMP; Knowledge Structure

1. Introduction. The well-known ones, such as Bezdek's Fuzzy C-Means (FCM), FCM algorithm was based on Euclidean distance function, which can only be used to detect spherical structural clusters. To overcome the drawback due to Euclidean distance, we could try to extend the distance measure to Mahalanobis distance (MD). However, Krishnapuram and Kim (1999) pointed out that the Mahalanobis distance can not be used directly in clustering algorithm. Gustafson-Kessel (GK) clustering algorithm and Gath-Geva (GG) clustering algorithm were developed to detect non-spherical structural clusters. In GK-algorithm, a modified Mahalanobis distance with preserved volume was used. However, the added fuzzy covariance matrices in their distance measure were not directly derived from the objective function. In GG algorithm, the Gaussian distance can only be used for the data with multivariate normal distribution.We know Gustafson-Kessel clustering algorithm and Gath-Geva clustering algorithm, were developed to detect non-spherical structural clusters, but both of them based on semi-supervised Mahalanobis distance, these two algorithms fail to consider the relationships between cluster centers in the objective function, needing additional prior information. Added a regulating factor of covariance matrix, , to each class in objective function, the fuzzy covariance matrices in the Mahalanobis distance can be directly derived by minimizing the objective function, but the clustering results of this algorithm is still not stable enough. For improving the stability of the clustering results, we replace all of the covariance matrices with the same common covariance matrix in the objective function in the FCM-M algorithm, and then, an improve fuzzy clustering method, called the Fuzzy C-Means algorithm based on common Mahalanobis distance (FCM-CM), is proposed.

Zadeh developed fuzzy theory and it flourishes methodologies in many fields. One of these fields is cognition diagnosis and it help represent knowledge structure (Coppi, 2006). It is a common viewpoint that human knowledge is stored in the form of structural relationship among concepts and their subordinate relationship is fuzzy, not crisp. There are some methodologies for concept structure analysis but little is known about methodologies of individualized concept structure (Schvaneveldt, 1990). Therefore, the development for methodology of individualized concept structure is an important issue and it is essential for cognition diagnosis and pedagogy. In this study, the integrated method of individualized concept structure based on fuzzy logic model of perception (FLMP) and interpretive structural modeling (ISM) will be developed. An example of empirical test data of linear algebra concept for students of learning deficiencies will also be analyzed and discussed. For the feasibility of remedial instruction based on the cognition diagnosis, clustering method is needed so that students within the same cluster own similar knowledge structures and students among different clusters have the most variance on knowledge structures (Lin et al., 2006).

2. Literature Review. Clustering technique plays an important role in data analysis and interpretation. Fuzzy clustering is a branch in clustering analysis and it is widely used in the pattern recognition field. Fuzzy clustering algorithms can only be used to detect the data classes with the same super spherical shapes. To overcome the drawback due to Euclidean distance, we could try to extend the distance measure to Mahalanobis distance (MD). However, Krishnapuram and Kim (1999) pointed out that the Mahalanobis distance can not be used directly in clustering algorithm. Gustafson-Kessel (GK) clustering algorithm and Gath-Geva (GG) clustering algorithm were developed to detect non-spherical structural clusters. In GK-algorithm, a modified Mahalanobis distance with preserved volume was used.

However, the added fuzzy covariance matrices in their distance measure were not directly derived from the objective function. In GG algorithm, the Gaussian distance can only be used for the data with multivariate normal distribution. To add a regulating factor of each covariance matrix to each class in the objective function, and delete the constraint of the determinants of covariance matrices in the GK algorithm, the Fuzzy C-Means algorithm based on Mahalanobis distance (FCM-M) was proposed. For improving the stability of the FCM-M clustering results, it is to replace all of the covariance matrices with the same common covariance matrix in the objective function in the FCM-M algorithm.

2.1. Fuzzy Logic Model of Perception. Suppose there be a combination of two factors. There are levels and levels for factor and respectively. The fuzzy true values are expressed as Fuzzy truth value and express the degree that the combination of and will support prototype. The probability that the combination of could be viewed as prototype can be expressed as follows.

$$p(c_i\ ,\ o_j) = (c_i\, o_j)[c_i o_j + (1-c_i)(1-o_j)]^{-1} \tag{1}$$

2.2. FCM-M Algorithm. For improving the limitation of GK algorithm and GG algorithm, we added a regulating factor of covariance matrix, $-\ln\left|+\Sigma_i^{-1}\right|$, to each class in the objective function, and deleted the constraint of the determinant of covariance matrices, in GK Algorithm as the objective function We can obtain the objective function of Fuzzy C-Means based on adaptive Mahalanobis distance (FCM-M) as following (Hasanzadeh et al., 2005)

$$J^m_{FCM-M}(U, A, \Sigma, X) = \sum_{i=1}^{c}\sum_{j=1}^{n} \mu_{ij}^m d^2\left(\underline{x}_j, \underline{a}_i\right) \tag{2}$$

Conditions for FCM-M are

$$\begin{aligned} &m \in [1,\infty);\, U = \left[\mu_{ij}\right]_{c\times n};\, \mu_{ij} \in [0,1],\, i = 1,2,\ldots,c,\ j = 1,2,\ldots,n \\ &\sum_{i=1}^{c} \mu_{ij} = 1,\ j = 1,2,\ldots,n,\ 0 < \sum_{j=1}^{n} \mu_{ij} < n,\ i = 1,2,\ldots,c \end{aligned} \tag{3}$$

$$d^2\left(\underline{x}_j,\underline{a}_i\right) = \begin{cases} \left(\underline{x}_j - \underline{a}_i\right)' \Sigma_i^{-1}\left(\underline{x}_j - \underline{a}_i\right) - \ln\left|\Sigma_i^{-1}\right| & if \left(\underline{x}_j - \underline{a}_i\right)' \Sigma_i^{-1}\left(\underline{x}_j - \underline{a}_i\right) - \ln\left|\Sigma_i^{-1}\right| \geq 0 \\ 0 & if \left(\underline{x}_j - \underline{a}_i\right)' \Sigma_i^{-1}\left(\underline{x}_j - \underline{a}_i\right) - \ln\left|\Sigma_i^{-1}\right| < 0 \end{cases} \tag{4}$$

2.3. FCM-CM Algorithm. For improving the stability of the clustering results, we replace all of the covariance matrices with the same common covariance matrix in the objective function in the FCM-M algorithm, and then, an improve fuzzy clustering method, called the Fuzzy C-Means algorithm based on common Mahalanobis distance (FCM-CM) is proposed. We can obtain the objective function of FCM-CM as following :

$$J^m_{FCM-CM}(U, A, \Sigma, X) = \sum_{i=1}^{c}\sum_{j=1}^{n} \mu_{ij}^m d^2\left(\underline{x}_j, \underline{a}_i\right) \tag{5}$$

Conditions for FCM-CM are

$$\begin{aligned} &m \in [1,\infty);\, U = \left[\mu_{ij}\right]_{c\times n};\, \mu_{ij} \in [0,1],\, i = 1,2,\ldots,c,\ j = 1,2,\ldots,n \\ &\sum_{i=1}^{c} \mu_{ij} = 1,\ j = 1,2,\ldots,n,\ 0 < \sum_{j=1}^{n} \mu_{ij} < n,\ i = 1,2,\ldots,c \end{aligned} \tag{6}$$

$$d^2\left(\underline{x}_j,\underline{a}_i\right) = \begin{cases} \left(\underline{x}_j - \underline{a}_i\right)' \Sigma^{-1}\left(\underline{x}_j - \underline{a}_i\right) - \ln\left|\Sigma^{-1}\right| & if \left(\underline{x}_j - \underline{a}_i\right)' \Sigma^{-1}\left(\underline{x}_j - \underline{a}_i\right) - \ln\left|\Sigma^{-1}\right| \geq 0 \\ 0 & if \left(\underline{x}_j - \underline{a}_i\right)' \Sigma^{-1}\left(\underline{x}_j - \underline{a}_i\right) - \ln\left|\Sigma^{-1}\right| < 0 \end{cases} \tag{7}$$

Using the Lagrange's multipliers, we can rewrite the objective function of FCM-CM as following

$$\bar{J} = J^m_{FCM-CM}(U, A, \Sigma, X) = \sum_{i=1}^{c}\sum_{j=1}^{n} \mu_{ij}^m \left[\left(\underline{x}_j - \underline{a}_i\right)' \Sigma^{-1}\left(\underline{x}_j - \underline{a}_i\right) - \ln\left|\Sigma^{-1}\right|\right] + \sum_{j=1}^{n} \alpha_j \left(1 - \sum_{i=1}^{c} \mu_{ij}\right) \tag{8}$$

Minimizing the objective function respect to all parameters in Equation (5) with the constraint (6), we can obtain the updating equation as follows

$$\frac{\partial \bar{J}}{\partial \underline{a}_i} \stackrel{\Delta}{=} 0 \Rightarrow \underline{a}_i = \frac{\sum_{j=1}^{n} \mu_{ij}^{m} \underline{x}_j}{\sum_{j=1}^{n} \mu_{ij}^{m}} \tag{9}$$

$$\frac{\partial \bar{J}}{\partial \alpha_j} \stackrel{\Delta}{=} 0 \Rightarrow \sum_{i=1}^{c} \mu_{ij} = 1, \quad j = 1, 2, \ldots, n \tag{10}$$

$$\frac{\partial \bar{J}}{\partial \mu_{ij}} \stackrel{\Delta}{=} 0, \sum_{i=1}^{c} \mu_{ij} = 1 \Rightarrow \mu_{ij} = \frac{\left[\left(\underline{x}_j - \underline{a}_i\right)' \Sigma^{-1} \left(\underline{x}_j - \underline{a}_i\right) - \ln\left|\Sigma^{-1}\right| \right]^{\frac{-1}{m-1}}}{\sum_{s=1}^{c} \left[\left(\underline{x}_j - \underline{a}_s\right)' \Sigma^{-1} \left(\underline{x}_j - \underline{a}_s\right) - \ln\left|\Sigma^{-1}\right| \right]^{\frac{-1}{m-1}}} \tag{11}$$

3. Data Resource Analysis and Main Results. The performances of clustering Algorithm FCM, GK, GG, FCM-M, and FCM-CM all with the fuzzifier m=2, are compared in these experiments. The results of FCM, GK, and GG are obtained by applying the Matlab toolbox developed by Feil et al. (2007).

3.1. The Experiments with Iris Data. The Iris data has sample size 150 which features of the Iris data contains Length of Sepal, Width of Sepal, Length of Petal, and Width of Petal. The samples were assigned the original 3 clusters based on the clustering analysis. The characteristics of 3 clusters for Iris data were shown in Table 1

TABLE 1. Mean clustering Accuracies for Iris Data

Algorithm	IRIS(50,50,50)
FCM	0.8933
GK	0.7649
GG	0.9000
FCM-M	0.9000
FCM-CM	0.9270

TABLE 2. The characteristics of 6 clusters for math assessment data

Cluster	samples size	The cherateristic of the cluster which is the misconception of sample points
1	50	Enhance exercise
2	36	Combine area of sector
3	47	Combine area of sector, basic area of sector
4	53	Draw the graph
5	30	Combine area of sector, Draw the graph
6	25	Combine area of sector, basic area of sector, Draw the graph

3.2. The Experiment with Mathematics Concepts Data. A real assessment data set with 7 items from 241 students of an elementary school in Taiwan was applied in this experiment. These instances were assigned to 6 clusters by mathematics experts and teachers. The characteristics of 6 clusters for Math Assessment Data were shown in Table 2.

From Table 3, we can find that the proposed FCM-CM outperforms other four methods, and has the best performance.

TABLE 3. Mean accuracies for mathematics concepts data

Algorithm	Accuracies
FCM	0.4339
GK	0.4106
GG	0.3703
FCM-M	0.4379
FCM-CM	0.4524

3.3. Knowledge Structures. The software and linear algebra test are implemented by authors. The test includes 19 items with 933 task-takers of university students with learning deficiencies. Those students failed the linear algebra once and must take the linear algebra course again. There are 6 concept attribute within each item and they are depicted in Table 4.

TABLE 4. Concept attributes of test

Concepts	Concept Attributes
1	operation of matrix
2	system of linear equations
3	determinants
4	vector space and the property of Rn
5	eigenvalue and eigenvector
6	geometry of linear algebra

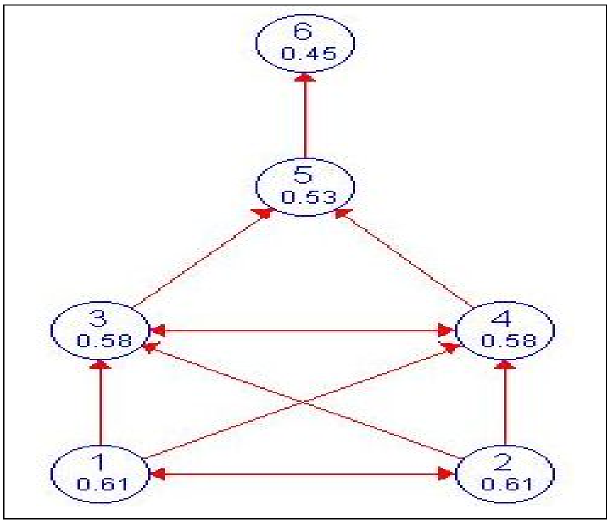

FIGURE 1. Knowledge structure of student 786

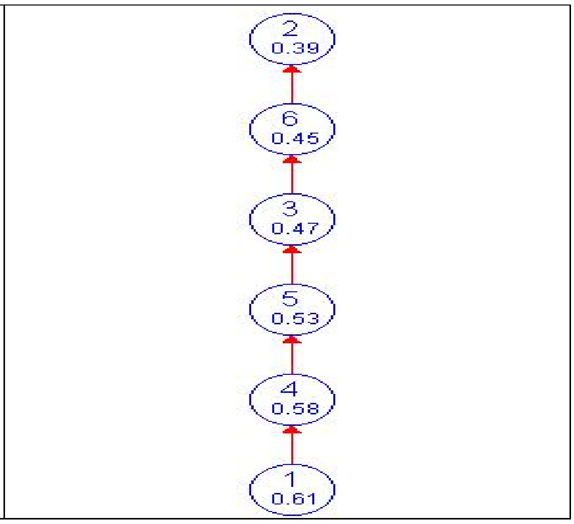

FIGURE 2. Knowledge structure of student 933

Although the combined algorithm of FLMP and ISM could provide the concept structure of each task-taker respectively, it is unfeasible to display the concept structure of all task-takers in this paper. As shown from Figure 1 to Figure 2, one student is randomly selected from the sample. As to student 786, mastery of concept 1 and concept 2 which is 0.61. Concept 1 and concept 2 are also the basis for concept 3, 4, 5, 6. For student 933, mastery of concept 1 is 0.61. Concept 1 is also the basis of the other concepts. It is clearly understood that knowledge structures of two students vary a lot.

4. Conclusions. FCM is based on Euclidean distance function, which can only be used to detect spherical structural clusters. GK algorithm and GG algorithm were developed to detect non-spherical structural clusters. However, GK algorithm needs added constraint of fuzzy covariance matrix, GG algorithm can only be used for the data with multivariate Gaussian distribution. A Fuzzy C-Means algorithm based on Mahalanobis distance (FCM-M) was proposed to improve those limitations of above two algorithms, but it is not stable enough when some of its covariance matrices are not equal. An improved Fuzzy C-Means algorithm based on Common Mahalanobis distance (FCM-CM) is proposed. The experimental results of two real data sets consistently show that the performance of our proposed FCM-CM algorithm is better than those of the FCM, GG, GK and FCM-M algorithms. In this paper, each cluster of data can easily describe features of knowledge structures. We can manage the knowledge structures of Mathematics Concepts to construct the model of features in the pattern recognition completely. An integrated method of FLMP and ISM for analyzing individualized concept structure is provided. With this integrated algorithm, the graphs of concept structures will display the characteristics of knowledge structure. This result corresponds with foundation of cognition diagnosis in psychometrics. This study investigates an integrated methodology to display knowledge structures based on fuzzy clustering with Mahalanobis Distances. In addition, empirical test data of linear algebra for university students are discussed. It shows that knowledge structures will be feasible for remedial instruction (Tatsuoka and Tatsuoka, 1997). This procedure will also useful for cognition diagnosis. To sum up, this integrated algorithm could improve the assessment methodology of cognition diagnosis and manage the knowledge structures of Mathematics Concepts easily.

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EMPIRICAL STUDY ON THE MODERATING EFFECTS OF OFFSETTING INVESTMENTS ON THE RELATIONSHIP BETWEEN TRANSACTION-SPECIFIC INVESTMENTS AND LONG-TERM ORIENTATION

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ABSTRACT. *A distributor can develop a supplier's long-term orientation through offsetting investments, which changes the distributor's position in the relationship with a supplier, and achieves safeguarding to transaction-specific investments. The empirical results prove that there is a negative correlation between the distributor's transaction-specific investments and the supplier's long-term orientation. However, the distributor can develop the supplier's long-term orientation through offsetting investments which mediate the relationship between the distributor's transaction-specific investment and the supplier's long-term orientation.*

Keywords: Offsetting Investments; Transaction-Specific Investments; Long-Term Orientation

1. Introduction. To make products sell well, a supplier sometimes asks a distributor to make transaction-specific investments in a channel relationship, but these investments are specific and impossible to transfer from the relationship to another relationship (Williamson et al., 1975) or if it transfers, the switch costs will happen (Heide, 1994). As a result, the investing party sometimes obtains opportunistic threat from the non-investing party who may terminate the relationship or take these investments as pledges and not offer deserved compensations, Jap and Ganesan (2000). Therefore, Williamson puts forward that we should offer defense for transaction-specific investments.

There are two different methods to protect transaction-specific investments in foreign existing marketing channel literatures: the diversified control mechanisms and the mechanism of accelerating long-term durable relationship. The former contains relationship standard, qualification examination process, Heide and John (1990), supervision (Rajiv, 1990), and definite and standard contract (Lush and Brown, 1996), and the latter includes bilateral idiosyncratic asset investments, Anderson and Weitz (1992). Then Jap suggests that the investing party (that is retailer) uses a method that contains three mechanism of supplier's transaction-specific investments, standard relationship and definite contract, and develops the non-investing party's behavior of durable relationship, and offers an empirical research of defense for transaction-specific investments (Jap and Ganesan, 2000). But Jap doesn't mention the problem whether the investing party has the ability to use the three control mechanism to develop the behaviors of a supplier's durable relationship.

This paper introduces the concept of offsetting investments so that we can enhance the investing party's ability of defense of transaction-specific investments, develops a conceptual framework based on the above problems, puts forward the hypothetical relationship between these variables, describes the process and way of collecting data, tests these hypotheses, and analyses our research results based on testing these hypotheses. Finally, we conclude with a discussion of the managerial implications and the limitations of our results, and directions for future research.

2. Research Framework and Hypothesis. We begin with the definitions of several key variables in channel relationships, and then present a framework describing the interrelationship among several variables (the conceptual model is listed in figure 1).

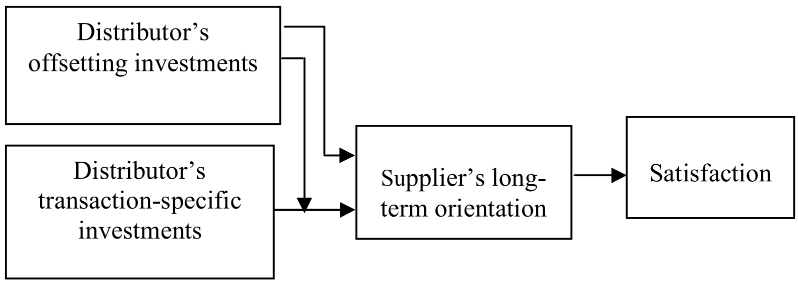

FIGURE 1. Conceptual framework of variables

Supplier's long-term orientation. Supplier's long-term orientation is the willingness that a supplier will develop a long-term stable relationship with a distributor. Distributor's transaction-specific investments involve tangible assets (such as capital equipments and information systems) or intangible assets (such as concrete strategies or process) that are made to a supplier by a distributor. Transaction-specific investments have the character of un-transfer, that is, if we take the transaction-specific investments into another relationship, loss of investments will happen (Williamson, 1985), and create a barrier of relationship termination, Heide and John (1988). Gundlach, Achrol and Mentzer's research shows that the party whose investments are less than the other party trends to take behaviors of opportunism, Gundlach et al. (1995). Therefore, we argue that there is a negative relationship between the distributor's transaction-specific investments and the distributor's perception of the supplier's long-term orientation. It is consistent with Jap's empirical research that there is a negative relationship between the retailer's transaction-specific investments and the retailer's perception of the supplier's commitment to relationship.

H1: There is a negative relationship between the distributor's transaction-specific investments and the distributor's perception of the supplier's long-term orientation.

The effect of distributor's offsetting investments to supplier's long-term orientation. Distributor's offsetting investments mean that a distributor makes transaction-specific investments for the clients or customers of an upstream supplier, including an agent develops the relationship with client and the disrelated status with his acting product lines in the minds of customers, increases the value of products, develops the specialization process for ordering, transporting and servicing (Heide and John, 1988). The results of distributor's offsetting investments make the distributor construct a close relationship with clients, so the distributor can help his supplier to sell more products and achieve more profits, as a result, his supplier depends on the distributor more. El-Ansary and Stern argue that the more the channel members supply their exchange partners with rewards of gratifications and economy, the more their partners depend on them (Ansary and Stem, 1972). If the supplier has this dependence on the distributor, the distributor creates a motivation that the supplier maintains their relationship. Frazier suggests that when the supplier perceives the performance level of the distributor high, supplier has motivation to maintain the relationship, Frazier (1983). Meanwhile, the distributor's power increases, namely, the distributor has the ability to affect the supplier's decisions, Hunt and Nevin (1974).

H2: There is a positive relationship between the distributor's offsetting investments and the distributor's perception of the supplier's long-term orientation.

The regulation of distributor's offsetting investments. A distributor takes the offsetting investments as investments for the clients who buy his supplier's products, and it creates a relationship between the distributor and clients. As a result, the relationship between the distributor and final customers becomes closer, and the potential ability of the distributor instead of an upstream supplier increases. Meanwhile, the distributor's offsetting investments change the dependent relationship between the distributor and the supplier, that is, the distributor more depends on the supplier who achieves the idiosyncratic asset investments from the distributor, and the dependence of the supplier to the distributor also increases, so the interdependence symmetry increases. Anderson and Weitz argue that symmetry is stabler than asymmetry, so the supplier may have the long-term orientation, Anderson and Weitz (1989).

H3: When the distributor's offsetting investments increase, the negative effect of the distributor's transaction-specific investments to supplier's long-term orientation will decrease.

Supplier's long-term orientation and satisfaction. Satisfaction is a positive affective state that one firm assesses all aspects of work relationship with another firm, Iames and Narus (1984). Channel relationship research has shown the satisfaction of channel members means increasing morale, cooperation and durable relationship and decreasing lawsuits between channel members, Hunt and Nevin (1974). When the distributor perceives that the supplier has the long-term orientation, they know that the supplier will make the relationship develop along benign direction, thus causing the distributor's perception of mutual harmony relationship increases, and the distributor achieves high rewards and better perception of quality of products and support, as a result, the satisfaction of relationship increases.

H4: There is a positive relationship between the supplier's long-term orientation and the distributor's perception of relationship satisfaction.

3. Methodology.

3.1. Sample and Data Collection. This research investigates sole agent of sedan brands and clothing brands. So there is interdependence between a manufacturer and a distributor. The sample includes distributors of international automobile exhibition and garment exposition in 2006. There are 36 exhibitors in the international automobile exhibition and most of them are local agents, after field work, all of them are sole agents; whereas there are 425 exhibitors in the garment exposition, after checking and eliminating 236 exhibitors who aren't suitable for the investigation, there are only 189 agents meeting our requirements.

The targets of this investigation are general managers or marketing managers of distributors. Through this field interview, we know that these general managers or marketing managers have often dealings with manufacturers, so they are very familiar with the relationship between their firms and manufacturers. The ages of these managers having dealings with manufacturers lie in the range from 2 years to 20 years, and the average ages are 8.5 years. This investigation sent 225 questionnaires and reclaimed 194 questionnaires in the locale fair, because we collect these data one by one, a response rate achieves 80%. The main reasons of nonrespondents were because they did not attend the investigation or the general managers were not here. Aparting from 3 questionnaires which were not filled perfectly, there were 191available questionnaires.

3.2. Scales. When we choose the measure scales of variables, we totally use the existing scales and introduce them into our research framework, and we also use multiple items scale for each variable, so that we can improve the quality of information collection. Table 1 shows the concrete items.

The scales of distributor's transaction-specific investments quote the scales developed by Anderson (1985); Heide and John (1988), and we adjust them into our research models. The scales focus on the aspects of time, energy, personnel training and market developing in the relationship between the distributor and the supplier. The scales of distributor's offsetting investments depend on the scales of offsetting investments developed by Heide and John, and the items of scales mainly focus on that the distributor builds individual relationship with clients and supplies clients with specialized service, Heide and John (1988).The scales of supplier's long-term orientation depend on the measure scales of long-term orientation developed by Ganesan (1994), and the items of scales focus on that the supplier feel that the relationship between the distributor and the supplier is very important, and they can achieve future benefits, concern the long-term goals and want to maintain the relationship durably. Finally, we depend on the scales of satisfaction developed by GeySkens and Steenkamp (2000); Kashyap (2004), and items of scales focus on satisfaction of distributor to supplier's marketing and selling support.

3.3. Variables Measure. Item analysis and trust test. This paper uses item-total correlative analysis way to make item analysis, the correlation coefficient of all items reach the significant level of 0.05, so leaving all items. We take Cronbach α coefficient to make trust test. From table 1, we can see that there are 7 initial variables, and the least α coefficient is 0.763, beyond 0.70, they show that the research variables have benign reliability show.

3.4. Validity Test. This paper adopts the Amos 4.0 of analysis software to make verification factor analysis so that we examine the structure validity of scales, the results are showed in table 2. All indexes in table 2 reach the standard index, and it shows that the scales have the benign structure validity.

TABLE 1. Scales design

items	α coefficient	average	s-d
A the distributor's transaction-specific investments	0.935	2.888	0.906
A1we spend much time and energy on learning the supplier's organization characteristics			
A2 our salesmen spend much time and energy on learning the supplier's products selling skills			
A3 we must harmonize closely with the supplier's personnel, and we can complete our sale tasks			
A4 we have spent much time and energy on developing sale markets for the supplier			
B the distributor's offsetting investments	0.793	2.720	0.671
B1 we sell the supplier's products, and build a very good relationship with clients			
B2 the personal relationship built by our salesmen and clients can affect our sale largely.			
B3 we take positive reflection to deal with the clients' requirement			
B4 we supply clients with specialized service so that we can increase value of products			
C the supplier's long-term orientation	0.901	3.448	0.896
C1 the supplier believe that we can make them achieve more benefits as time goes			
C2 the supplier believe that it is important for them to maintain the relationship with us			
C3 the supplier only concern the long-term goals with us			
C4 the supplier hope that they can maintain the durable relationship with us			
D satisfaction	0.884	2.713	1.045
D1 we are very content for the marketing and marketing support supplied by the supplier			
D2 we are quite happy to become a distributor of the supplier			
D3 sometime we think that it is waste time to maintain the relationship with the supplier			
D4 we are very content for the interaction with the supplier			

S-d=standard deviation

TABLE 2. Results of verification factor analysis (n=191)

	χ^2	df	χ^2/df	GFI	AGFI	NFI	NNFI	CFI	SRMR	RMESA
Standard			<3	>0.90	>0.90	>0.90	>0.90	>0.90	<0.08	<0.10
Distributor's transaction specific investments	1.543		0.772	0.996	0.980	0.998	0.989	1.000	0.012	0.000
Distributor's offsetting investments	5.096		2.548	0.985	0.925	0.977	0.931	0.984	0.042	0.074
upplier's long-term orientation	5.321		2.660	0.986	0.930	0.978	0.935	0.986	0.030	0.053
atisfaction	1.598		0.799	0.996	0.979	0.993	0.979	1.000	0.017	0.000

4. Results. We take forcing into method of regression analysis method used widely in the statistic software SPSS, the testing standards of variables by regression equations depend on the standardization regression coefficient of variables which must pass the testing F coefficient or F probability, the SPSS defines F coefficient >2.70, F probability >0.1, and the default value adopts the way of random assignment to dispose. The results of regression analysis method mainly report the standardization regression β coefficient, significance level, adjustive coefficient R2 of multiple determinations, and F testing coefficient of independent variables to dependent variables. To decrease multiple collinearities, we adopt the centralization method for all the independent variables (Hua et al., 2003). Table 3 reports the regression coefficient, significance level and collinearity diagnosis results.

Supplier's long-term orientation. In regression analysis of supplier's long-term orientation, as dependence variable, supplier's long-term orientation have a negative distinct correlation with distributor's transaction-specific investments ($t=-2.093$, $p<0.05$), and have a positive distinct correlation with distributor's offsetting investments ($t=3.077$, $p<0.01$), supporting H1 and H2; the mediating effect of distributor's offsetting investments to the negative relationship between distributor's transaction-specific investments and supplier's long-term orientation has a positive significant role ($t=3.149$, $p<0.01$), supporting H3.

Level of satisfaction. In regression analysis of satisfaction, as dependence variable, there is a positive significant dependent interaction between satisfaction and supplier's long-term orientation ($t=7.338$, $p<0.01$), supporting H4.

TABLE 3. Results of regression analysis

β coefficient (Std. error)	Supplier's long-term orientation	satisfaction
Distributor's transaction-specific investments	-0.577*（0.082）	——
Distributor's offsetting investments	0.876**（0.285）	——
Distributor's transaction-specific investments * distributor's offsetting investments	0.331**（0.105）	——
Supplier's long-term orientation	——	0.411**（0.056）
constant	2.133**（0.934）	1.599**（0.386）
Adjustive R^2 coefficient	0.303 （0.863）	0.219 （0.676）
F coefficient	4.706**	18.772**

n=191, *p<0.05, **p<0.01

5. Discussion and Conclusion. Results of this empirical research show there is a negative relationship between the distributor's transaction-specific investments and the distributor's perception of the supplier's willingness of maintaining relationship, which shows in some extent that the supplier who have power advantage have opportunistic behaviors in some extent. Therefore, the distributor offers defense for transaction-specific investments, it is consistent with the view in exchange cost analysis. The results of distributor's offsetting investments, however, changes the distributor's position in relationship with the distributor, namely, it creates dependence of the supplier to the distributor, so they develop the supplier's willingness to maintain relationship. The empirical results also show that there is a positive relationship between the distributor's offsetting investments and the distributor's perception of the supplier's long-term orientation. Meanwhile, the empirical results also show that the use of distributor's offsetting investments adjust the negative relationship between the distributor's offsetting investments and the distributor's perception of the supplier's long-term orientation.

5.1. Limitations. The limitations of our research mainly embody two aspects as follows: first of all, this paper only interviews distributors empirically, but ideally, we not only should collect distributors' data, but also should collect suppliers' data, and we should examine the supplier-distributor dyad data. But because it is difficult to collect these data, this problem becomes a fault of our research. Secondly, we only consider that offsetting investments develop suppliers' long-term orientation, but we should also study other control mechanisms, for example, how to develop supplier's long-term orientation.

5.2. Directions for Future Research. Directions for future research mainly embody three aspects as follows, firstly, our results may be used to research the relationship between the downstream channel members who have power advantage and the upstream channel members who don't have power advantage, thus it shows that our results have universality in some extent; secondly, other control mechanisms can be researched in future, for example, the effects of definite contracts and standard contracts to suppliers' long-term orientation; finally, maybe we can research the relationship between long-term orientation and economic performance, such as profits and sales, thus channel members have enough confidence to develop the exchange partners' long-term orientation.

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TOOL OUTSOURCING RISK RESEARCH BASED ON BP NEURAL NETWORK

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ABSTRACT. *Tool outsourcing has been facing many risks. If the outsourcing enterprise can't carry on the analysis, appraisal and control of tool outsourcing sufficiently, then the outsourcing enterprise not only can't obtain benefits, but also has the inestimable loss from tool outsourcing. This paper analyzes risk factors of tool outsourcing and then establishes forewarning index system for tool outsourcing. Finally, we provide theoretical basis for the tool outsourcing risk management forewarning of outsourcing enterprises.*
Keywords: BP Neural Network; Fishbone Diagram; Tool Outsourcing; Risk Estimation

1. Introduction. The essence of tool outsourcing management is the principal-agent relationship between outsourcing enterprises and tool service suppliers (Aron et al., 2005). Information asymmetry, information distortion and the uncertainty of market environment between client and agent will cause many kinds of risk during the period of implementing tool outsourcing.

After implementing tool outsourcing, the service quality and quality supervision system are not perfect. How to effectively encourage tool service suppliers and gain win-win result between outsourcing enterprises and service suppliers is an important problem. Consequently, because there are still many risk factors during the period of tool outsourcing, the outsourcing enterprise should take considerate analysis and avoidance.

Lonsdale (1999), Whitmore (2006), Pettibone (2009) respectively studied outsourcing risk problems in aspects of outsourcing risk source, outsourcing risk estimation and outsourcing risk avoidance policy. Zhang (2005), Da (2005), Kainz (2001) studied tool management from the following aspects as management model and management process. Nowadays, domestic and international research about outsourcing risk is mainly limited to risk identification and control strategy in the period of outsourcing. A completely reasonable method of outsourcing risk evaluation which can gain a global admission and acceptance does not exist.

2. BP Neural Network Model.

2.1. The Introduction of BP Neural Network. BP neural network is a multi-level feed-forward neural network based on BP algorithm. As a paralleled and dispersed treatment model, BP neural network has the characteristics of nonlinear mapping, self-adapting learning and fault-tolerance property and could simulate in the complicated and capricious investment and operation environment. This paper makes full use of BP neural network to estimate tool outsourcing risk, which can provide alarm for outsourcing enterprises when abnormal situation appears and attract more attention from outsourcing enterprises to solve this problem and then guarantee company's tool outsourcing safety. Tool outsourcing risk evaluation making use of BP neural network is not only more objective and accurate, but also states the close relationship between the factors of tool outsourcing risk index system and evaluation outcomes. So the tool outsourcing risk evaluation model based on BP neural network has a great priority.

2.2. BP Neural Network Structure and Algorithm. The learning process of BP neural network consists of four parts (Wang et al., 2000):

(1) Input model clockwise propagation (Input model is from input layer to output layer via middle layer);

(2) Output error anticlockwise propagation (The output error is from output layer to input layer via middle layer);

(3) Circular memory training (The calculation process is operating in the rotation and circulation between model clockwise propagation and error anticlockwise propagation);

(4) Judge of learning results (It is to judge the global error whether prone to minimum value or not).

The Procedure of whole learning process of BP neural network:

(1) Initialization, assign connection weights W_{ij} , V_{jt} and threshold θ_j , r_t , $i=1,2,...,n, j=1,2,...,p, t=1,2,...,q, k=1,2,...,m,$ a random value between -1 to +1.

(2) Randomly select a couple models $A_k=[a_1^k, a_2^k, ...a_n^k]$, $Y_K=[y_1^k, y_2^k...y_q^k]$ and then provide it to BP neural network, and then calculate middle layer's different neurons input s_j (activated value) using input model $A_k=[a_1^k, a_2^k, ...a_n^k]$ with connection weights W_{ij} and threshold θ_j, and then calculate S_j through activation function.

$$f(x)=\frac{1}{1+e^{-x}} \tag{1}$$

(3) Calculate different unites output of middle layer b_j :

$$b_j = f(s_j) \tag{2}$$

$$s_j=\sum_{i=1}^{n} W_{ij}.a_i-\theta_j \tag{3}$$

(4) Calculate different unites input l_t (activated value) of output layer with output b_j of middle layer, connection weights V_{jt} and threshold r_t and then calculate the response value c_t of different unites by activation function with l_t ,

$$c_t=f(l_t) \tag{4}$$

$$l_t=\sum_{j=1}^{p} V_{jt}.b_j-\gamma_t, t=1,2,...,q \tag{5}$$

(5) Calculate calibration error d_t^k of different units with expected output model $Y_k=[y_1^k, y_2^k \dots y_q^k]$ and BP neural network's practical output C_t :

$$d_t^k=(y_t^k-c_t).c_t(1-c_t), t=1,2,...,q \tag{6}$$

(6) Calculate correction error e_j^k of middle layer with V_{jt}, d_t, b_j:

$$e_j^k = [\sum_{t=1}^{q} d_t . V_{jt}] b_j (1 - b_j), \; j = 1, 2, ..., p \tag{7}$$

(7) Calculate new connection weights between middle layer and output layer with d_t^k, b_j, V_{jt}, and r_t:

$$V_{jt}(N+1) = V_{jt}(N) + \alpha . d_t^k . b_j \tag{8}$$

$$\gamma_t(N+1) = \gamma_t(N) + \alpha . d_t^k \tag{9}$$

N : learning times

(8) Calculate new connection weights between input layer and middle layer with e_j^k, a_i^k, W_{ij} and θ_j:

$$W_{ij}(N+1) = W_{ij}(N) + \beta . e_j^k . a_i^k \tag{10}$$

$$\theta_j(N+1) = \theta_j(N) + \beta e_j^k \tag{11}$$

(9) Randomly select next couple of learning model and then provide it to BP neural network, return to step 3, until all m couples models could be trained.

(10) Randomly re-select a couple models from m learning models and then return to step 3, until the network global error function E is less than the preliminarily-setting limit value(network can converge) or learning circuit number is greater than preliminarily-setting value(network can't converge).

(11) The end: In the above learning procedures, step 3—6 is the clockwise propagation process of input learning model; step 7—8 is the anticlockwise propagation process of network error; the training and convergence process is fulfilled respectively by step 9and step 10.

3. Tool Outsourcing Risk Identification and Design.

3.1. Tool Outsourcing Risk Source. Tool outsourcing risk mainly arises from outsourcing decision and outsourcing execution two periods, as following table 1.

TABLE 1. Tool outsourcing risk source

Tool outsourcing risk source	Outsourcing Decision Stage	Strategy risk
		Transaction risk
	Outsourcing Execution Stage	Management risk
		Relationship risk
		Out-of-control risk

3.2. The Factors of Tool Outsourcing Risk. Tool outsourcing risk contains strategy risk, transaction risk, management risk, relationship risk and out-of-control risk. The fishbone diagram as figure 1 (Cai et al., 2009):

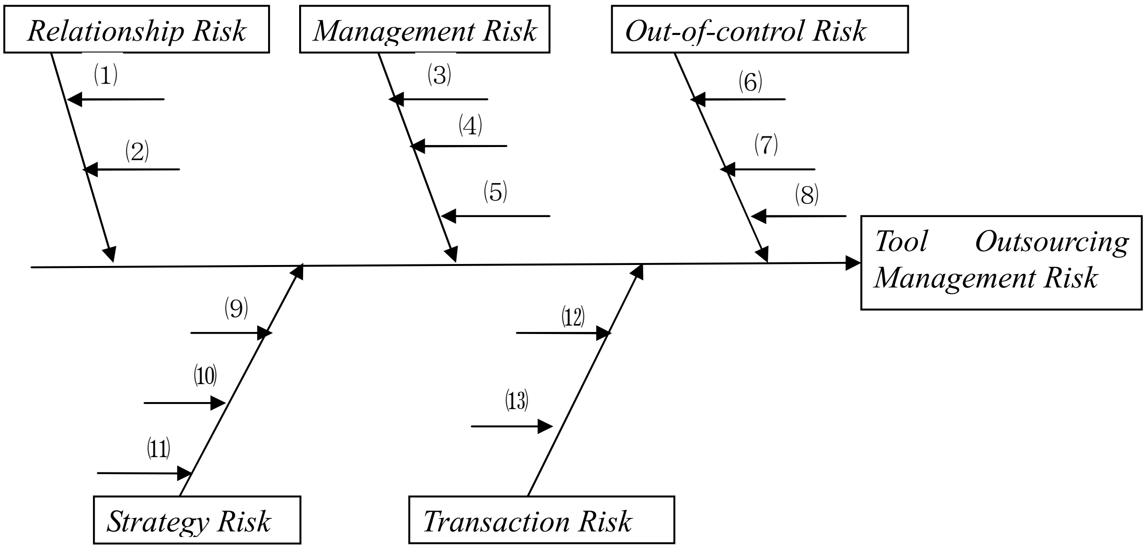

FIGURE 1. Tool outsourcing risk source fishbone diagram

(1)------Lacking of effective incentive mechanism
(2)------Competition mechanism is not sufficient
(3)------Business process in disorder
(4)----- Lacking of effective tool management performance estimation system
(5)------Culture difference and unsatisfactory communication
(6)------Lacking of executable service level agreement
(7)------Lacking of recurrent job examination
(8)------Vendor supervision is deficient
(9)------Determination of outsourcing limit is indistinct
(10)------Lacking of market maturity analysis
(11)------Key business identification is not sufficient
(12)------Contract clause is not perfect
(13)------Lacking of professional outsourcing team

According to the principle of authenticity, comprehensiveness, scientific property and fairness for indicator system, taking into account of sensitivity and dynamic of the indicators, and simultaneously, every index could be complementary and could not be reduplicative to comprehensively reflect tool outsourcing risk situation. Consequently, every forewarning module has several representative indicators and all indicators construct tool outsourcing risk forewarning indicators system. The figure 2 is the tool outsourcing risk forewarning indicators system.

3.3. Tool Outsourcing Risk Evaluation Indicator System. According to the tool outsourcing risk source fishbone diagram, tool outsourcing risk, for instance, the strategy risk, transaction risk, management risk, relationship risk and out-of-control risk, can be embodied by 13 different indicators. Every indicator has different score form 1 to 7, 7 means the most important, 1 means the least important, as following table 2.

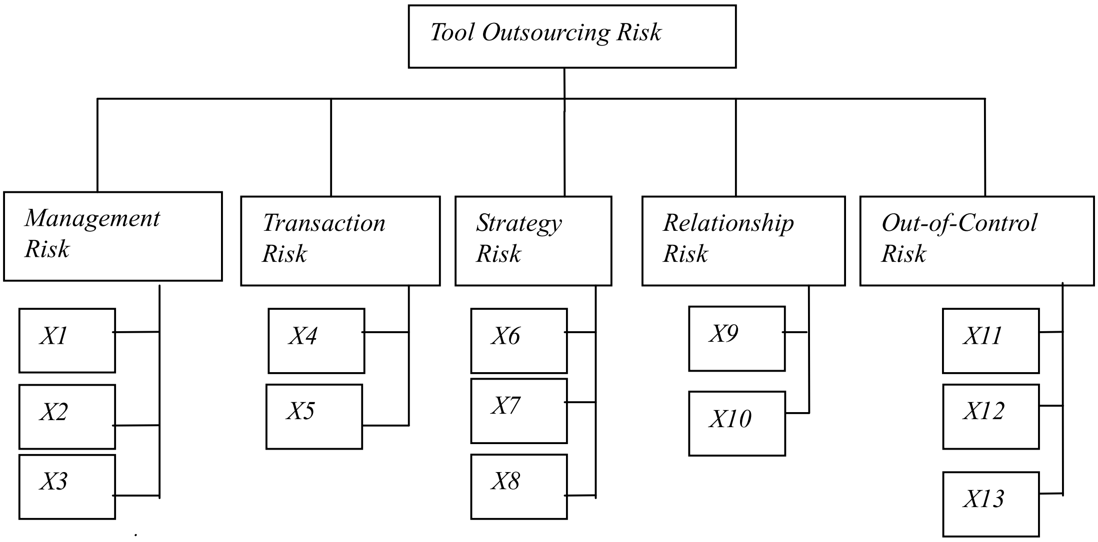

FIGURE 2. Tool outsourcing risk indicators forewarning system

$X1$ ------ Tool Performance Estimation System
$X2$ ------ Business Process
$X3$ ------ Culture Communication Degree
$X4$ ------ Contract Clause Perfect Degree
$X5$ ------ Outsourcing Team Specialization Degree
$X6$ ------ Outsourcing Scope Determination Accuracy
$X7$ ------ Outsourcing Market Maturity
$X8$ ------ Key Business Identification
$X9$ ------ Effective Incentive Mechanism
$X10$ -----Competition mechanism
$X11$ -----Service Level Agreement
$X12$ -----Job Assessment
$X13$ -----Vendor Supervision

TABLE 2-1. Tool outsourcing risk quantitative index

Related Factors	1	2	3	4	5	6	7
Tool Performance Estimation System X1							
Business Process X2							
Culture Communication Degree X3							
Contract Clause Perfect Degree X4							
Outsourcing Team Specialization Degree X5							
Outsourcing Scope Determination Accuracy X6							
Outsourcing Market Maturity X7							
Key Business Identification X8							

TABLE 2-2. Tool outsourcing risk quantitative index

Related Factors	1	2	3	4	5	6	7
Effective Incentive Mechanism X9							
Competition Mechanism X10							
Service Level Agreement X11							
Job Examination X12							
Vendor Supervision X13							

4. Evaluation of Tool Risk by BP Neural Network Model.

4.1. Constructing the Tool Outsourcing Risk Forewarning Model. This paper is to operate the neural network design procedure by MATLAB. When designing BP neural network, the following problems should be taken into consideration: determining the network's topological structure, neuron's transmission function, network's initialization (the initialization of connection weights and threshold); training samples' normalization processing; training parameters setting; sample data input mode and so on Zhou and Kang (2005). The network's topological structure contains the number of hidden layer, network input, hidden layer, output layer.

(1) The number of hidden layer: BP neural network is to calculate from input layer to output layer. Although the speed is faster when the number of hidden layer becomes more, it costs more time in practical application. The speed can be improved by adding nodes number of hidden layer. Consequently, when applying BP neural network to forecast tool outsourcing risk, it is best to choose 3-hierarchy BP neural network with only one hidden layer.

(2) Decision of the input layer's unit number: According to tool outsourcing risk indicator forewarning system, it is to input 13 indicators. The factors of this model are all qualitative factors. When inputting nodes input, it is better to limit the indicator between 0 and 7 in order to apply in network model.

(3) Decision of the hidden layer's unit number: The number of hidden layer nodes has an impact on neural network performance. When the quantity of hidden layer nodes is less, learning capacity is so limited that it is too difficult to store all laws which training samples contain. The quality of hidden layer nodes is so more that it costs more network training times and non-regular contents of the samples, for instance, noise and disruption, could be stored, which has a bad generalization. According to the empirical formula $i = \sqrt{n+m} + a$, i is the number of neurons in hidden layer, n means the number of neurons in input layer, m means the number of neurons of output layer, a is a constant which is from 0 to 1. Therefore, based on different models with different numbers of neurons in hidden layer, the author is about to respectively simulate, compare and then determine the most suitable number of neurons in hidden layer. It is supposed to be 12.

(4) Select unite number of output layer: Selection of output nodes corresponds to estimation results. In the model the ultimate result is an estimation value, which is tool outsourcing risk's comprehensive estimation value representing different risk degrees.

Hence the author chooses one output nodes.

The author constructs the enterprise tool outsourcing risk forewarning system by adopting 3-layer BP neural network. The node number of input layer, hidden layer and output layer is respectively 13,12,1.

(5) Select neurons' transmission function: The hidden layer of this model adopts tangent S form neurons and the output layer of this model adopts linear neurons, which can be approximate to any continuous functions. If the hidden layer contains enough neurons, it can be approximate to any discontinuous functions which have limited breakpoints.

(6) Data's normalization processing: Quantitative indicator data can not be directly taken into estimation in the researches of tool outsourcing risk. Because tool outsourcing risk forewarning system is a complicated system, the indicators taken into risk estimation are not only so many, but also have different properties, dimensions and magnitudes. In order to compare different quantities which have different dimensions, all data need to be transformed appropriately, which is the dimensionless processing.

TABLE 3. Samples normalization processing

Index	Sample1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7
1	0.798	0.468	0.798	0.404	0.798	0.318	0.296
2	0.875	0.75	0.745	0.56	0.75	0.25	0.318
3	0.713	0.75	0.794	0.753	0.753	0.246	0.399
4	0.774	0.75	0.816	0.584	0.791	0.323	0.421
5	0.904	0.863	0.802	0.752	0.831	0.266	0.314
6	0.813	0.848	0.843	0.318	0.815	0.25	0.653
7	0.693	0.818	0.75	0.693	0.75	0.323	0.499
8	0.661	0.785	0.745	0.323	0.704	0.246	0.568
9	0.771	0.683	0.727	0.548	0.728	0.296	0.563
10	0.624	0.824	0.74	0.74	0.763	0.266	0.484
11	0.637	0.762	0.59	0.629	0.633	0.314	0.495
12	0.789	0.875	0.704	0.628	0.75	0.246	0.323
13	0.795	0.759	0.813	0.646	0.728	0.296	0.325
Sample8	Sample9	Sample10	Sample11	Sample12	Sample13	Sample14	Sample15
0.798	0.56	0.246	0.798	0.468	0.798	0.404	0.798
0.56	0.435	0.266	0.875	0.75	0.745	0.56	0.75
0.875	0.375	0.323	0.713	0.75	0.794	0.753	0.753
0.875	0.603	0.296	0.774	0.75	0.816	0.584	0.791
0.777	0.463	0.325	0.904	0.863	0.802	0.752	0.831
0.845	0.653	0.25	0.813	0.848	0.843	0.318	0.815
0.75	0.318	0.246	0.693	0.818	0.75	0.693	0.75
0.704	0.499	0.25	0.661	0.785	0.745	0.323	0.704
0.814	0.421	0.318	0.771	0.683	0.727	0.548	0.728
0.84	0.657	0.266	0.624	0.824	0.74	0.74	0.763
0.715	0.484	0.314	0.637	0.762	0.59	0.629	0.633
0.875	0.539	0.323	0.789	0.875	0.704	0.628	0.75
0.625	0.495	0.296	0.795	0.759	0.813	0.646	0.728

4.2. Model Training and Verification. This paper chooses MATLAB 6.5 to train and verify tool outsourcing BP neural network forewarning model. The author collects 15 questionnaires from 15 different tool outsourcing enterprises which participate in the 4th manufacturing enterprise outsourcing forum in the 12th 2008. The members of Outsourcing Committee of Shanghai Science Management gave these estimable values. The comprehensive value of risk rating is given by several leading experts through analyzing indicator values, as well as empiricism and relative theories.

The author adopts one-hidden-layer BP network and uses tool outsourcing risk estimation indicator as input variable. The input variable is respectively $X1, X2, ..., X13$, and the input nodes number is 13. The value range of output nodes is from 0 to 7 and the number of output nodes is 1. The author divides the enterprise tool outsourcing risk grade. According to the closeness degree between the output results and standard value of enterprise tool outsourcing risk, the author judges the enterprise's risk grade. The Table 4.2 states the enterprise tool outsourcing risk grade coefficient.

TABLE 4. Enterprise tool outsourcing risk grade coefficient

Enterprise Tool Outsourcing Risk Grade	Enterprise Tool Outsourcing Risk Grade Coefficient
Low risk	5.5-7
Low to moderate risk	4.5-5.5
Moderate risk	3.5-4.5
Moderate to high risk	2.5-3.5
High risk	0-2.5

When the author adopts levenberg-Marquardt training algorithm, the training error and training time of network gain a minimum value at the same time. Hence trainlm training function is used by this model.

By indicators' normalization processing, all basic data is ready for training and test, which can be seen in table 3. The author uses the first 12 couples' data of normalized data table as learning training dataset to input the network and then makes the last 3 couples data of normalized data table as network's test dataset. The number of hidden layer nodes is 13 and the threshold function is tansig function. Purelin linear function is adopted into output layer. In the experiment, the learning rate n is 0.01 and the acceptable error is 0.001. Training time is 5000, using trainlm function. After completing the neural network training, the last 3 couples sample data are used to verify this model. When the network training is at step 3, the network error is 8.65568e-007, network performance reaches the standard.

When training the risk forecast model by Matlab, it can directly call traingda function to train after determining input value and expected output. After building an M file, the author input the following data in interface according to tool outsourcing risk evaluation indicator data.

```
p1=[0.661 0.500 0.703 0.610 0.688 0.705 0.875 0.702 0.734 0.584 0.570 0.707 0.601]';
p2=[0.798 0.750 0.750 0.731 0.800 0.750 0.750 0.745 0.820 0.759 0.637 0.668 0.644]';
p3=[0.867 0.815 0.794 0.797 0.858 0.728 0.693 0.785 0.693 0.664 0.590 0.711 0.771]';
p4=[0.266 0.315 0.334 0.314 0.325 0.410 0.250 0.246 0.323 0.343 0.250 0.296 0.356]';
p5=[0.734 0.810 0.750 0.608 0.654 0.748 0.568 0.661 0.590 0.613 0.484 0.539 0.495]';
p6=[0.798 0.875 0.713 0.774 0.904 0.813 0.693 0.661 0.771 0.624 0.637 0.789 0.795]';
```

```
p7=[0.468 0.750 0.750 0.750 0.863 0.848 0.818 0.785 0.683 0.824 0.762 0.875 0.759]';
p8=[0.798 0.745 0.794 0.816 0.802 0.843 0.750 0.745 0.727 0.740 0.590 0.704 0.813]';
p9=[0.404 0.560 0.753 0.584 0.752 0.318 0.693 0.323 0.548 0.740 0.629 0.628 0.646]';
p10=[0.798 0.750 0.753 0.791 0.831 0.815 0.750 0.704 0.728 0.763 0.633 0.750 0.728]';
p11=[0.318 0.250 0.246 0.323 0.266 0.250 0.323 0.246 0.296 0.266 0.314 0.246 0.296]';
p12=[0.296 0.318 0.399 0.421 0.314 0.653 0.499 0.568 0.563 0.484 0.495 0.323 0.325]';
p=[p1 p2 p3 p4 p5 p6 p7 p8 p9 p10 p11 p12];
t=[5.303 5.928 6.010 2.484 5.144 6.073 6.089 6.097 4.616 6.044 2.233 3.484];
 [tn,mint,maxt]=premnmx(t);
net=newff(minmax(p),[13,1],{'tansig','purelin'},'trainlm');
net.trainParam.epochs=5000;
net.trainParam.goal=0.001;
net=train(net,p,t);
a=sim(net,p);
[m,b,r]=postreg(a,t);
%forecasting risk
 p_test=   [0.798 0.560 0.875 0.875 0.777 0.845 0.750 0.704 0.814 0.840 0.715 0.875 0.625
            0.560 0.435 0.375 0.603 0.463 0.653 0.318 0.499 0.421 0.657 0.484 0.539 0.495
            0.246 0.266 0.323 0.296 0.325 0.250 0.246 0.250 0.318 0.266 0.314 0.323
           0.296]';
y=sim(net,p_test)
```

And then the data is operating in command window and appears in Matlab display interface:TRAINGD, Performance goal met.When the above cue about the target has been achieved appears and the dynamic diagram of training can be seen in the figure 3.

FIGURE 3. Tool outsourcing evaluation performance diagram based on BP neural network

TRAINLM, Epoch 3/5000, MSE 8.65568e-007/0.001, Gradient 0.0183008/1e-010

TRAINLM, Performance goal met. This states that this network training is successful.

4.3. Testing the BP Model. The 3 couples test values is to verify network's adaptability. After simulating, the output results are as following: The output Y value is 6.0535，3.939，2.1805.The table 5 is the error of network simulation results.

The output results of network model respectively have displayed risk grade, for instance, low risk, moderate risk, high risk. The error rate is less than 5%, which means this model can accurately forecast tool outsourcing risk in accordance with the indicator system. The accurate model needs more training samples in order to be convenient for network learning, which makes the network have a better fault-tolerance property. In the practice, Maximum error of less than 10% can meet the demand of accuracy.

TABLE 5. Network simulation result error

	Sample for Verification 1	Sample for Verification 2	Sample for Verification 3
Simulation Result	6.0536	3.939	2.1805
Practical Evaluation	6.195	4.010	2.276
Error	2.283%	1.771%	4.196%

5. Conclusions. The author constructs tool outsourcing risk evaluation indicator system and tool outsourcing risk evaluation model by BP neural network model. The author adopts 15 auto enterprises data as training sample, which can evaluate the enterprise's tool outsourcing management risk.

Because the number of enterprise which makes tool outsource is so small and these tool outsourcing enterprises are also in the beginning stage, the training and forecast functions maybe have a better application if the number of sample is much bigger.

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DATABASE OF FUZZY PROBABILITY DISTRIBUTION FUNCTION AND ITS APPLICATION

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ABSTRACT. *This paper gives the definition of a new fuzzy distribution function which is defined and classified some of its properties. Database building is proposed to provide the information of the fuzzy distribution functions. Some examples illustrate the method to test whether or not two fuzzy samples have been drawn from the same distribution function. The results show that it is useful to classify the fuzzy numbers into some properties in the database.*
Keywords: Fuzzy Data; Fuzzy Probability Distributions; Fuzzy Statistics and Data Analysis; Test Hypothesis

1. Introduction. Conventional statistical analysis is pursued using numerical values, so called crisp values. The values are not supposed to be any fuzzy numbers. The traditional statistical analysis is considered with associated random variables, point estimation techniques, hypotheses and parameters of interest and so on Akbari et al. (2009). Two-sample test statistic is one of the most useful nonparametric methods to compare two samples, as it is sensitive to differences in both the location and the shape of the empirical cumulative distribution functions of the two samples (Conover, 1971). But when data are given vaguely, that is, the given data are fuzzy numbers, knowing the distribution function of fuzzy data plays a pivotal rule in dealing with problems in the real world. The distribution function must be estimated under the specified condition or in the situation given in advance. In real life, vague information is widely used when describing data in natural language (Nguyen and Wu, 2006). On the other hand, in dealing with fuzzy data, the underlying probability distribution of the fuzzy data is unknown. The situation makes it difficult to put such information into statistical terms. Therefore, the objective of the paper is to establish a technique to handle such information and knowledge.

In order to find the probability distribution function with fuzzy data, we have to take the concept of fuzzy statistic into consideration. Following Zadeh (1965, 1973), fuzzy data are treated here. Fundamental statistics, such as mean, median and mode are useful measurements in illustrating some characteristics of the sample distribution. Recently, the fuzzy statistical analysis and applications are studied and focused on the social science such as Casalino et al. (2004), Dubois and Prade (1980), Wu (1995), and Wu and Sun (2001), which demonstrate the central role of fuzzy statistic and apply it to social survey. All research studies used to deal with problems using the central points of fuzzy numbers. Pei-Chun Lin, et al. defined a new weight function in terms of central point and radius. The function will show more effective to observe original fuzzy data.

Specifically, the objective of this paper is to define fuzzy distribution function, and clarify its property. The rest of the paper consists of the following. Section 2 gives the brief review of related studies. In Section 3, the main procedure is described to construct the database with fuzzy distribution function. In Section 4, we describe some empirical studies. Finally, the concluding remarks and the topics of further studies are addressed in Section 5.

2. Problem Statement and Preliminaries. Let us introduce some definitions using LR-type fuzzy numbers (Esogbue and Song, 2003), which are used in the next section.

Definition 1. A fuzzy number $A = [a, b, c, d]$ is called trapezoidal with tolerance interval [b, c], left width $L = b - a$ and right width $U = d - c$ if its membership function has the following form:

$$\mu_A(x) = \begin{cases} 1 - \dfrac{b-t}{L} & if\ b - L \leq t \\ 1 & if\ b \leq t \leq c, \\ 1 - \dfrac{t-c}{U} & if\ c \leq t \leq c\cdot \\ 0 & otherwise \end{cases}$$

and it is also denoted by $A \equiv (b, c, L, U)$.

Definition 2. Especially, if $b = c$, the fuzzy number is called a triangular fuzzy number $B = [a, b, d]$, the left width $L = b - a$ and right width $U = d - b$. Its membership function is written in the following form:

$$\mu_B(x) = \begin{cases} 1 - \dfrac{b-t}{L} & if\ b - L \leq t: \\ 1 & if\ t = b, \\ 1 - \dfrac{t-d}{U} & if\ d \leq t \leq d\cdot \\ 0 & otherwise \end{cases}$$

and it is also denoted by $B \equiv (b, L, U)$.

Definition 3. An interval fuzzy number is denoted as $C = [a, d]$ with central point $o = \frac{d+a}{2}$ and radius $l = \frac{d-a}{2}$. We also use the notation $C \equiv (o, l)$.

Moreover, two operations on LR-type fuzzy numbers, namely fuzzy addition and scalar multiplication, are given as follows.

Lemma 1 Let $A_1 = (a, b, c, d)$ and $A_2 = (\bar{a}, \bar{b}, \bar{c}, \bar{d})$ be any two fuzzy numbers and λ be any real number. Then

(a) $A_1 + A_2 = (a + \bar{a}, b + \bar{b}, c + \bar{c}, d + \bar{d})$.
(b) $\lambda A_1 = (\lambda a, \lambda b, \lambda c, \lambda d)$, $\forall\, \lambda \geq 0$.

From the a bove definitions and Le mma 1, we al so need to kno w how to calcul ate the fuzzy expe cted value and fuzzy var iance. We give a brief sta tement in th e fo llowing subsection.

Definition 4. Fuzzy Expected Value

Let A, B and C be continuous fuzzy random variables on the probability space $(\Omega, \mathcal{F}, P)$. Then the fuzzy expected value of A, B and C are defined as follows.

If $A_i \equiv (b_i, c_i, L_i, U_i)$ is trapezoidal fuzzy numbers, $\forall\, i = 1,2,\dots,n$, then

$$E(A_i) = (E(b_i), E(c_i), E(L_i), E(U_i)).$$

Especially, if $B_i \equiv (b_i, L_i, U_i)$ is triangular fuzzy numbers, $\forall\, i = 1,2,\dots,n$, then

$$E(B_i) = (E(b_i), E(L_i), E(U_i)).$$

Moreover, if $C_i = (o_i, l_i)$ is interval fuzzy numbers, $\forall\, i = 1,2,\dots,n$, then

$$E(C_i) = (E(o_i), E(l_i)).$$

Definition 5. Fuzzy Variance

Let A, B and C be continuous fuzzy random variables on the probability space $(\Omega, \mathcal{F}, P)$. Then the fuzzy expected value of A, B and C are defined as follows.

If $A_i \equiv (b_i, c_i, L_i, U_i)$ is trapezoidal fuzzy numbers, $\forall\, i = 1,2,\dots,n$, then

$$var(A_i) = (var(b_i), var(c_i), var(L_i), var(U_i)).$$

Especially, if $B_i \equiv (b_i, L_i, U_i)$ is triangular fuzzy numbers, $\forall\, i = 1,2,\dots,n$, then

$$var(B_i) = (var(b_i), var(L_i), var(U_i)).$$

Moreover, if $C_i = (o_i, l_i)$ is interval fuzzy numbers, $\forall\, i = 1,2,\dots,n$, then

$$var(C_i) = (var(o_i), var(l_i)).$$

When we know the probability distribution function with each elements of A, B and C, we can easily find out the fuzzy expected value and fuzzy variance.

In the next section, we want to give a database of fuzzy distribution function.

2. Database of Fuzzy Probability Distribution Functions.

2.1. F uzzy P robability Distribution Func tion (FP DF). In o rder to dem onstrate the database of distribution function with fuzzy data, we need to define a new function which is called Fuzzy Probability Distribution Function (FPDF).

Definition 6. f is a Fuzzy Probability Distribution Function (FPDF) defined on $\mathbb{R}^3$ with location and sca le parameter, (b, L, U), where b is the second el ement of tri angular fuzzy numbers $[a, b, c]$, $L = b - a$ and $U = c - b$. Moreov er, this function is de noted by $f_F(b, L, U)$.

Notation If b_i, L_i and U_i are independent, then fuzzy probability distribution function can be written in the following:

$$f_{F_i}(b,L,U) \equiv f_i(b) * f_i(L) * f_i(U), \ \forall i = 1,2,\ldots n$$

Here, we give the procedure of building fuzzy probability distribution functions with triangular fuzzy data.

Procedure of building fuzzy probability distribution functions with triangular fuzzy data:

Step 1: Get the triangular fuzzy numbers.

Step 2: Computing b_i, L_i and U_i, $\forall i = 1,2,\ldots,n$.

Step 3: Identify the underlying distribution by simulating b_i, L_i and U_i,

$$\forall i = 1,2,\ldots,n.$$

Step 4: Get the distribution functions of $f_i(b)$, $f_i(L)$ and $f_i(U)$, $\forall i = 1,2,\ldots n$.

Step 5: Compute the fuzzy distribution function $f_{F_i}(b,L,U)$, $\forall i = 1,2,\ldots n$.

When we know this procedure, we can construct the database of fuzzy probability distribution functions. We give this concept in the following subsection.

2.2. Database of Fuzzy Probability Distribution Functions. When we know how to find out the fuzzy distribution functions, we can build the database of each fuzzy distribution function as shown in TABLE 1.

TABLE 1. Database of fuzzy probability distribution functions

$f_{F_i}(b_i,L_i,U_i)$	b_i	L_i	U_i	Property
$f_{F_1}(b_1,L_1,U_1)$	D_{b_1}	D_{L_1}	D_{U_1}	I
$f_{F_2}(b_2,L_2,U_2)$	D_{b_2}	D_{L_2}	D_{U_2}	II
$\vdots$	$\vdots$	$\vdots$	$\vdots$	
$f_{F_n}(b_n,L_n,U_n)$	D_{b_n}	D_{L_n}	D_{U_n}	N

Property 1.

If we have $b_1 \sim D_{b_1} = \Gamma(k_1,\theta_1)$, $L_1 \sim D_{L_1} = \Gamma(k_2,\theta_2)$ and $U_1 \sim D_{U_1} = \Gamma(k_3,\theta_3)$, where $\Gamma(k_i,\theta_i), i = 1,2,3$, is gamma distribution function, then we can find the expected value and variance easily. We use moment method estimator (MME) to estimate our parameter in each distribution function. Moreover, b, L and U have the same property as gamma distribution function. We will show the detail statement in the next section.

Property 2. If we have $b_1 \sim D_{b_1} = W(\lambda,\kappa)$, $L_1 \sim D_{L_1} = \Gamma(k_4,\theta_4)$ and $U_1 \sim D_{U_1} = \Gamma(k_5,\theta_5)$, where $W(\lambda,\kappa)$ is Weibull distribution function and $\Gamma(k_i,\theta_i), i = 4,5$, is gamma distribution function, then we can find the expected value and variance easily. We use moment method estimator (MME) to estimate our parameter in each distribution function. Moreover, b has the same property as Weibull distribution function, L and U have the same property as gamma distribution function. We will also show the detail statement in the next section.

We get the surface plot by one kind of Property of b, L and U in FIGURE 1.

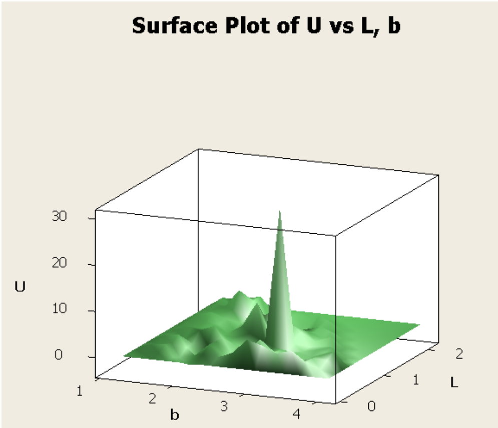

FIGURE 1. Surface plot of U vs L and b

Definition 7 . Let $X_1 \equiv (b_1, L_1, U_1)$ and $X_2 \equiv (b_2, L_2, U_2)$ are two triangular fuzzy numbers. We say that X_1 and X_2 have the same property. It means that b_1 and b_2 have the same distribution, L_1 and L_2 have the same distribution and U_1 and U_2 have the same distribution. Otherwise, we say that they don't have the same properties.

In the next section, we give some empirical studies to demonstrate how to find out the fuzzy distribution function and its application.

4. Empirical Studies. Example 4.1, A Japanese dining hall manager planned to introduce a new boxed lunch service near universities in Taipei city and decided to take a survey to investigate which place will have good returns to sell a boxed lunch for students. He gives the questionnaires to two schools' (Shin Chien University and Chungchi University) students. Samples were randomly selected in each school. The investigator asked them the following questions: 1. more than which times (real numbers) can you accept to buy a boxed lunch a week? 2. How many times (real values) should you buy a boxed lunch a week? 3. More than which times (real values) can't you accept to buy a boxed lunch? We collected those answers of the questionnaires and get triangular fuzzy numbers. The answers are shown in Table 2.

Moreover, we found the fuzzy distribution function by simulating each parameter. We gave the results as Table 3.

TABLE 2. Triangular fuzzy numbers of two schools

Shin Chien University	(2,4,9)	(3,3,5) (1	,2,3)	(3,3,7) (2	,3,4) (2	3,	3)
Chungchi University	(6,7,8)	(4,4,5) (1	,1,2)	(2,3,5) (4	,5,8) (3	5,	6)

TABLE 3. The probability distribution function for parameter of b_i, L_i and U_i

	b_i	L_i	U_i
Shin Chien University (X)	$\Gamma(11.07, 0.27)$	$\Gamma(3.65, 0.39)$	$\Gamma(1.80, 1.21)$
Chungchi University (Y)	$W(2.44, 3.52)$	$\Gamma(7.25, 0.17)$	$\Gamma(2.92, 0.57)$

We could see that b_1 and b_2 have different distribution function, L_1 and L_2 have the same distribution function and U_1 and U_2 have the same distribution function. By Definition 7, we concluded that the two schools have different property of the acceptable times of buying a boxed lunch a week.

Example 4.2 In the same problem as Example 4.1, we used the method in Pei-Chun Lin, *et al.* to test whether two samples have the same distribution function. First, we found the 200 weight values of triangular fuzzy numbers. Then we could get the cumulative distribution function of $S_{100}(X)$, $S_{100}(Y)$ and $|S_{100}(X)-S_{100}(Y)|$. We give the result in Table 4.

TABLE 4. The cumulative distribution function of $S_{100}(X)$, $S_{100}(Y)$ and $|S_{100}(X)-S_{100}(Y)|$

	1 2		3	4	5 6 7	8 9				10	11	12	13	14	15	16	17	18
$S_{100}(X)$	0.00	0.00 0	.01	0.01 0	. 02 0	. 04	0.05	0.09	0.10	0.10	0.10	0.11	0.12	0.15 0	. 15 0	. 16	0.23	0.23
$S_{100}(Y)$	0.01	0.02 0	.02	0.03 0	. 03 0	. 03	0.03	0.03	0.03	0.06	0.08	0.08	0.08	0.08 0	. 09 0	. 09	0.09	0.10
$\|S_{100}(X)-S_{100}(Y)\|$	0.01	0.02 0	.01	0.02 0	. 01 0	. 01	0.02	0.06	0.07	0.04	0.02	0.03	0.04	0.07 0	. 06 0	. 07	0.14	0.13

	19 20		21	22	23	24	25 26	27		28	29 30		31 32	33		34 35		36
$S_{100}(X)$	0.25	0.25 0	.25	0.25 0	. 29 0	. 31	0.31	0.31	0.33	0.33	0.35	0.41	0.43	0.43 0	. 43 0	. 43	0.43	0.45
$S_{100}(Y)$	0.10	0.14 0	.19	0.21 0	. 21 0	. 21	0.24	0.25	0.25	0.30	0.30	0.30	0.30	0.34 0	. 37 0	. 42	0.47	0.47
$\|S_{100}(X)-S_{100}(Y)\|$	0.15	0.11	0.06	0.04 0	. 08 0	. 10	0.07	0.06	0.08	0.03	0.05	0.11	0.13	0.09 0	. 06 0	. 01	0.04	0.02

	37 38		39	40	41	42	43 44	45		46	47 48		49 50	51		52 53		54
$S_{100}(X)$	0.49	0.49 0	.49	0.52 0	. 62 0	. 63	0.63	0.64	0.64	0.64	0.64	0.73	0.73	0.73 0	. 80 0	. 80	0.90	0.91
$S_{100}(Y)$	0.47	0.50 0	.52	0.52 0	. 52 0	. 52	0.54	0.54	0.60	0.61	0.63	0.63	0.67	0.71 0	. 71 0	. 75	0.75	0.75
$\|S_{100}(X)-S_{100}(Y)\|$	0.02	0.01 0	.03	0.00 0	. 10	0.11	0.09	0.10	0.04	0.03	0.01	0.10	0.06	0.02 0	. 09 0	. 05	0.15	0.16

	55 56		57	58 59	6	0	61 62	63		64 6	5	66 67		68 69	70		71	72
$S_{100}(X)$	0.91	0.91	0.91	0.94	0.95	0.95	0.98	0.98	0.98	0.99	0.99	0.99	1 1 1	1 1				1
$S_{100}(Y)$	0.76	0.78 0	. 86	0.86 0	. 86	0.87	0.87	0.88	0.90	0.90	0.91	0.93	0.93 0	. 94	0.95 0	. 96	0.99	1
$\|S_{100}(X)-S_{100}(Y)\|$	0.15	0.13 0	. 05	0.08 0	. 09	0.08	0.01	0.10	0.08	0.09	0.08	0.06	0.07 0	. 06	0.05 0	. 04	0.01	0

From Table 4, the test statistic was obtained:

$$D = max\,|S_{100}(X)-S_{100}(Y)| = 0.16.$$

at a significance level $\alpha = 0.05$. For large numbers, D must be at least 0.192 in order to reject H_0, for $1.36\sqrt{\frac{100+100}{100\cdot 100}} = 0.192$. Since the observed value did not exceed the critical value, we did not reject H_0. We concluded that the two schools have the same distribution of the acceptable times of buying a boxed lunch a week.

5. Conclusion. In this paper, we defined a new fuzzy distribution function. Moreover, we constructed a database of fuzzy distribution functions. We executed many simulations of real fuzzy data to build up a complete database. But we have also some studies to work on in the future as follows:

(1) How is the range between two parameters of each underlying distribution function defined so as that we can get a good simulation in the properties? Moreover, how can we say that two samples have the same property?

(2) Can we test whether the original fuzzy data distribute to some properties in the database or not?

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DISTURBANCE OF POPULATION & HIGHER EDUCATION DEVELOPMENT: A NON-LINEAR REGRESSION ANALYSIS

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ABSTRACT. *We constructed a non-linear regression model to analyze the impact of disturbance of population on the scale of higher education. According to our non-linear regression model analysis, the gross enrollment rate of higher education should reach 55% by the year 2020, and average annual increase rate of China gross college enrollment number is about 3%.Then the popularization of higher education will be realized by the year 2020, and the lack source of students could be released.*
Keywords: Disturbance of Population; Higher Education; Non-linear Regression Model

1. Introduction. The decreasing birth rate and the rising popularity of overseas studies have combined to drag the number of candidates for this year's make-or-break college entrance exam below 10 million - for the first time since 2007. It mirrors the decreasing birth rate caused by the one-child policy. Typically, students taking this year's entrance exam started primary school education 12 years ago. According to education ministry statistics, primary school enrolment has decreased since 1996. In 2008, it was a third less than the 1995 peak. Apart from the falling number of high school graduates, the trend toward overseas college studies has also led to the drop in candidate numbers. Chinese parents have more choices and are able to make their own judgment on the education quality of Chinese and foreign universities. Besides these two reasons, what other reasons may cause the decrease in number of college entrance exam candidates? One of other reasons is the disturbance of population happened 51 years ago. So, we constructed a nonlinear regression model to analyze the impact of disturbance of population on the scale of higher education.

2. The Disturbance of Population. By the nineteenth century China's history was characterised by continuous wars, revolution and famines and the nation had become politically and economically weak in spite of its long and rich cultural tradition and his past rich civilisation. Accordingly, before 1950 China had demographic characteristics of a pre-modern society with high mortality and high fertility rates. This situation produced certain stability in population size or, at least, lead to a slow increase. With the return of peace, after the foundation of The People's Republic of China in 1949, due to the stability of the society, the development of production and the improvement of medical and health care conditions, the people lived and worked in peace and happiness. The death rate was reduced markedly, while the population increased rapidly, thus the situation then was characterized by more births, fewer deaths and high growth. This is first birth peak period(1949-1957) after the founding of New China.

The age composition of a population is the comprehensive reflection of fertility and mortality. As can be seen in Figure 1, between 1958 and 1961, mainly because of policy errors and nation-wide natural calamity, China experienced a period of famine that lead to a large drop in fertility and a large excess of deaths.

FIGURE 1. Year composition of China population (unit: person)

Source: China Population and Employment Statistics Yearbook-2009, the sum of the national sample survey on population equals 1.18 million people.

This period of crisis was followed by a recovery period in which fertility rate increased rapidly and reached a peak in 1963 because of compensatory childbearing after the famine. In the 1960s, China's population entered its second peak birth period. From 1962 to 1973, the annual number of births in China averaged 26.69 million, totalling 300 million. In 1969, China's population exceeded 800 million.

As a consequence of these demographic changes, China had to manage the problem of improving health, education and life quality for an ever large number of people with an economy that is still weak and inadequate resources. For this reason in 1970s the Government formulated the first anti-natalist policy named “later-longer-fewer”, and that promoted later births, longer spacing between births and fewer births. This policy was followed in 1979 by the family planning program ‘one-child policy’.

The second and third baby boom born people had access to child-bearing age in 1986-1993, which is the third-born population peaked. The third-born population peaked is due to the two previous births over the formation of the peak age. There is a fluctuation cycle of age composition of a population, which is about 24 years. As the time goes by and delayed childbearing, there would be a cycle of an extension, and a smaller cyclical peak values.

3. The Non-Linear Regression Model of Population Disturbance. We can divide age composition data into two parts:0～50 age group and 50～95 age group. Firstly, we do linear regression analysis on the data of 50～95 age group. The regression results in TABLE 1 show the coefficient of each variable in 50～95 age group reach the significant level of 1%.The adjusted R^2 equals 0.94, displaying a much better model fitting.

TABLE 1. Linear regression results (50～95 age group)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Y	-444.2115	17.19144	-25.83911	0.0000
C	39479.92	1267.104	31.15761	0.0000
R-squared	0.938173	Mean dependent var		7274.587
Adjusted R-squared	0.936768	S.D. dependent var		6155.816
S.E. of regression	1547.946	Akaike info criterion		17.56975
Sum squared resid	1.05E+08	Schwarz criterion		17.64926
Log likelihood	-402.1043	Hannan-Quinn criter.		17.59953
F-statistic	667.6594	Durbin-Watson stat		0.239899
Prob(F-statistic)	0.000000			

P represents population, Y represents age, and we can get equation(1):

$$P = -444.21147086*Y + 39479.9185939 \quad (1)$$

Secondly, we do linear regression analysis on the data of 0～50 age group. The regression results show the adjusted R^2 equals 0.34, displaying a much worser model fitting(as shows in TABLE 2). We can speculate that there exists obvious disturbance of population. So, we had better use non-linear regression model to analyze the impact of disturbance of population. We can also get equation(2):

$$P = 153.198914027*Y + 13057.3996983 \quad (2)$$

TABLE 2. Linear regression results (0～50 age group)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Y	153.1989	29.73693	5.151807	0.0000
C	13057.40	862.7127	15.13528	0.0000
R-squared	0.351347	Mean dependent var		16887.37
Adjusted R-squared	0.338109	S.D. dependent var		3842.235
S.E. of regression	3125.916	Akaike info criterion		18.97127
Sum squared resid	4.79E+08	Schwarz criterion		19.04703
Log likelihood	-481.7673	Hannan-Quinn criter.		19.00022
F-statistic	26.54112	Durbin-Watson stat		0.469830
Prob(F-statistic)	0.000005			

We use Equation (2) to generate a line trend Pt (seen from FIGURE 2).Define Po=P-Pt. Then, we use Po and Y to simulate the disturbance of population.

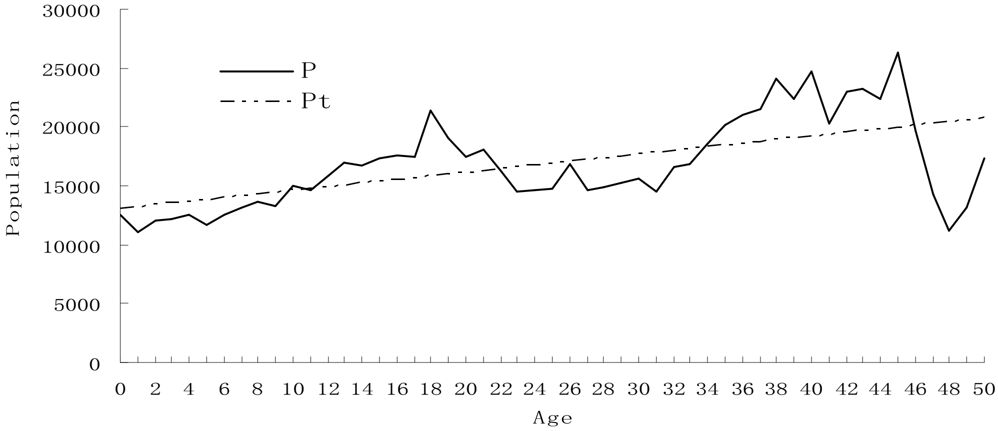

FIGURE 2. Age composition of China population and it's line trend(unit: person）

Source: China Population and Employment Statistics Yearbook-2009, the sum of the national sample survey on population equals 1.18 million.

Po approximately follow the sine distrbution:

FIGURE 3. Trend and fluctuation of po series (unit: person）

Po approximately follow the sine distrbution:

$$Po=C(1)+C(2)*@SIN(Y*6.28/C(3)+C(4)) \quad (3)$$

In Equation (3), C(3) represents sine wave cycle, C(2) represents sine wave amplitude, C(1) represent vertical intercept, and C(4) represent horizontal intercept. The non-linear regression results of Po and Y is shown in TABLE 3.

The nonlinear regression results in TABLE 3 show the coefficient of each variable in 50～95 age group reach the significant level of 5%.The R^2 equals 0.63, which is greater than 50%. Campared with linear regression model, nonlinear regression model displaying a better model fitting .We could get Equation (4):

$$Po=671.07+3656.91*@SIN(Y*6.28/-23.34+2186.25) \quad (4)$$

From TABLE 3, we can see that sine wave cycle equals 23.34 years, approximately equals 24 years. China had a rapid decline in fertility rate in 1961,which could be called “baby bust”.So,1961 plus 48 (2 wave cycles) equals 2009.There was first decrease in participation in University entrance examen in 2009.As delayed childbearing, there would be a cycle of an extension. 2010 is the second straight year of decline, and the number is expected to decrease in the following years.

TABLE 3. Nonlinear regression results (0～50 age group)

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	671.0714	295.8777	2.268070	0.0280
C(2)	3656.914	412.4323	8.866702	0.0000
C(3)	-23.33909	0.664595	-35.11776	0.0000
C(4)	2186.251	0.224788	9725.852	0.0000
R-squared	0.626823	Mean dependent var		473.8039
Adjusted R-squared	0.603003	S.D. dependent var		3279.087
S.E. of regression	2066.076	Akaike info criterion		18.17987
Sum squared resid	2.01E+08	Schwarz criterion		18.33139
Log likelihood	-459.5868	Hannan-Quinn criter.		18.23777
F-statistic	26.31523	Durbin-Watson stat		1.017984
Prob(F-statistic)	0.000000			

4. The Impact on the Scale of Higher Education. We use this non-linear regression model to predict the future scale of university-age population. Most students enter university at 18 years old. We give two types population predicted, the one is average admission age population(18 years old),the other is college-age population(18-22 years old).We respectly caculate the admission age population(18 years old) rate of change and the college-age population(18-22 years old) rate of change, which could be seen from Figure 4 and Figure 5.

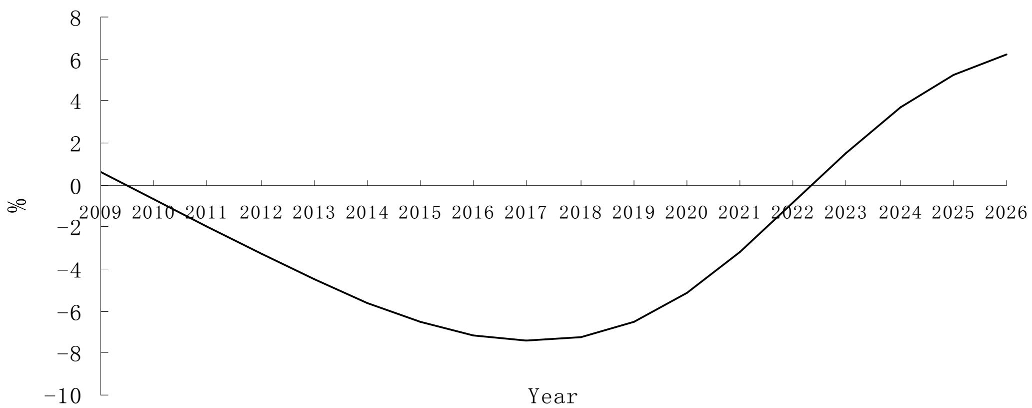

FIGURE 4. The admission age population (18 years old) rate of change

We can see from FIGURE 4 that the annual average decrease rate of admission age population is about 2.54% in 2009-2026, and the annual average decrease rate of admission age population is about 6.09% in 2014-2021.

We can see from FIGURE 5 that the annual average decrease rate of college-age population is about 2.92% in 2009-2026, and the annual average decrease rate of admission age population is about 6.03% in 2015-2021.

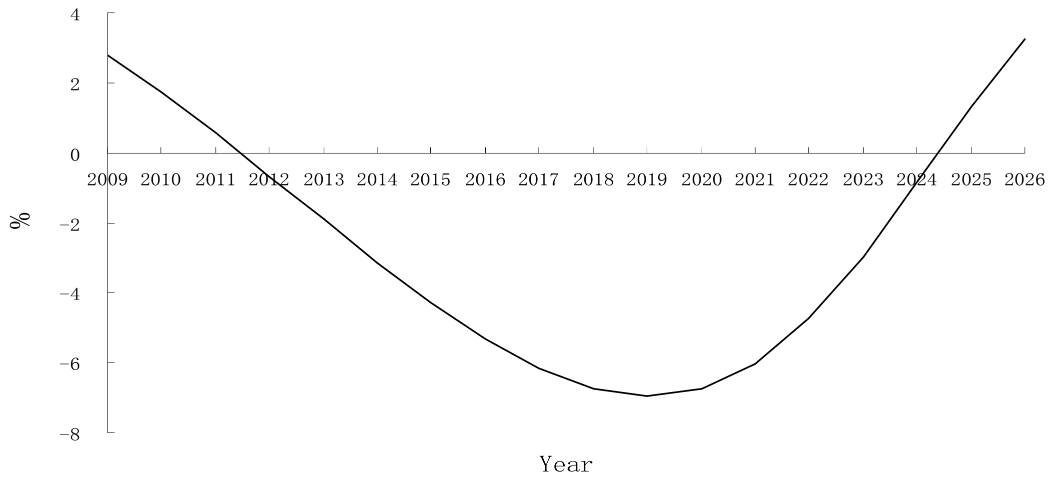

FIGURE 5. The college-age population (18-22 years old) rate of change

5. Conclusions. We can see from former analysis that the decrease of university-age population would diminish the pool market. The gross college enrollment rate in China will reach 25% in 2010.According to our research forecasts to 2020 only increased by 1.5% per year, the average annual increase of 0.29 million people can reach the future of higher education gross enrollment rate of 40% target.

However, the annual average decrease rate of college-age population that is about 3% is higher than that of average annual increase rate of China gross college enrollment rate, which is 1.5% we caculated under college gross enrollment rate of 40% target. At present, the strategic goals of education development at all levels in China lack scientific basis, especially the target of the gross enrollment rate in higher education being 40% by the year 2020. According to our nonlinear regression model analysis, the gross enrollment rate of higher education should reach 55% by the year 2020, and average annual increase rate of China gross college enrollment rate is about 3%.Then the popularization of higher education will be realized by the year 2020.

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TOWARDS INDUSTRIAL ECOLOGY GROWTH ALONG THE PO YANG LAKE REGION

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ABSTRACT. *Po Yang Lake Ecological Economic Zone was ratified by China. Jiangxi provincial government accordingly takes active to plan, act and monitor the pollution abatement, environmental remediation and business retirement. Those that do harm to the environment will not be introduced to the industrial parks, even though the initial investment funds are substantial. However all enterprise environmental management has been performed, it is in fact an outer layer. The high goal is to construct of ecological economy in form of .circular economy and sustainable development. It is concluded that in order to pursue this, industrial ecology growth for the region is required.*
Keywords: Enterprise Environmental Management; Po Yang Lake; Ecological Economy; Industrial Ecology

1. Introduction. Environmental protection is the world concern which draws all officials, researchers, businessmen as well as ordinary men to invest time and money in it. All governments and organizations have had to get to the table to discuss the global warning and environmental abatement. For some parts of the world environmental protection is an ingredient part of their commitment, for other parts, they are approaching them in their own way.

China is a developing country, burdening the responsibilities for the world environmental protection during the courses of rapid economic growth. Policies, laws and regulations are made to plan, implement, monitor and review environmental change throughout the countries. Huge investment, meanwhile, is put into the environmental engineering and businesses to contain pollutions. However, problems arise when manufacturing is booming and environmental technology lags behind. These problems are put into agenda of the governments and the way out are coming out all the time to cut the pollutions and remedy environment.

In 2009, Chinese governmental first ratify the Program of Po Yang Lake Ecological Economic Zone which marks strategy to preserve clean water and unpolluted region along the Po Yang Lake, the largest fresh lake in China. The project has exerted great influences in China since China is nicknamed “world factory”. The program symbolizes a transition from traditional type of growth to modern one emphasizing prevention of air emissions, water discharges, use of raw materials, use of energy, use of natural resources, use of volatile organic compounds.

2. Basic Model for Enterprise Environmental Management. Before starting the above thesis, let us introduce a model of environmental management and its relationship with an environmental management system (EMS). The former is the process of planning, doing, checking, and acting, which is convenient for illustration (see figure 1). It is said that an environmental management system (EMS)is the part of an overall management system which includes organizational structure, planning activities, responsibilities, practices, procedures, processes, and resources for achieving environmental policy (U.S. Department of the Interior Office of Environmental Policy and Compliance), According to U.S. Department of the Interior Office of Environmental Policy and Compliance, Purpose of an EMS is to bring together the people, policies, plans, review mechanisms, and procedures used to manage environmental issues at a facility or in an organization.

Those who are committed to meeting your environmental responsibilities could get your EMS certified, such as through ISO 14001, BS 8555, Green Dragon or the Eco-Management and Audit Scheme (http://www.businesslink.gov.uk/). The most widely used and respected is the International Standard ISO 14001.

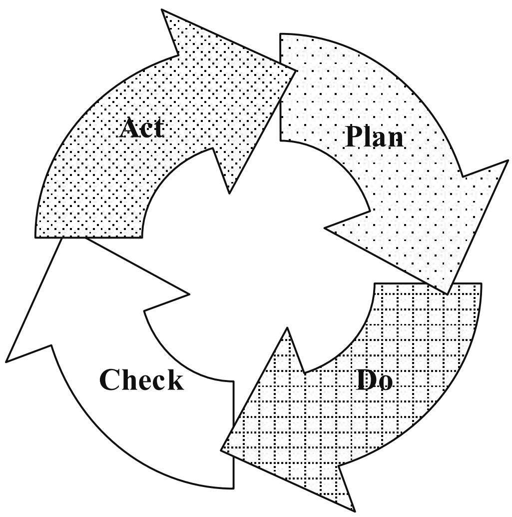

FIGURE 1. A basic EMS framework

The most successful model is built on a Plan, Do, Check, Act model, which depicts the continuous cycle of environmental management system from the procedure of planning, doing, and checking to acting. At the first step of planning, it requires setting specific goals for that organization to accomplish the concerning environment. Then, the organization needs to take whatever steps are necessary to implement the processes laid out in the planning stage. Checking involves supervising the environmental management plan, assessing its effects and responsively adjusting the procedures as necessary. Finally, acting involves reviewing the plan after it is complete and check to see if the activities conducted are in compliance with the target so as to get feedback and adjust the plan accordingly.

When we use basic EMS framework in broad sense, a cause - effect method is available. One is to define the elements of an organization's activities, products, or services which can interact with the environment. Another is to observe any change to the environment whether adverse or beneficial, wholly or partially resulting from an organizations activities, products, or services. Example for cause and effect as follows: a) causes: air emissions, water discharges,, use of raw materials, energy use, use of natural resources, use of volatile organic compounds; b) effects: depletion of natural resources, air pollution, hazardous waste generation, soil and water contamination.

3. Objective and Practices in Po Yang Lake Region. Ecological economics is a newly developed discipline, dealing with the interactions between humans and the natural world (Illge and Schwarze, 2006), in the economy that is connected to and sustained by, a flow of energy, materials and ecosystem services. Jiangxi is one of the provinces having good environment protection. The government of Jiangxi province proposes a blueprint of clean water and green mountains, in which Po Yang Lake is under the basic environmental protection in decades. However, it is susceptible to pollute because industrial facilities are available at an alarming speed with in policy to catch up with the advanced regional economy. Therefore, the central government was responding to the local government request to ratify the program in 2009, imposing some of the tight constraints on protecting clean fresh water in Po Yang Lake whereby industrial layout is emphasized. Po Yang Lake ecological economic area is the first ecosystem designed to enhance harmonious coexistence between people and their environment along the lake and rivers, which also is the discipline that freshwater ecology deals with. This project indicates that China values environmental protection during her rapid development in transition from average in GPD per capita several thousands to ten thousands US dollars.

Under the Po Yang Lake ecological economic zone plan Environmental friendly industrial projects are assigned such as aviation industry, photoelectric industry and food industry and so on. The design goes along the way of industrial cluster with green manufacturing, forming a closed loop ecosystem to reuse material and energy as some industrial parks do, or of forming a comprehensive plan in the region to build ecosystem for sustainable economic growth (Jelinski, ET AL. 1992,). Therefore, industrial effluent abatement is a challenging task. Nevertheless, the program sheds light on industrial growth and paves the way to environmental friendly growth in the future. Table 1 depicts the constraint imposing by the state till 2020. In order to maintain the considerable economic growth with pollutant abatement, therefore people should switch from traditional idea, investment, and industrial design and production mode to the new ones (Ehrenfeld, 1997).

In order to move ahead with the ecological economic plan, local governments are mobilizing all the resources under the circumstances that allow.

Firstly, provincial government organizes a group of lecturers to enter into every city and every city respectively into every county to communicate the contents of ecological economy to the target listeners, thus enabling all the people along the lake acquire some knowledge about the lakeside protection. Employees at a company or members of an organization that has chosen to implement an environmental management plan must be given the proper environmental training.

Secondly, as far as environmental protection along the Po Yang Lake, needless to say that business play a vital important in pollution prevention. They must raise consciousness of

environmental management. While goals such as conservation and better methods of waste disposal are solid ideals to strive for, many of these techniques have been tried before. If everyone at the organization is not on board and using the same methods, the plan will serve no ultimate good. If an environmental management plan is properly enforced, however, the company will see benefits both to its business and to the environment.
Thirdly, environmental management does not come without costs. These include the investment of resources such as time and money, the cost of training the employees, the cost of hiring consultants or other professionals and the cost of technical resources for studying the environment and its impacts. It is widely believed, however, that the benefits of an environmental management plan far outweigh the costs in the long run. These include the prevention of pollution and the conservation of natural resources, increased energy efficiency, stronger environmental performance and an attention to and responsibility for taking care of the earth. Following a management plan for the environment is a great way to build strong employee relationships and foster company support around one goal.

TABLE 1. Po yang lake ecological economic zone program in environmental protection

Item	2008	2015	2020
Wetland (sq. km)	3100	3100	3100
Water quality	Roughly III	Above III	Above III
Water quality III from five outlet	78%	85%	90%
Forest coverage	60.05%	63%	63%
Energ. consump. per GDP		20%	less 15% the 2015 figure
Water consump. per-unit indust. Value-added		25%	less 25% the 2015 figure
COD reduction		10%	less 10% the 2015 figure
CO2 reduction		10%	less 10% the 2015 figure
GDP per capita (RMB)	19810	45000	80000
DI per capita in urban area(RMB)		Annual increase by 8.5%	Annual increase by 8.0 %
NI per capita in rural area (RMB)		Annual increase by 8.5%	Annual increase by 8.5%
Urbanization	42.2%	50%	60%

4. Way out: Industrial Ecology. Industrial ecology began to emerge as people realized that the industrial world was having an impact on the environment. Industrial ecology is thought to compare industrial ecology to non human natural ecosystem as some researchers have nicknamed ‘biological analogy’ (Frosch and Gallopoulos, 1989). An ecosystem refers to all the life forms (plant and animal) and their relationship to one another in a cohesive, relatively independent area. In a perfect world an ecosystem is in balance, the life forms depend on each other; whilst in a real world ecosystems are rarely in balance. For example, pollution runoff from a factory can affect marine life in a lake, causing the fish population to plummet, thus destabilizing the entire surrounding ecosystem. Because of many biological ecosystems function successfully in recycling resources, industries do function in recycling materials and renewing energies. One of most examples of industrial reuse and recycling is Kalundborg, Demark (Ehrenfeld and Gertler, 1997). The industrial districts are composed of a cluster of industrial facilities that exchange by-products among an oil refinery, a power plant, a pharmaceutical fermentation plant and a wallboard factory.

Moreover, industrial ecology is mostly supported by environmental technology development from remediation to sustainment. Thus, industrial ecology depends on technology innovation in which eco-design play a key role in anticipating and preventing environmental harms (Korhonen, 2004).

The Po Yang ecological economic zone is inclusive of 18 counties, therefore, each county and the city begins mapping out appropriate environmental and industrial engineering plan to remedy problems as well as to cut waste and emission in compliance with the program. A few of eco-industrial parks have tried and succeeded in green manufacturing and recycling in materials and energy.

Much has been done for preserve the clean water flowing down the Lake from industrial aspect. On the one hand, industrial parks reinforce the responsible attitudes toward the investment projects. Those that do harm to the environment will not be introduced to invest in the industrial parks, even though the initial investment funds are substantial. Thus, all the investment projects that go to the industrial park are subject to government regulations.

On the other hand, all the city and the county government towns have sewage disposal plant, which cost them millions Yuan. This remedy brings about great improvement in pollutant abatement and re use of water. However, LCA is not on the agenda as a measure to reinforce environment protection.

Moreover, some of the industrial parks are directed at circular economy, symbolizing eco-industrial park. Nanchang hi-tech industrial is credited with national eco-industrial park and Hengfeng eco-industrial Park is licensed as one of the ten eco-industrial parks in Jiangxi province (Tang and Zhang, 2010).

The road map to reach the target is depicted in the Po Yang Lake ecological economic blueprint concentrating on three points in eco- design as follows: a) To carry out energy consumption plan; b) To lay out recycling plan which will take place in industrial park or regional economy and; c) To design a retired mechanism that could force harmful firms and products out under the life cycle management. However, at present this may stay in designing phase for a period of time but it is a good beginning.

5. Conclusion and Further Discussion. Global environmental deterioration has exerted great influence to human being; therefore environmental management deserves valid consideration, in which industrial ecology was sparked off by researchers and practitioners, emphasizing minimizing the wastes and save energy in harmony with the whole atmosphere. Po Yang Lake ecological economic zone program granted by Chinese government tries to solve the problems that a moderately developing region meets in their development to modernization. The program should deal with pollutant abatement and eco-design for recycling and retiring of materials and products, process as well as energy-saving for the purpose of circular economy and sustainable development. However, this is a hard task and it is at the beginning.

The thorniest problems to be dealt with along the Po Yang Lake are rapid growth pull by the central government and urgent requirement of local people, therefore growth is viewed as priority for betterment, whereas, government and all walks of life create a desire to protect the deteriorated environment. As the manufacturing industry is accounting for more than 50% of the sector of the economy in Jiangxi province, the second sector is still the drive for expansion. This problem is hard to solve for the time being. Industrial ecology is one of the methods applied to present a good answer; however, it does not come without cost. Huge investment is required such as cost of research and development and technical transactions and the cost of technical resources for studying the environment and its impacts. Since the advanced countries do not provide a complete and satisfactory answer to this question as to how to manage the industrial pollutions well, and therefore, the followers' road is not likely smooth.

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FUZZY EVALUATING GOAL ORIENTED AND MARKETING STRATEGY IN COMMUNITY COLLEGES

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ABSTRACT. *This study evaluates community colleges' goal values and marketing strategies. Redefining the current community college vague goal, this work uses participant preference to investigate the college's needs, future trends, and marketing strategies. The results show that vocational training has become the top ranking course in community colleges. Life skill is one of the most popular courses to meet students' needs. Students expect to enhance vocational training in community colleges as part of their marketing strategy for future career development. It is suggested that design-related training with vocational values and special courses for life skills are important for community colleges to help students prepare for job expertise.*

Keywords: Fuzzy Goal Oriented; Marketing Strategy; Community Colleges

1. Introduction. The community college in Taiwan has become the new dimension for further extended higher education, and re-evaluating its goal value and efficiency has become an important topic. The founding of the National Association for the Promotion of Community Universities (NAPCU) in September 1999 has opened a new era of community colleges in Taiwan. The original intent was to inspire citizens' critical thinking and enhance the formation of civil society. However, the purpose and value of the community college was not well defined.

The traditional idea of community colleges generated from extending technical and vocational education, combined with adult education and lifelong education. The current situation in Taiwan for planning general courses in community college consists of three categories: exploring fundamental issues (academic programs), developing public areas (community programs), and enriching the meaning of life (life skills course).New ideas concerning the community college include building viewpoints through persistent reflection and discussion. This paper investigates the target values and marketing strategies for the future community college, based on participants' preference.

Fuzzy statistics are becoming more important in measuring ambiguous concepts in social sciences. Why is it that the traditional numerical model cannot explain complex human and social phenomena? Manski (1990) reminded of the risk of too much demand for digital data and over-interpretation. Using fuzzy data may avoid such risks. However, ambiguous data are consistent with human logic during the computing process. Human thoughts and feelings are ambiguous and uncertain, and on the satisfaction scale, happiness, sadness, strength, weakness, optimism, pessimism, and so on are not easy to assess. Language and concepts are limited for analysis by traditional logic technology. The fuzzy sets concept, first proposed by Zadeh, uses the principle of fuzzy measure and classification to deal with the dynamic environment, to give a more reasonable description (Zadeh, 1965; Wu, 2010).

This study uses a fuzzy questionnaire, fuzzy modes, a fuzzy mean, and a fuzzy Chi-square test to compare with each other to analyze the membership function status of community colleges in terms of participants' demand, future trends, and marketing strategy. The purposes of this study are as follows: 1. To establish a goal value system for community colleges. 2. To analyze the needs of community college students. 3. To analyze the future direction of community colleges from three dimensions-the value of life, the region, and the world. 4. To analyze the marketing strategy of community colleges.

2. Goal Orientation and Marketing Strategy.

2.1. Goal Orientation of the New Generation Community College. The first community college, Wen-Shan Community college, was established in Taipei in 1998, now totaling 87 in number. The current community college can be divided into "concept-based " and "market-based". By self-directed learning, students enter the community college and take courses through the market (Knowles, 1980). However, difficulties occurring in community college courses that include participants' low interest in academics, low attendance, and unclear core values and goal orientation t make it extremely difficult for community colleges to survive. According to difficulty values, the current values of community colleges can be divided into personal, regional, and world levels:

(1) Personal value dimensions. Participants believe that their individual needs are the major consideration, and take life skill courses to enhance their quality of life.. Hence, there are no differences between a community college and a cram class.

(2) Regional value dimensions. The community college complies with the public recreational demand to conduct classes, and modifies the developing direction for life skills learning. The community college offers educational opportunities, once available only to elite students, and channels for adults to better understand themselves, other people, and modern society.

(3) World value dimensions. The community college is the best place to nurture new ideas and disseminate knowledge. However, the lack of specific action and reflection cannot achieve the ideal of civil society. Although the number of community colleges has increased, the quality has not improved. Therefore, the Cram School Association has often questioned the value of the community college, causing the government to deny it funding.

The goal value might vary in different phases; different demands generate different levels of values. Achieving the ultimate goal of civil society requires enhancing life quality at the basic individual level and moving up to the regional level, and finally, up to global civil society.

2.2. Assessing the Value of the New Generation Community College. The new community college has been established for 12 years in Taiwan, and has exceeded expectations in the fast "chaos market". As the former Director of the Department of Social Education indicated, “development of the community college in Taiwan is a miracle”. Community colleges resemble cram schools. However, the situation can be remedied as Tocqueville’ mentioned, “the electors trust their representative to be as eager in their private interests as in those of the country” (Tocqueville, 1840). The key point is to properly integrate private interests within the public good. Fukuyama (1995) pointed out that trust in the group creates high-performance. People join organizations out of an interest in cooperating with society, which adds meaning to life.

The purpose of community colleges is to promote liberal arts in society and re-orientate social values. The goal values of the community college lie in how to guide an individual’s philosophy of life concerning the value of the regional community, and to achieve global values, depending on the marketing strategy and internalized curriculum and teaching.

2.3. Marketing Strategy for the New Generation of Community Colleges. Westervelt (2006) suggested that the construction of a brand marketing plan ought to have the following steps: 1. Set the brand marketing objectives; 2. Brand commitment; 3. Brand attributes; 4. Brand type; 5. Brand positioning; 6. Brand positioning frame; 7. Customer; 8. Ads; 9. Budgets. Glatsten (2008) proposed establishing a strong brand and giving customers the best experience. Therefore, brand and marketing is a chain, brand image is a promise - a promise that must be kept. Each individual step in the community college process contains a number of touch points that participants encounter, for instance, how to meet participant’s course requests and the community college concept. The following presents an analysis of the three aspects of life value, regional value, and world value.

2.3.1. Response to the Marketing Strategies of Life Value. Harvard Business School recommends that office workers should have the ideal "π-type talent," which refers to professional depth and interdisciplinary breadth. According to Ohmae’s recommendation in 2002, “being a generalist will be even better if one possesses the two keys of professional “π-type talent”. Only if one enhances his or her own added value as the "π-type talent" with a second expertise can he or she stand firm against the wave of lay-off. The curriculum design of the community college should not only meet the needs for learners’ personal life, but also include training courses to develop their second expertise.

2.3.2. Response to Regional Value Marketing Strategies. Value management was developed after World War II, mainly due to wartime material shortages, in an effort to find quality and cost alternatives. Community colleges should use the values of creative thinking, local materials development, local characteristics, curriculum, and established marketing network.

2.3.3. Response to the Marketing Strategies of World Value. Inglehart (1977) pointed out that after the post-war economic boom; people began to change value orientation, similar to Maslow's needs theory, from basic economic security to higher satisfied emotional needs.

The "Universal Declaration of Human Rights," published by the United Nations in 1948, covers civil, political, economic, social, and cultural rights, such as personal protection of basic rights. Community college education and its marketing strategy should implement the protection of human rights and the value of civil society.

3. Fuzzy Methods.

3.1. Research Process. This research establishes the value of the community college system to find their marketing strategy.

Education policy should be adjustable and inclusive. The differences among educational needs, benefits pursuing, and types of activities for value subjects will reflect on the conflicts toward value cognition and value choice.

3.2. Fuzzy Statistics to Analysis. Traditional statistics deals with a single answer or a certain range of the answer through a sampling survey, and is unable to sufficiently reflect the complex thought of an individual. If people can use the membership function to express the degree of their feelings based on their own choices, the answer presented will be closer to real human thinking. Therefore, collecting information based on the fuzzy mode should be the first step, and fuzzy statistics, such as fuzzy mode and fuzzy median, fit modern requirement. The current and next section demonstrates the definitions for fuzzy mode and fuzzy median generalized from traditional statistics. The discrete case is simpler than the continuous one.

Definition 3.1. Fuzzy sample mode (data with multiple values). Let U be the universal set (a discussion domain), $L=\{L_1,L_2,\cdots,L_k\}$ a set of k-linguistic variables on U, and $\{FS_i, i=1,2\cdots,n\}$ a sequence of random fuzzy sample on U. For each sample FS_i, assign a linguistic variable L_j a normalized membership $m_{ij}(\sum_{j=1}^{k} m_{ij}=1)$, let $S_j=\sum_{i=1}^{n} m_{ij}$, $j=1,2,\cdots,k$. Then, the maximum value of S_j (with respect to L_j) is called the fuzzy mode (FM) of this sample. That is $FM=\{L_j \mid S_j=\max_{1\le i\le k} S_i\}$.

Note: A significant level α for fuzzy mode can be defined as follows: Let U be the universal set (a discussion domain), $L=\{L_1,L_2,\cdots,L_k\}$ a set of k-linguistic variables on U, and $\{FS_i, i=1,2\cdots,n\}$ a sequence of random fuzzy sample on U. For each sample FS_i, assign a linguistic variable L_j a normalized membership $m_{ij}(\sum_{j=1}^{k} m_{ij}=1)$, let $S_j=\sum_{i=1}^{n} I_{ij}$, $j=1,2,\cdots,k$ $\quad I_{ij}=1 \; if \; m_{ij}\ge\alpha,\; I_{ij}=0 \; if \; m_{ij}<\alpha$, α is the significant level. Then, the maximum value of S_j (with respect to L_j) is called the fuzzy mode (FM) of this sample.

That is $FM = \{L_j \mid S_j = \max_{1 \le i \le k} S_i\}$. More than two sets of L_j that reach the conditions, assures that the fuzzy sample has multiple common agreement.

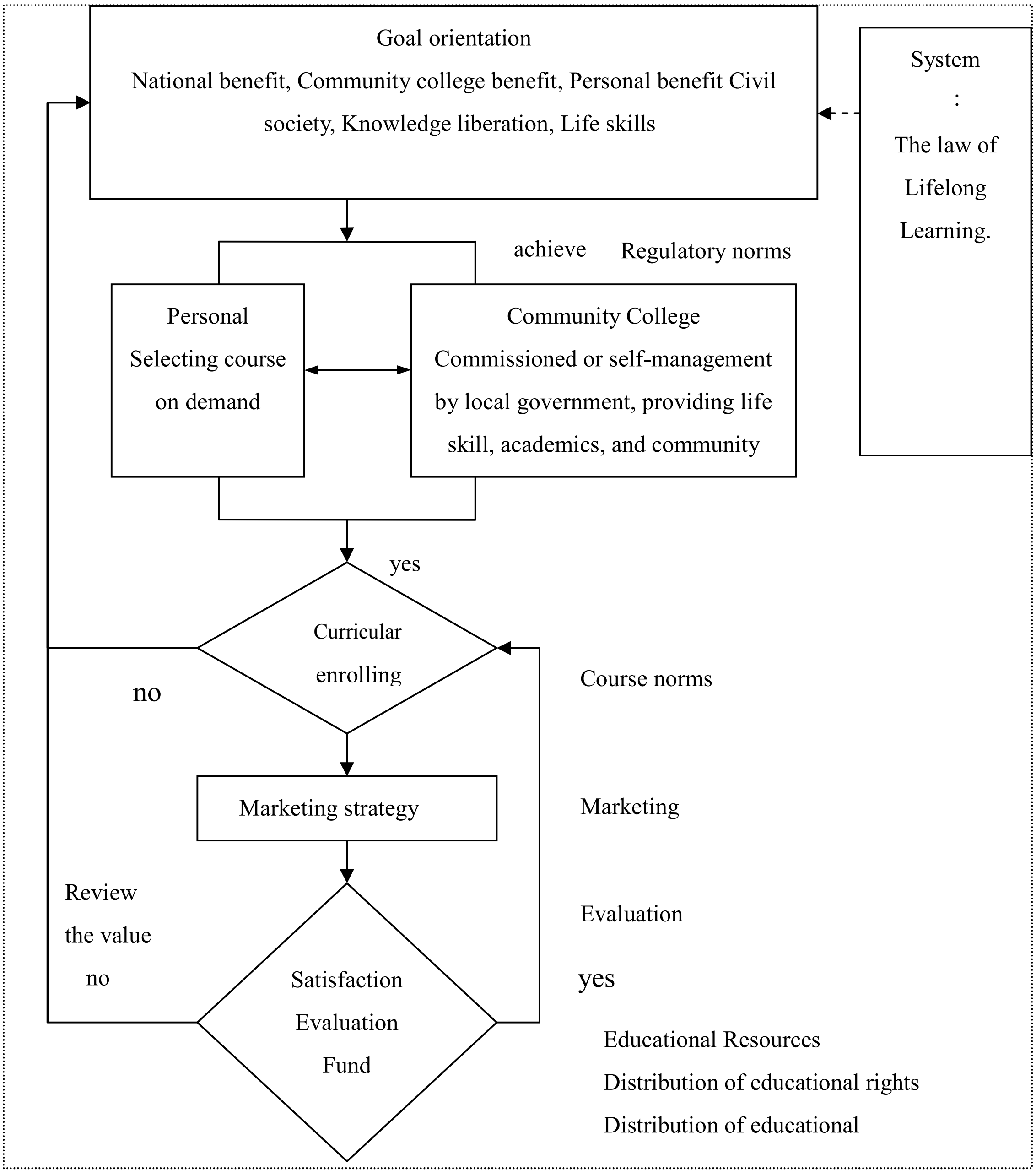

FIGURE 1. Dynamic process of community college structure

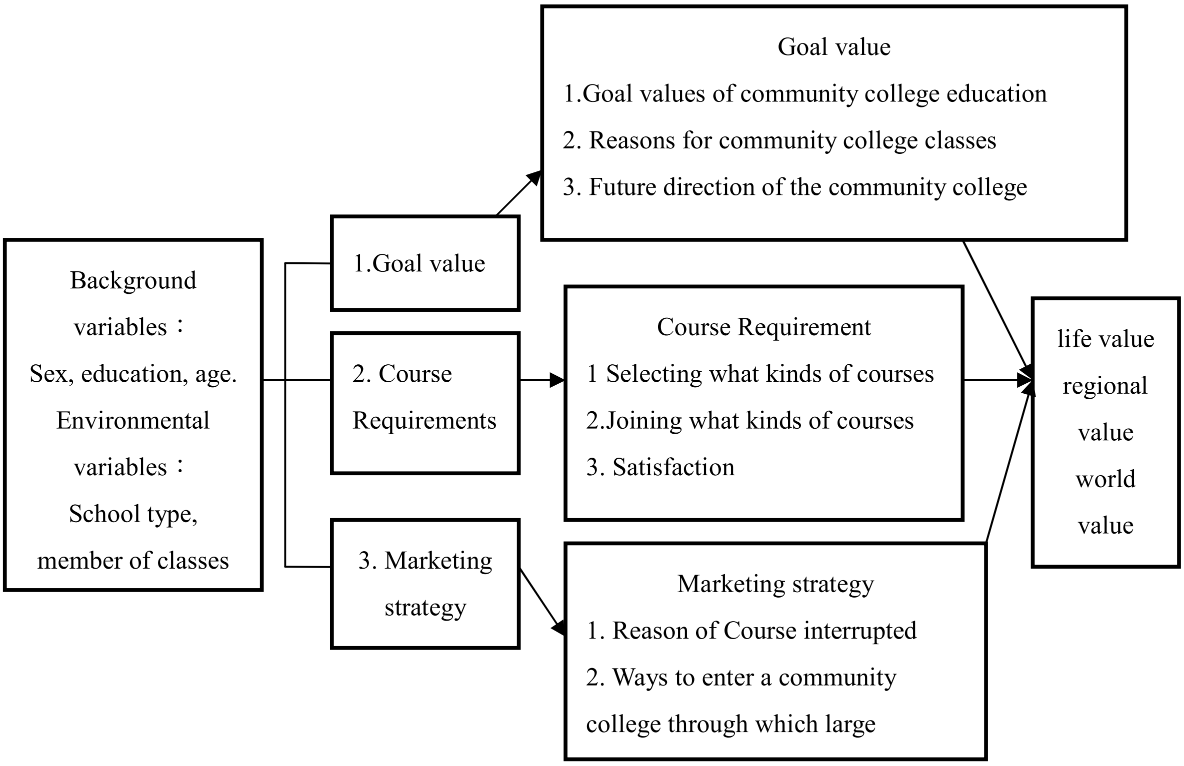

FIGURE 2. Research framework

Definition 3.2. Fuzzy sample mode (data with interval values). Let U be the universal set (a discussion domain), $L=\{L_1,L_2,\cdots,L_k\}$ a set of k-linguistic variables on U, and $\{FS_i=[a_i,b_i],a_i,b_i\in R,i=1,2,\cdots,n\}$ be a sequence of random fuzzy sample on U .For each sample FS_i, if there is an interval [c, d] that is covered by certain samples, these samples are a cluster. Let MS be the set of clusters which contains the maximum number of sample, then the fuzzy mode FM is defined as

$$FM=[a,b]=\{\cap[a_i,b_i]\,|\,[a_i,b_i]\subset MS\}.$$

If $[a,b]$ does not exist (i.e. $[a,b]$ is an empty set), this fuzzy sample does not have a fuzzy mode.

Example 3.1 Suppose eight voters are asked to choose a chairperson from four candidates. Table 1 is the result from the votes with two different types of voting: traditional response versus fuzzy response.

From the traditional voting, three persons voted for *B*. Hence the mode of the vote is *B*. However, from fuzzy voting, *B* only gets a total membership of 2.1, while *C* gets 3.4. Based on traditional voting, *B* is elected the chairperson, while based on fuzzy voting or membership voting, *C* is the chairperson. The fuzzy vote more accurately reflects voters' preference; *C* deserves to be the chairperson more than *B* does.

TABLE 1. Response comparison for eight voters

Candidate / Voter	traditional response				fuzzy response			
	A	B	C	D	A	B	C	D
1		∨				0.7	0.3	
2	∨				0.5		0.4	0.1
3				∨			0.3	0.7
4			∨		0.4		0.6	
5		∨				0.6	0.4	
6				∨	0.4		0.4	0.6
7		∨				0.8	0.2	
8			∨				0.8	0.2
Total	1	3	2	2	1.3	2.1	3.5	1.6

3.3. Fuzzy χ^2 -Test of Homogeneity. Consider a K-cell multinomial vector $n=\{n_1, n_2, ..., n_k\}$ with $\sum_i n_i = n$ .The *Pearson chi-squared test* ($\chi^2 = \sum_i \sum_j \frac{n_{ij} - e_{ij}}{e_{ij}}$) is a well known statistical test for investigating the significance of differences between observed data arranged in K classes and theoretically expected frequencies in K classes. The large discrepancies between the observed data and expected cell counts will result in larger values of χ^2

An ambiguous question is whether (quantitative) to consider discrete data categorical and use the traditional χ^2 *-test*. For example, suppose a child is asked the following question: "*how much do you love your sister*?" If the response is a fuzzy number (say, 70% of the time), it is certainly inappropriate to use the traditional χ^2 -test for analysis. The following presents a χ^2 -test for fuzzy data:

Procedures for testing hypothesis of homogeneity for discrete fuzzy samples. (1) Sample：Let Ω be a domain, $\{L_j, j=1,...,k\}$ be ordered linguistic variables on Ω, and $\{a_1, a_2, \cdots, a_m\}$ and $\{b_1, b_2, \cdots, b_n\}$ be a random fuzzy sample from population A, B with standardized membership function mA_{ij}, mB_{ij}. (2) Hypothesis: Two populations A, B have the same distribution ratio.

$$H_0 : F\mu_A =_F F\mu_B \quad \text{Where} \quad F\mu_A = \frac{\frac{1}{m}MA_1}{L_1} + \frac{\frac{1}{m}MA_2}{L_2} + ... + \frac{\frac{1}{m}MA_k}{L_k}$$

$$F\mu_B = \frac{\frac{1}{n}MB_1}{L_1} + \frac{\frac{1}{n}MB_2}{L_2} + ... + \frac{\frac{1}{n}MB_k}{L_k}, MA_j = \sum_{i=1}^{m} mA_{ij}, MB_j = \sum_{i=1}^{n} mB_{ij}$$

(3) Statistics

$$\chi^2 = \sum_{i \in A,B} \sum_{j=1}^{c} \frac{([Mi_j] - e_{ij})^2}{e_{ij}}$$

To perform the Chi-square test for fuzzy data, we transfer the decimal fractions of M_{ij} in each fuzzy category cell into the integer M_{ij} by counting 0.5 or higher fractions as 1 and discard the rest.

(4) Decision rule: Under significance level α, if $\chi^2 > \chi^2_\alpha(k-1)$, then we reject H_0.

Procedures for testing hypothesis of homogeneity for interval fuzzy samples

(1) Sample：Let Ω be a discussion domain, $\{ L_j, j=1,...,k \}$ be ordered linguistic variables on the total range of Ω, and $\{ a_i = [a_{li}, a_{ui}], i=1,...,m \}\}$ and $\{ b_i = [b_{li}, b_{ui}], i=1,...,n \}$ and be a random fuzzy sample from population A, B with standardized membership function mA_{ij}, mB_{ij}.

(2) Hypothesis: Two populations A, B have the same distribution ratio. i.e

$$H_0: \ F\mu_A =_F F\mu_B \text{, where } F\mu_A = \frac{\frac{1}{m}MA_1}{L_1} + \frac{\frac{1}{m}MA_2}{L_2} + ... + \frac{\frac{1}{m}MA_k}{L_k}$$

$$F\mu_B = \frac{\frac{1}{n}MB_1}{L_1} + \frac{\frac{1}{n}MB_2}{L_2} + ... + \frac{\frac{1}{n}MB_k}{L_k}, MA_j = \sum_{i=1}^{m} mA_{ij}, MB_j = \sum_{i=1}^{n} mB_{ij}.$$

(3) Statistics

$$\chi^2 = \sum_{i \in A,B} \sum_{j=1}^{c} \frac{([Mi_j] - e_{ij})^2}{e_{ij}}$$

To perform the Chi-square test for fuzzy data, we transfer the decimal fractions of M_{ij} in each fuzzy category cell into the integer M_{ij} by counting 0.5 or higher fractions as 1 and discard the rest.)

(4) Decision rule: Under significance level α, if $\chi^2 > \chi^2_\alpha(k-1)$, then we reject H_0.

4. An Empirical Study.

4.1. Research Objects. This study used a quantitative survey to collect data for Nantou County Community College. The questionnaire included eight items, answered by fuzzy form. The study distributed 100 questionnaires, with 75 returned, totaling 64 valid samples. The response rate was 75 %. Table 2 shows the descriptive statistics.

4.2. Fuzzy Statistical Analysis.

(1) The goal value of community college students: Students indicated that the core values of community college education for civil society fuzzy mode are 9.5.; Knowledge Liberate was 23; Life skills were 31.7. The current finding shows that community college students ranked life skill with the highest educational value.

(2) Reasons students join community college classes: The fuzzy mode for course need was 35.1, 6.2 for “Go with friends”, and “Idle” with more than 22.8. The finding shows that course demand is the main reason why students enroll in the community college.

(3) Future direction of the community college: The fuzzy mode for students preferring academic credits was 9.2. Professional course was 15.3, Diploma was 5.9, Vocational Training was 18.7, and Maintain the status was 14. The finding shows that the future direction of the community college is vocational training.

4.3. Course Requirement.

(1) Current enrolling situation: The academic course fuzzy mode was 19.69, Life skill class was 35.2, and Club class was 9.2. The finding shows that most students enroll in life skills classes.

(2) Course requirements of community college students. Participants wishing to join the academic course fuzzy mode were 19.9, Club Class was 4.9, Citizen Class was 1.2, Vocational Training was 12.9, Physical Health was 5.8, Life Skill Class was 22.4, and Local History, Ecology, and Industry were 5.7. The finding shows that life skills class is the most popular course.

(3) Overall Community college satisfaction. Community college participants were very satisfied overall. The fuzzy mode was 10.6, Fairly satisfied was 22.9, Satisfaction was 22.8, Not satisfied was 4.9, and Very dissatisfied was 0.8. The finding shows that the majority of community college participants are very satisfied, with a small number of people dissatisfied.

4.4. College Enrollment Marketing Strategy.

(1) The reason why participants stop classes. The fuzzy mode for participants who join community college classes, and continue was 19.69. The fuzzy mode for reasons for stopping class t because of no message was 35.2, Location is too far was 9.20, No one to go with was 1, Not interesting was 9.8, Too busy was 18.3, Forget to enroll was 8.4, and Have had bad experiences was 0.9. The finding shows that no message is the main cause of intermittent class.

(2) How participants enter community college. The fuzzy mode for participants using the internet to enter community college was 14.7, Notice by friends was 20.2, Notice by Chief Village was 0, Reading the newspaper was 3.4, Watching TV news as 0.9, Propaganda ads was 24.2, radio was 0, and Promotion car was 1.7. The finding shows that propaganda ads, recommended by friends and internet access are the three main sources of information.

4.5. Chi-square Test of Participants with Different Background Variables on Community Values and Future Direction. Applying the Chi-square test to examine the value of community college status reveals no significant difference between gender, education, and age.The finding for the future direction of the community college shows significant difference between different education levels. Persons with higher education wish to have more vocational training. The point of maintaining status reveals significant difference between genders, in that women want to maintain a far greater status than men do.

Some factors have higher Chi-square values: (1) Maintain status and ages: Students 41 ~ 60 yrs who hope to maintain their present situation. (2)Academic credits and ages: Students 41 ~ 60 yrs who hope to obtain academic credits. (3)Vocational training and ages: Students 41 ~ 60 yrs who hope to obtain vocational training.

TABLE 2. Descriptive statistics of nantou county community college

Sex	Female 41(64.1 %), Male 23(35.9 %)			
Age	20-40	41-60	61+	
	6(9.4 %)	49(76.6 %)	9(14.1 %)	
Education	Under high School		College	Graduated School
	27(42.2 %)		37(73 %)	0 ％

TABLE 3. Goal value of the community college

	Fuzzy memberships				Fuzzy mode
The goal value of community college students :	Civil society	Knowledge Liberate	Life skills		Life skills (31.7)
	0.15	0.36	0.49		
Reasons for students join community college classes.	Courses demand	Go with friends	Idle time		Courses demand（35.1）
	0.55	0.10	0.35		
The future direction of the community colleges	Academic credits And Diploma	Maintain the status	Professional courses	Vocational training	Vocational training (18.7)
	0.23	0.21	0.24	0.29	

TABLE 4. Course requirement

	Fuzzy memberships			Fuzzy mode
Current enrolling situation	Academic course	Life skills class	Club class	Life skills class (35.2)
	0.31	0.55	0.14	
Course requirements of community college students.	Academic course, Club class, Citizen class, History, Health, Ecology, Industry ,etc	Vocational training	Life skills class	Life skills class (22.4)
	0.45	0.20	0.35	
Community college overall satisfaction	Not satisfied	Satisfied	Fairly satisfied	Fairly satisfied (33.8)
	0.09	0.35	0.52	

TABLE 5. Marketing strategy of community college's enrollment

	Fuzzy memberships				Fuzzy mode
The reason why participants stop classes	Never stop	Not interesting or no one to go with, too far, or have had bad experiences	No message	Too busy, or forget to enroll	No message (35.2)
	0.16	0.23	0.19	0.41	
How participants enter through community college	By friends	TV, Promotion car , Newspaper Radio 0r Village chief	Propaganda ads	Internet	Propaganda ads (24.2)
	0.32	0.09	0.38	0.23	

TABLE 6. Chi-square test of participants with different background variables on community values and future direction (α =0.05)

Factors	academic credits	Vocational training	Maintain status
Sex (male, female)	Accept H_0 χ^2 =8.58	Accept H_0 χ^2 =6.18	Reject H_0 χ^2 =17.65
Age (20-40, 41-60, 61~).	Accept H_0 χ^2 =20.03	Accept H_0 χ^2 =22.78	Accept H_0 χ^2 =21.75
Education (high school, college , graduate)	Accept H_0 χ^2 =3.73	Reject H_0 χ^2 =19.17	Accept H_0 χ^2 =1.99

5. **Conclusions.** This study examines the value of goals with respect to life, regions, and the world. Using a questionnaire approach and fuzzy statistical analysis, this research discusses the membership function of community colleges according to participants' demand, future trends, and marketing strategy. The results are as follows: there is a tendency to value r life skills in the community college. Providing vocational training courses has become a priority in community colleges. Students anticipate a new direction for community colleges in the future. The Life skills course is the most popular course and the 40-year-old student group were the main participants. The participants gave the higher degree of overall satisfaction to community colleges. "No message" is the main reason why participants stopped attending their courses. Advertisement is the largest source for participants to access community college related information. Most participants are not interested in civil society courses.

Analyzing marketing strategy, this study finds vocational training to be an important future direction for community colleges. The findings show that preparing students' second expertise for a better job, designing field-related vocational training, preparing special courses for the future are important.

Based on the findings, this study makes the following suggestions: (1) Life skill courses need to combine with civil society courses. (2) Enhancing local characteristics to show regional value. (3) For marketing strategy, attract new students to join community colleges by life skill courses. (4) Design special courses for students over the age of 40 years old. (5) Increase budgets for community colleges to subsidize more free courses and support the ideal of civil society in practice.

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RESEARCHES ON HUMAN RESOURCE DEVELOPMENT AND ECONOMIC GROWTH IN YANBIAN KOREAN AUTONOMOUS PREFECTURE

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ABSTRACT. *The research of this text is based on the human resources development and the economic growth in Yanbian Korean autonomous prefecture. From the subsistent problems on the human resources development and the economics growth in Yanbian Korean autonomous prefecture, the text puts forward the specific policy recommendations, pointing out that Investing and developing the education can provide strong intellectual support for the economic development of Yanbian Korean autonomous prefecture, it is a fundamental solution to solve the human resources' shortage and the best way to weak the economic development in Yanbian Korean autonomous prefecture.*

Keywords: Yanbian Korean Autonomous Prefecture; Human Resource Development; Education; Economic Growth

1. Introduction. Yanbian Korean autonomous prefecture is not only an important window and communication in the three provinces in northeast China, but also a regional economy, population, geography intersection in the northeast Asia. Compared with other minority nationality regions, the Yanbian Korean autonomous prefecture develops better in educational business and human resource is relatively abundant. But the current status of human resources can't satisfy the needs of its regional economic growth. Most industrial development is slow and the unreasonable industrial structure seriously bound to its economic development, the most important factor is the lack of all kinds of technical talents. Investment and developing culture undertakings can provide the powerful intellect support to Yanbian Korean autonomous prefecture in its economic construction and its the best way to solve the weak economic development.

2. The Human Resources Development and Economic Growth Condition in Yanbian Korean Autonomous Prefecture. Yanbian Korean autonomous prefecture is located in the southern border of the frontier of China and the North Korea, its economic development is rapid in recent years. Especially the speed of its economic growth accelerates obviously in the development of the third industry, but meanwhile, human resources development can't satisfy the actual need, it is one of the most important contradictions at present.

2.1. The Human Resources Development Condition in Yanbian Korean Autonomous Prefecture.

2.1.1. The Measure and Stock of Human Resources in Yanbian Korean Autonomous Prefecture. A region's human resources quantity change trend is the important indicator which can reflect the region's economic strength and potential economic strength. By the end of 2008, the population in the whole country is 132802 million, while the Yanbian Korean autonomous prefecture‘s population is 218.7 million. The minority autonomous prefecture of natural population growth in Yanbian Korean national is far below the national average level, its human resources quantity is relatively limited. For example, in Yanji province, the higher schools have 4482graduates and 18103 students in 2008. The ordinary secondary specialized schools have 2067 graduates and 5175 students in 2008. The adult higher school have 677 graduates in 2008[5]. Compared with other ethnic minority areas, the human resources capital is aboundant in Yanbian Korean autonomous prefecture.

2.1.2. The flow Condition of Human Resources in Yanbian Korean Autonomous Prefecture. The economic development level and the living standard in Yanbian Korean autonomous prefecture is lower than the developed cities, so a lot of professional and technical talents and senior mechanic flow out. In addition, local nationality have been hired by the Korean firms in coastal areas. Most of the workers in the outflow are about 25-45 years old, anyhow, the human recourses are in a severe situation in Yanbian Korean autonomous prefecture. In Yanji, for example, as is shown in table 1, we can easy to see the evacuation population is more than the rolling in population in yanbian Korean.

TABLE 1. The statement of current position in Yanji 2008

The total immigratery population	63490	The total migrants population	5988
Intra-province immigratery population	60937	Transfer to intra-province	3088
Intra-state immigratery population	58100	Transfer to intra-state	1126
Outside province immigratery population	2553	Transfer to outside province	2900

Information resources: Yanji statistical yearbook(2009)

2.1.3. The Education Condition in Yanbian Korean Autonomous Prefecture. Yanbian Korean autonomous prefecture is well known as its high level of personal education, the spread of its compulsory education is in the leading position of 30 minority autonomous prefecture. Since the reform and opening up, the education scale unceasingly expands, the investment in education is also increased year by year, the school running conditions and the teachers' quality and teaching level are obviously improved.

2.2. The Economic Development in Yanbian Korean Autonomous Prefecture.

2.2.1. The Economic Scale and Speed. Economies of scale is an important index of economic strength. The economic scale in yanbian Korean autonomous prefecture comes out top among the minority autonomous prefecture during the 1980s and 1990s, we can see it experienced an era of rapid development in that period. In recent years, The country pays more attention to the economic development in national regions, frequently appearing preferential policies for the national regions to create more beneficial development condition, the economic output in yanbian Korean autonomous prefecture has been rising steadily. For example, the GDP in Yanji city changed from 212.05 billion yuan, 245.08 billion yuan, 307.17 billion and 379.79 billion yuan from 2005 to 2008. As is shown in figure 1.

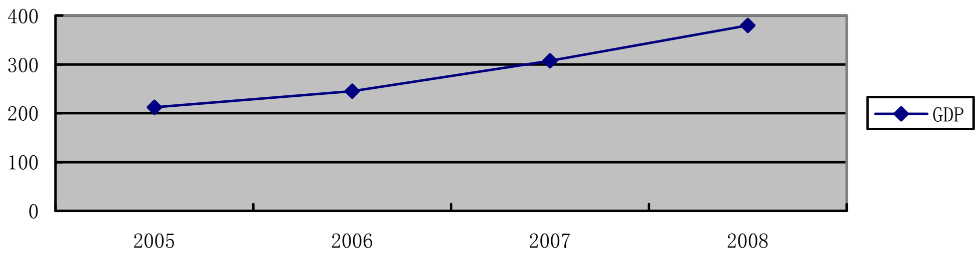

FIGURE 1. GDP in Yanji (2005-2008) (billion yuan)

Information resources: Yanji statistical yearbook(2009)

2.2.2. The Living Standard. The fundamental goal of economic development is satisfying people's growing material and cultural needs in maximum. In the 1980s the Yanbian residents' consumption level is higher than average. In the 1990s, the residents' consumption level is higher in Yanbian national level, but the increase rate has reduced, while the consumption concepts also have changed a lot. For example, the rural and urban residents' per capita income specific data in Yanji from 2004 to 2008 has changed a lot as is shown in figure 2.

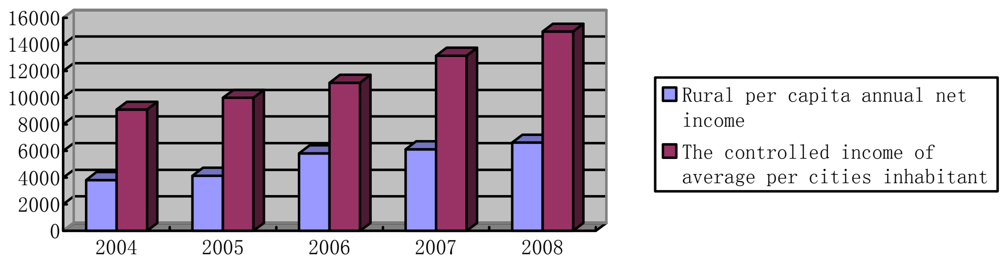

FIGURE 2. The controlled income of Yanji resident (yuan)

Information resources: Yanji statistical yearbook (2009)

3. The Existing Problems of Human Resources Development in Yanbian Korean Autonomous Prefecture.

3.1. The Human Resource Allocation is Unreasonable, the Talents Outflows Excessively. The primary and second industry in yanbian Korean autonomous prefecture develops slowly, the labor mainly throw into the rapid developing tertiary industry. Many talents in order to obtain better treatment would rather give up their own professional, while transfer to the tertiary industry which cann't fully exert their talent. Meanwhile, the human resources in yanbian Korean autonomous prefecture flow out rapidly will seriously restrict its economic development speed. How to attract talent and sages should be given attention.

3.2. The School Education Level is Lagging. The education for economic development is not directly, but through the human element indirectly impact the economic development. Education investment channel mainly comes from government financial investment. In 2005, the financial education expenditure in yanbian Korean autonomous prefecture is 5.98 billion yuan; in 2007, the state education expenditure total input 15.7 million yuan, including education budget appropriation 12.37 billion yuan; the local finance in education investment increased in degress recent years. Although the government's education investment scale is increasing, in the whole society, it still cannot meet the requirements development. Education investment still need more support states. The senior education personnel is only 28%, its absolute quantity is urgent to improved.

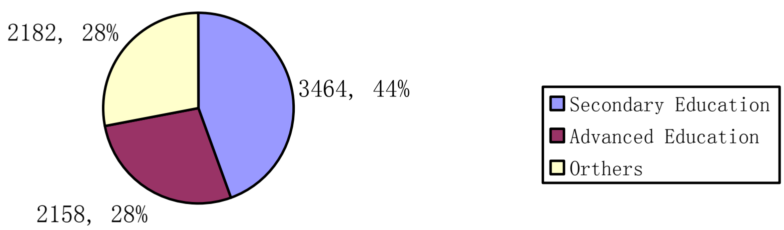

FIGURE 3. The personnel engaged in the education of Yanji

Information resources: Yanji statistical yearbook (2009)

3.3. Higher Education Specialty Separates from the Actual Needs. Higher education has made important contributions to the economic development in yanbian area. But current higher education is unfavorable in training the talents which are needed by local economic and social development. One problem of the economic construction in yanbian Korean autonomous prefecture is lacking the economy talents, management personnel and technical personnel, and due to the geographical location and economic conditions, it is difficult to introduce the talents from the outside universities, therefore, Yanbian university is an important source of high-quality talents and training base. But the yanbian university's professional sets importance on humanities social sciences education, the weak economy and technology level can't satisfy the needs of the development of regional economy.

3.4. Vocational Education and Training Education Development Lags a Lot. Vocational education plays a very important role in training practical talents. But the government and society paid few attentions to it. The vocational education in yanbian Korean autonomous prefecture is not little from the whole quantity, but on the career education is still exist some obvious disadvantages: first, the scale of running school is small, Second, the teacher can't adapt to the actual requirements, Third, the structure is unreasonable, professional setting is behind the needs of the economic development.

4. The Suggestions.

4.1. The Allocation of Human Resource Should Match the Regional Industrial Structure. The industrial and agricultural in Yanbian area has dropped in 1990's, while the third industry has rised proportion. The shortages of the engineering and technical personnels is a common problem to the whole area. To improving the efficiency of agricultural production and stabling its development level, “industrialization” is the only choice of agriculture and the human resources in agricultural industry should distribute reasonably. In the meanwhile, for promoting the sustainable development, the most important thing is to optimize the human resource configuration. In Yanbian area, because the third industry is fast developing, so the human resources should be allocated reasonably.

The third industry in maintaining the economic growth of yanbian Korean autonomous prefecture is in the most important position. The development of the third industry is to promote social prosperity and progress, but in the second industry has not been fully developed before, the development of the third industry is often not solid, even deformity. Reasonable allocation of human resources in the third industry should from the following two aspects: First, the policy should be strict in regulating the excessive developing industry, which not only can improve the service quality and efficiency of the industry, but to "squeeze" the more human resources, make its diversion to need more of their profession, then improve the human resources’ use efficiency; Second, the development of tourism in Yanbian has unique natural resources and cultural resources advantages. According to features the tourism resources development, the development of tourism products should be characteristic. So the specific tourism human resources need to excavate.

4.2. Promoting the Further Development of Education.

4.2.1. Increasing the Investment in Education. The most urgent need in Yanbian Korean prefecture is the higher education talents, therefore, the education investment occupies an important position. Education investment funds may be government investment, also can be the social investment or private investment. Government financial investment is limited, completely by the government, neither scientific nor actual. Social and individual is a great source of investment in education, it is necessary to the corresponding policy guide and institutional guarantee for the cancellation of the education field. For example, to attract domestic and foreign investment restrictions in education, allow and encourage to run for the purpose of education at all levels, thereby promote physical education and social resources to attract business flow.

4.2.2. Paying Attention to Professional Training and Education. First, in the workplace, the laid-off workers and unemployed personnel faced their ideas, such as adapting ability is too bad, the age is too old, the skills and cultural quality are low, etc. The government should support and guide available, more professional training organization, also can buy training services to introduce competition mechanisms and improve the efficiency and quality of vocational training. Secondly, the vocational training to the in-service labor personnels should be provided mainly by the employing units.

4.3. Better Policy Guidance to Keeping Talents. At present the Yanbian Korean prefecture is in an underdeveloped economy condition, whether in the capital or in the subjective choice for regional talents, it is difficult to introduce talents. The limited funds can only be used to introduce the most active in the key state personnel and irreplaceable position. District Therefore, the state shall establish the scientific attitude, care, respect talented personnel. In actively promote the development of local economy at the same time, the real humanistic consciousness and establish modern concept of talent, creative talents play a role of the good environment and conditions, build the atmosphere then break out personnel which only see the qualifications and arranging backward ideas, pay attention to the level and ability and establish the mechanism of talents training, so it is possible to suppress the manpower resource of the outflow of human resources and attract outside voluntarily.

5. Conclusions. From the actual condition of Yanbian Korean autonomous prefecture, through the above analysis, we can see that the human resource development plays an important role in promoting the economic growth. Based on the good education, the Yanbian Korean autonomous prefecture government should recognize the defects; attach importance to the education reform and innovation.

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ON QUALITATIVE BEHAVIOR OF A STOCHASTIC HIV MODEL

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ABSTRACT. *This paper is about modeling under uncertainty of phenomena in terms of differential equations (as models) and stochastic variations. These are typical physical phenomena where we need to assess the uncertainty involved as well as their dynamics for the purposes of understanding and predictions. We focus entirely on a HIV model in which the variation among cells with respect to intracellular delay in viral production can be approximated by a Gamma distribution. We analyze the qualitative behavior of the solution by proving its positivity and boundedness and by explicitly giving its limiting values.*

Keywords: Gamma Distribution; HIV; Stochastic Model; Dynamic System

1. Introduction. Former works have shown that the inclusion of delays in the viral production of infected cells dramatically changes estimates of specific parameters. Nelson et al.(2000) argue that the delay affects the estimated value for the infected T-cell loss rate when we assume that the drug is not completely effective. Grossman et al. (1986) showed that including a delay in the model for the death of infected cells leads to different conclusion regarding residual transmission of infection (during antiviral pharmaceutical therapy). Therefore the developments of mathematical models for HIV infection that incorporate these delays are more accurate representations of the biological data. Base on those, our model here consisting of a set of second type Volterra integral equations which can account for the interaction among a replicating virus, CD4+ T-cell and the cytotoxic lymphocytes (CTL). We assume that the intracellular delay in the viral production is a continuous random variable having a Gamma probability distribution, a high flexible distribution that can mimic a variety of biologically plausible delays. We describe the dynamics of the infections in the most natural situation, that is in the absence of drugs but only the CTL plays the immune role and by using the fact that there is no differentiation between infected and non-infected CD4+T-cell when CD4+T-cell is routinely counted in patients. We wish to collect as much information as possible on the qualitative behavior of the analytical solution of the problem in order to use it as starting point in the study of more complete models.

Consider the following nonlinear mathematical model of three second type Volterra integral equations.

$$T(t) = T_0 e^{-\delta_3 t} + \int_0^t e^{-\delta_3(t-\tau)}[\delta_1 - \delta_2 V(\tau) T(\tau)]d\tau$$

$$V(t) = V_0 e^{-\delta_5 t} + \int_0^t e^{-\delta_5(t-\tau)} V(\tau)[\delta_4 F(t-\tau) T(\tau) - \delta_6 C(\tau)]d\tau \quad t \in [0, t_f] \tag{1}$$

$$C(t) = \int_0^t e^{-\delta_8(t-\tau)} \delta_7 V(\tau) d\tau$$

$T(t), V(t), C(t)$ represent three populations which are present in a volume unit of plasma at time t: which are the population of CD4+ T lymphocytes, viruses and Cytotoxic T-Lymphocytes respectively. All parameters are positive and describe as follow:

δ_1 = Constant rate of CD4+ T cell replacement,

δ_2 = Rate of infection,

δ_3 = Rate of clearance of CD4+ T cells,

δ_4 = rate of virus production,

δ_5 = Infectious viral clearance rate,

δ_6 = rate of clearance of virus due to CTL,

δ_7 = rate of CTL stimulation by virus,

δ_8 = rate of clearance of CTL.

Notice that for $t = 0$, $T(0) = T_0 > 0$, $C(0) = C_0 \geq 0$, $V(0) = V_0 > 0$.

The function F(t) is a continuously distributed intracellular delay, Mittler (1998). It takes into account the temporal lag between initial viral infection and the first release of new virions. We assume that the delay is a continuous random variable having a Gamma probability distribution, i.e. the probability density function of the delay is in the form

$$f_{n,b}(t) = \frac{t^{n-1}}{(n-1)!b^n} e^{-\frac{t}{b}} \quad , \ n \in \mathbb{N} \ , b \in \mathbb{R}^+ \tag{2}$$

Where n, b are the parameters of the Gamma distribution whose product represents the expected value, i.e.

$$E = \int_0^\infty t f(t) dt = nb$$

The Distribution function is

$$F(t) = \int_0^t f(\tau) d\tau = 1 - e^{-\frac{t}{b}} \sum_{k=0}^{n-1} \frac{t^k}{k! b^k} \tag{3}$$

The ordinary differential equation systems have been used to represent models with discrete delays as in our previous work, Dumrongpokaphan et al. (2007), whereas an integro-differential approach has been chosen by many authors for continuously distributed delays. We present a brief derivation from basic principles, with assumptions based on the biology, which supports the mathematical form in treating the delays as stochastic or random variables. Consider the delay between viral infection and viral production for infected cells. It is unreasonable to expect the entire population of infected cells to simultaneously commence viral production τ hours after infection. We suppose that the delay between infection and production varies across the population with probability distribution $F(t)$ and corresponding density $f(t)$. To obtain the (expected) number of virus at time t that have been produced by infected cells, we must consider the number of each populations provided in a particular time subinterval, say Δ_k; repeat the process for all the subintervals of $[0,t_f]$; add the quantities obtained and pass to the limit for Δ_k going to zero.

2. Preliminaries. For a mathematical point of view, we want to show that the solution of system (1) exist.

Let
$$Y(t)=X(t)+\int_0^t K(t,\tau,Y(\tau))\,d\tau$$
where $Y=[Y_1,Y_2,Y_3]^T$, $X=[X_1,X_2,X_3]^T$, $K=[K_1,K_2,K_3]^T \in \mathbb{R}^3$

are defined as follows
$$Y(t)=[T(t),V(t),C(t)]^T \;;\; X(t)=\left[\frac{\delta_1}{\delta_3},V_0e^{-\delta_5 t},0\right]^T$$

$$K(t,\tau,Y)=\begin{bmatrix}-e^{-\delta_3(t-\tau)}\delta_2Y_1(\tau)Y_2(\tau)\\ e^{-\delta_5(t-\tau)}Y_2(\tau)[\delta_4F(t-\tau)Y_1(\tau)-\delta_6Y_3(\tau)]\\ e^{-\delta_8(t-\tau)}\delta_7Y_2(\tau)\end{bmatrix}$$

Note that $K(t,\tau,Y)$ is continuous with respect to the three variables and satisfies a local Lipchitz condition with respect to Y so there is a unique solution in some small interval $[0,t_1]$ which in turn can be continued to a larger one. We assume that $[0,t_f]$ is in that interval.

For a biological point of view, we want to show that the solution of system (1) are positive and bounded since T,V,C represent populations in a volume unit of plasma. Note that in the absence of virus, the number of CD4+ T cells should remain constant, because they are provided and removed at constant rate. Therefore
$$T_0=\frac{\delta_1}{\delta_3}$$
Hence (1) becomes
$$T(t)=\frac{\delta_1}{\delta_3}-\int_0^t e^{-\delta_3(t-\tau)}\delta_2V(\tau)T(\tau)\,d\tau$$

$$V(t)=V_0e^{-\delta_5 t}+\int_0^t e^{-\delta_5(t-\tau)}V(\tau)[\delta_4F(t-\tau)T(\tau)-\delta_6C(\tau)]d\tau \quad t\in[0,t_f] \tag{4}$$

$$C(t)=\int_0^t e^{-\delta_8(t-\tau)}\delta_7V(\tau)d\tau$$

Consider their derivative,

$$T'(t)=-\delta_2V(t)T(t)+\delta_3\int_0^t e^{-\delta_3(t-\tau)}\delta_2V(\tau)T(\tau)d\tau$$

$$=\delta_1-\delta_3T(t)-\delta_2V(t)T(t)$$

$$V'(t)=-\delta_5V_0e^{-\delta_5 t}-\delta_6V(t)T(t)-\delta_5\int_0^t e^{-\delta_5(t-\tau)}V(\tau)[\delta_4F(t-\tau)T(\tau)-\delta_6C(\tau)]d\tau$$

$$+\int_0^t e^{-\delta_5(t-\tau)}V(\tau)\delta_4f(t-\tau)T(\tau)d\tau$$

$$=-\delta_5V(t)-\delta_6V(t)C(t)+\int_0^t e^{-\delta_5(t-\tau)}V(\tau)\delta_4f(t-\tau)T(\tau)d\tau$$

$$C'(t)=\delta_7V(t)-\delta_8\int_0^t e^{-\delta_8(t-\tau)}\delta_7V(\tau)d\tau$$

$$=\delta_7V(t)-\delta_8C(t)$$

Therefore the system of the rate of change of T,V,C is

$$T'(t)=\delta_1-\delta_3T(t)-\delta_2V(t)T(t)$$

$$V'(t)=-\delta_5V(t)-\delta_6V(t)C(t)+\int_0^t e^{-\delta_5(t-\tau)}V(\tau)\delta_4f(t-\tau)T(\tau)d\tau \tag{5}$$

$$C'(t)=\delta_7V(t)-\delta_8C(t)$$

Theorem 2.1. $T(t)$, $V(t)$, $C(t)$ of **(4)** are always positive for all $t>0$

Theorem 2.2. $T(t)$ is bounded. Furthermore, if $\delta_5+b^{-1}>\delta_3$ then $V(t)$ and $C(t)$ are also bounded.

Remark 2.1. For the condition $\delta_5+b^{-1}>\delta_3$, we can think about it from the biological meaning. It is natural to assume the average time of virus emission from a T-cell is less than the average life time of a T-cell. Otherwise the T-cell will die before new virus come out. The expectation of the life time of a T-cell is $1/\delta_3$ and the expectation time of virus emission is *nb*. Hence $nb<1/\delta_3$ leads to $b^{-1}>n\delta_3$, which implies $b^{-1}>\delta_3$ since $n\geq 1$. So our condition $\delta_5+b^{-1}>\delta_3$ is reasonable.

3. Main Results. In this section, the main interest is the emission of virus. We study the behavior of $T(t)$, $V(t)$, $C(t)$ as $t \to \infty$ to provide necessary and sufficient conditions in order to get $\lim_{t\to\infty} T(t) = \frac{\delta_1}{\delta_3}$ and.

By using the linear chain trick, our model can be transformed in a system of n + 3 ordinary differential equations. For more convenient let

$$E_j(t) = \int_0^t f_{j,b}(t-\tau)\delta_4 e^{-\delta_5(t-\tau)} V(\tau)T(\tau)\,d\tau \ . \tag{6}$$

Where $f_{j,b}(\tau)$ is the Probability density function given in (2) and then with the boundedness of $T(t)$ and $V(t)$, we have that E_j, $j = 1,\dots,n$ are continuous and bounded functions for all $t > 0$. Then system (5) can be transform to

$$E_1'(t) = -\left(\delta_5 + \frac{1}{b}\right)E_1(t) + \frac{\delta_4}{b}V(t)T(t) \tag{7}$$

$$E_j'(t) = -\left(\delta_5 + \frac{1}{b}\right)E_j(t) + \frac{1}{b}E_{j-1}(t)\ , \ j = 2,\dots,n \tag{8}$$

$$V'(t) = -\delta_5 V(t) - \delta_6 V(t)C(t) + E_n(t) \tag{9}$$

$$T'(t) = \delta_1 - \delta_3 T(t) - \delta_2 V(t)T(t) \tag{10}$$

$$C'(t) = \delta_7 V(t) - \delta_8 C(t) \tag{11}$$

$$E_j(0) = 0, \ \ j = 1,\dots,n \qquad C(0) = 0 \qquad V(0) = V_0 \qquad T(0) = \frac{\delta_1}{\delta_3}.$$

The functions E_j given in (6), are auxiliary functions related to the probability density (2) which do not represent any specific biological component.

Lemma 3.1. Let $\tau : \mathbb{R}^+ \to \mathbb{R}$ be any function such that

(1) $\tau'(t)$ exists and is bounded for $t \in \mathbb{R}^+$

(2) $\int_0^\infty \tau(t)\,dt < \infty$. Then $\lim_{t\to\infty} \tau(t) = 0$.

Lemma 3.2. If $\tau : \mathbb{R}^+ \to \mathbb{R}$ is a differentiable function and $\liminf_{t\to\infty} \tau(t) < \limsup_{t\to\infty} \tau(t)$ then there exist two divergent sequences $\{t_j'\}_{j\ge 0}$ and $\{t_j''\}_{j\ge 0}$ such that

$$\lim_{j\to\infty} \tau(t_j') = \liminf_{t\to\infty} \tau(t)\ , \quad \tau'(t_j') = 0, j \ge 0$$

$$\lim_{j\to\infty} \tau(t_j'') = \limsup_{t\to\infty} \tau(t)\ , \quad \tau'(t_j'') = 0, j \ge 0$$

Theorem 3.1. Let $\delta_5 + b^{-1} > \delta_3$

If one of the functions $T, V, C, E_1,\dots,E_n$ converges as $t \to \infty$ then also the remaining functions converge as $t \to \infty$.

Theorem 3.2. Let $\delta_5 + b^{-1} > \delta_3$, $\omega_n = \delta_4 / (\delta_5 b + 1)^n$, $R_n = \delta_5 / \omega_n$ then

$$R_n \geq \frac{\delta_1}{\delta_3} \leftrightarrow \lim_{t\to\infty} V(t) = 0 .$$

Theorem 3.3. Assume that $\delta_5 + b^{-1} > \delta_3$.

If $R_n \geq \frac{\delta_1}{\delta_3}$ then $\lim_{t\to\infty} T(t) = \frac{\delta_1}{\delta_3}$, $\lim_{t\to\infty} V(t) = 0$, $\lim_{t\to\infty} C(t) = 0$, and $\lim_{t\to\infty} E_j(t) = 0, j = 1,...,n$ and if $R_n < \frac{\delta_1}{\delta_3}$ then $V(t)$ cannot vanish as $t \to \infty$.

Theorem 3.4. Assume that

(1) $\delta_5 + b^{-1} > \delta_3$,

(2) $R_n < \frac{\delta_1}{\delta_3}$,

(3) one of the functions $V, T, C, E_1, \ldots, E_n$ converges at infinity.

Then

$$\lim_{t\to\infty} T(t) = R_n,\ \lim_{t\to\infty} V(t) = \frac{\delta_4(\delta_1 - \delta_3 R_n)}{\delta_2\delta_5(\delta_5 b + 1)^n},\ \lim_{t\to\infty} C(t) = \frac{\delta_4\delta_7(\delta_1 - \delta_3 R_n)}{\delta_2\delta_5\delta_8(\delta_5 b + 1)^n}$$

$$\lim_{t\to\infty} E_j(t) = \frac{\delta_4(\delta_1 - \delta_3 R_n)}{\delta_2(\delta_5 b + 1)^n} + \frac{\delta_6\delta_7}{\delta_8}\left(\frac{\delta_4(\delta_1 - \delta_3 R_n)}{\delta_2\delta_5(\delta_5 b + 1)^n}\right)^2, j = 1,...,n$$

Proof: By Theorem 3.1 functions $V, T, C, E_1, \ldots, E_n$ converges at infinity thus

$$\lim_{t\to\infty} H'(t) = 0 .$$

By Theorem 3.3 we have $\lim_{t\to\infty} V(t) > 0$ and therefore from (3.12) we obtain

$$\lim_{t\to\infty} T(t) = R_n .$$

The rest can derive from (7)-(11).

4. Conclusions. We have used an integral formulation of the model as a more natural means to analyze boundedness and positivity of the solution. We found that if the clearance rate of CD4+ T cell is less than or equal to infectious viral clearance rate then the amount of CD4+ T cell and HIV are positive for $t > 0$. The condition $\delta_5 + b^{-1} > \delta_3$ is reasonable since it is natural to assume the average time of virus emission from a T-cell is less than the average life time of a T-cell. Otherwise the T-cell will die before new virus come out.

The following conditions can lead to the situation that $V(t) \to 0$ as $t \to \infty$.

(1) Infectious viral clearance rate (δ_5) and rate of clearance of virus due to CTL (δ_6) have to be high enough.

(2) Rate of virus production (δ_4) is very low.

If these conditions hold then we can maintain the infection stage in other word extend the latent period then patient won't go through the full blown AIDS.

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ANALYSIS OF THE RELATIONSHIP BETWEEN FORMS OF MANAGEMENT AND PERFORMANCE IN SPANISH FRANCHISES

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ABSTRACT. *Various theoretical approaches uphold the relevance of the relationship between the form of management and performance. Different management styles influence relationships of agency (Jensen,1998), the cost of governing transactions (Williamson,1985) and the allocation of resources between the exploitation and exploration of activities (March,1991) and this is manifested in firm performance. In light of these assumptions, this article presents an empirical verification of the relationship between the management of franchises in Spain and their performance, examining how different styles of management on the part of franchisers over their franchisees have significant effects on the growth and profits of franchiser firms.*

Keywords: Franchises; Styles of Management; Performance; Franchiser-Franchisee Relations

1. Introduction. This article examines how different forms of management of franchises in Spain affect their performance. According to data from the Spanish Franchise Association in 2009, in this country there are currently more than 900 registered brand names (approximately 80% of which are national), 70,000 establishments (owned either by the franchiser or the franchisee), with a total turnover of more than 25,000 million Euros.

Along similar lines to other studies related to franchises that examine the form of management and its relation to performance (Shane,1996; Shane,2001; Combs et al.,2006), this research examines the way in which franchisers in Spain combine forms of management or styles of direction that are analogous to the leadership types proposed by Liu et al. (1996). These forms of management are similar to the directive, transactional, transformational or empowering leadership styles, or to a mixture of these forms.

The study is structured as follows: it begins with a review of some of the most relevant theoretical and empirical contributions in the literature on franchises. This review allows us to relate forms of management, agency issues and firm governance costs with performance; or to relate performance with the allocation of resources to the exploitation or exploration of new opportunities. The hypotheses of the study are then derived from this review. The following section describes the empirical study, in which we verify the extent to which the hypotheses can be confirmed via the corresponding regression equations.

Finally, the conclusions provide additional comment on the results obtained and show that the approach used in this research forms a part of a long tradition that recommends mixing the hard or formal parts of the contract (work contracts or cooperation agreements) with the softer parts, based on social relationships that increase understanding and trust.

2. Theoretical Framework and Hypotheses. Combs and Castrogiovanni (1994), Combs and Ketchen (1999) and Combs et al. (2006) highlight the advantages of the franchise system because of the greater strategic flexibility and controllability of this form of organization, which saves on recruiting, training and monitoring costs; and because of the advantages and opportunities for growth that derive from lesser strain on capital and other resources. In line with the agency theory (Jensen and Meckling,1976; Fama and Jensen,1983a; Fama and Jensen,1983b). Shane (1996) suggests that by substituting managers on the payroll for owners of outlets, the problem of adverse selection is reduced, along with the subsequent one of moral randomness or opportunistic behavior, whilst enabling effective and efficient management.

In this sense, the proposal for managing incentives derived from Williamson (1985) is of particular interest. When applied to a franchiser firm, this proposal consists of passing on profits to independent units (outlets) as the alignment ex ante of the incentives of their owners (market incentives or high-powered incentives), completing the management of outlet owner behavior via the control ex post of those aspects of their business activity that are relevant to the franchiser firm (product quality or customer care and services). This control ex post, which relates to incentives that are internal to the common governance structure of the franchise, is similar to low-powered incentives Williamson suggests for the internal environment of organizations (less powerful incentives but which are essential for "completing" the system of incentives).

At this point, it should be noted that, in the alignment of incentives, there is a hard part, or "technical" part which could be called incentive design and a soft part, which is of a social nature and is based upon social acceptance and institutionalized norms and behavior (Orlikowski,1992; Weick and Roberts,1993) It could be claimed that no system of incentives is complete without the soft part. Jensen (1998) referred to this issue when examining quality management systems. This author claims that the best process and job designs kindle love for the product amongst workers, which goes further than control systems in reducing agency problems.

We are also interested in discovering whether the franchiser, through the objectives and policies transmitted to franchisees, combines policies aimed at business exploitation with others aimed at the exploration of improvements in procedures and/or ways of attending and adapting to customer needs. In any firm, exploitation and exploration compete for the scarce resources and limited capabilities of the organization (March,1991).

If the franchise is efficient, there will be a satisfactory fit between the form of management adopted by the franchiser, the form of governance and the social, administrative and technical organization of the franchise. A satisfactory fit implies that, besides using technical tools for control (supervision of standard procedures in outlets), social control is enabled by basing it on institutionalized norms and behavior.[1] If this occurs, it will enable the control of problems related to behavior and incentive alignment that appear in the agency theory (AT) and in transaction cost economics (TCE), and could guide the actions of franchise members towards a suitable mixture of the exploitation of resources and the exploration of new possibilities, as can be drawn from the resource-based approach (RBV).

In light of the ideas expressed above, it can be expected that the forms of management that improve the problem of agency and reduce franchiser-franchisee costs (enabling the involvement of the latter or through the use of control mechanisms) will have a positive and significant relationship with the performance of the franchiser. The same may also be said of the forms of management that enable a balanced use of resources between exploitation and exploration.

Hypothesis 1(H1): The forms of management or leadership that contribute to improving the relationships of agency and transaction costs (or the governance structure) between the franchiser and franchisees will have a positive and significant relationship with the performance of the franchiser.

Hypothesis 2(H2): The forms of management that enable franchised outlets to have a balanced mix of resources allocated to exploitation and exploration will have a positive and significant relationship with the performance of the franchiser

The list of possible items in the form of management of franchisers (table 1), and its results in terms of performance, should confirm the proposed hypotheses.

3. Empirical Study. We go on to describe the design of the empirical investigation, the methodology used and the verification of the hypotheses.

The reference population, 1026 franchises was taken from the quefranquicias web page in the year 2006, and questionnaires were sent to the managers of the franchiser firms, obtaining 103 replies, of which 7 were discarded due to bring incomplete. The maximum sample error for the 96 firms is thus 9.53%, with a confidence level of 95% at worst (dichotomous questions in which p = q = 50%). Questions on the form of management (or styles of leadership) of the franchiser were addressed to 192 franchised firms (small businesses), two for each franchiser firm, chosen from Spanish territory, which employed the most qualified managers. In this second case, both the reference population and the sample were duplicated, and thus the sample error is the same.

The questions addressed to the managers of the franchiser firms, using 5-point Likert scales were as follows: performance of the firm, importance attributed to the environment for firm performance, the dynamic nature of the environment, and complexity of the environment. Secondly, the dichotomous questions posed were: do you own outlets in Spain?, do you charge royalties?, do you invest in advertising?, does the franchisee make an initial payment to the franchiser?, in which year did the firm begin franchising? (Regression models 1 and 2, tables 3 and 4).

The construct performance of the firm was obtained via questions on the levels of

[1] The social institutionalization referred to here has notable precedents in the work of Barnard (1938), Gouldner (1961) and Ouchi (1980), and more recently in that of Jensen (1998).

importance and levels of satisfaction of performance indicators and by then multiplying the values obtained for importance by the values obtained for satisfaction in each item. The items related to performance are growth in sales, return on investment (ROI), return on equity (ROE), return on sales (ROS), growth in market share and net profit.

Lastly, the questions posed to franchised outlets, via five-point Likert scales, appear in the left-hand column in Table 1.

<<Insert Table 1 around here>>

The validity and reliability of the scales have been checked. Exploratory factor analysis has led to the explanatory variables or factors that become part of the regression equations

Verification of the hypotheses and discussion of the results

Regression models 1 and 2 are shown in tables 3 and 4. The first of these relates the control variables with performance and the second incorporates the forms of management or leadership, thus forming the complete model.

<<Insert Table 2 around here>>
<<Insert Table 3 around here>>

With regard to regression model 2, or the complete model, the regression equation obtained from the growth of the franchiser firm (growth in sales and/or market share) corresponds to management or leadership styles F1 and F3 (table 1), to the dynamic nature of the environment (DYN), royalties (ROY) and the upfront franchise fee (UFF):

GROWTH OF THE FRANCHISER FIRM = 0.321*** (F1) + 0.205** (F3) + 0.280** (DYN) + 0.461*** (ROY) – 0.228* (UFF).

The β coefficient of DS1 in its F1 form (0,321***), which is positive and significant, confirms hypothesis 1 (H1). This form of managing franchisees through supporting their initiatives, improving management and treating them in a way that increases trust on both sides fosters commitment to the franchise, diminishes problems of agency and reduces the cost of governing transactions; all of which, as the β suggests, is manifested in improved performance.

The β coefficient of DS3 in its new F3 form (0.205**), which is positive and significant, confirms hypothesis 2 (H2). This form of management of franchisees provides stimuli and information so that outlets can explore new possibilities and better exploit activities.

In terms of the control variables, the β coefficient of DYN (0.280**), which is positive and significant, probably shows that the dynamic environment provides greater opportunities for the growth of the firm, although the focus of this study does not allow us to research this question.

The β coefficient corresponding to ROY (0.461***), which is positive, significant and strongly correlated to growth, appears to be an important control variable in explaining the growth of the franchiser. Charging royalties is an important source of income for financing all kinds of policies, among which is the exploration of opportunities

Finally, the existence of UFF (– 0.228*), which is negative and significant, indicates that the initial payment hinders growth due to the incorporation of new franchisees.[2]

Turning now to the regression equation obtained with regard to the different measures of financial performance of franchiser firms (ROI, ROE, ROS, net profit), this equation corresponds to the constant 0.361***, styles of management or leadership F1 and F5, importance 1 of the environment (IME1), the dynamic nature (DYN) and royalties (ROY):

INCOME-PROFITS OF THE FRANCHISER FIRM = 0.361*** +0.245** (F1) + 0.281*** (F5) + 0.189* (IME1) + 0.229* (DYN) + 0.284* (ROY).

The β coefficient of DS1 in its F1 form (0.245**), which is positive and significant, supports hypothesis 1 (H1) for the same reasons put forward for the previous regression equation. This form of managing franchisees reduces problems of agency and cuts the cost of governing transactions, and is thus positively relate to performance.

The β coefficient of F5 (0.281***), which is positive and significant (and incorporates the initial proposal of directive style DS2), again confirms hypothesis 1 (H1) for opposite and complementary reasons to those of directive style 1. This form of management demands strict compliance with all procedures of production and commercialization, along with all actions that affect the image of the brand name, through inspections and formal control. Control dominates this form of governance aimed at consolidating existing routines and exploiting resources. If control is effective and efficient, it can contribute to curtailing problems of agency and to reducing the governance costs associated with transactions.

The β coefficient of IME1 (0.189*), which is positive and significant, indicates that the franchiser believes that he/she depends particularly on the competitive, consumer and technological environment.

The β coefficient of DYN (0.229*), which is positive and significant, shows that the dynamic nature of the environment favors income and profits for the firm, just as it favors growth, as we saw in the previous regression equation. An examination of the correlations between different constructs (Appendix, table 6) shows a positive and significant (bilateral) correlation of 0.05 between DYN and F5, which may be interpreted in the sense that, as far as income and profits are concerned, franchiser firms face up to the dynamic nature of the environment by intensifying their own routines and ensuring the fulfillment of procedures that guarantee the efficiency of the exploitation of resources. F3, which is related to growth (regression model 2, table 3), provides the stimuli for exploration.

The β coefficient of the ROY (0.284*), which is positive and significant, indicates, as expected, that royalties contribute to the income and profits of franchiser firms.

Finally, the constant 0.361*** indicates that there are elements or causes for the income and profit in franchises that are not explained by the regression model.

4. Conclusions of the Study. The overall conclusion of this study is that the performance of franchiser firms (growth, income and profits) corresponds to the formula:

(1) GROWTH = β1 (F1) + β2 (F3) + β3 (DYN) + β4 (ROY) – β5 (UFF).

(2) INCOME-PROFITS = α + γ1 (F1) + γ2 (F5) + γ3 (IME1) + γ4 (DYN) + γ5 (ROY).

[2] These last two results on control variables, however, proposed as hypotheses in the meta-analysis of Combs and Ketchen (2003), are not corroborated in this analysis.

Performance should not be expressed by just one formula, because growth and the different expressions of income and profit can move in opposite directions.

Finally avoiding repetition of issues already discussed this study attempts to contribute to research that relates the forms of management of franchises with performance. Scott Shane has addressed this question via the agency theory (Shane,1996) and the existence of efficient contracts (Shane,2001), and in the latter study highlights the fact that "many of the dimensions of efficient contracting on which firms are selected for survival are not hard contracting dimensions, but are dimensions of *social control*".

This mix of hard or formal parts in the contract, which demand strict compliance of the stipulated agreements and procedures, and soft parts based on social relationships that increase understanding and trust between the parties, is the aspect we have attempted to explore with our approach to different forms of management or styles of leadership in table 1. We are thus applying a long tradition of schools of organizational thought on contracts to forms of governance. From the fields of sociology or economy, the search for a balance between the hard and soft parts of the contract have appeared in studies such as those of Barnard (1938), Gouldner (1961), Ouchi(1980) or Tsui *et al* (1997); and, although these authors refer fundamentally to internal contracts between the business owner and employees, this line of thought can be extended to any type of contractual relationship.

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Appendix.

TABLE 1-1. Forms of management adopted by franchisers, basic theories and types of leadership

	Forms of management in franchises (question posed to franchised).	Social effects/ control in the form of governance/org.	Incentive alignment/ behavior, routines, capabilities	Basic theories/ types of leadership
1 DS1 (F1)	The franchiser clearly relays the objectives of the franchise with regard to products or services.	Contributes to governing the agency relationship and transactions.	Alignment *ex ante* of incentives. Enables commitment to objectives.	AT, TCE. Transformational or Empowering leadership.
2 DS1 (F1)	The franchiser encourages considering the characteristics of the environment as opportunities, in the framework of the franchise business practices.	Improves the agency rel. and transactions *Exploitation/explora-tion* of resources.	Enables commitment, incentives *ex ante*. Improves the routines and capabilities of the franchise.	AT, TCE, RBV. Transformational or Empowering leadership.
3 DS3 (F2)	The franchiser makes me aware of aspects in the industrial sector that I had not previously considered.	Improves the agency rel. and transactions. Guides resources towards *exploitation*.	Enables commitment, incentives *ex ante*. Improves the routines and capabilities of the franchise.	AT, TCE, RBV. Transactional or Transformational leadership.
4 DS1 (F3)	The franchiser encourages me to address problems in a novel way by proposing variations on the practices of the franchise.	Improves the agency rel. and transactions. Guides resources towards *exploration*.	Enables commitment, incentives *ex ante*. Improves the routines and capabilities of the franchise.	AT, TCE, RBV. Transformational or Empowering leadership.
5 DS3 (F3)	The franchiser provides chances for improving my training and that of my employees in production or customer care.	Improves the agency rel. and transactions. Guides resources towards *exploitation*.	Enables commitment, incentives *ex ante*. Intensification of established routines.	AT, TCE, RBV. Transactional or Transformational leadership.
6 DS4 (F4)	The franchiser makes me not trust in receiving leniency if there are involuntary errors in procedures.	Improves the agency relationship if properly controlled. Makes transactions more expensive.	Hinders commitment, incentives *ex ante*. Consolidation of established routines.	AT, TCE. Strict use of Directive leadership.

TABLE 1-2. Forms of management adopted by franchisers, basic theories and types of leadership

	Forms of management in franchises (question posed to franchised).	Social effects/ control in the form of governance/org.	Incentive alignment/ behavior, routines, capabilities	Basic theories/ types of leadership
7 DS2 (F5)	The franchiser carries out inspections and if established practices are not followed may not renew franchise contract.	Control as a form of governance. Guides resources towards *exploitation*.	Alignment *ex post* of incentives. Consolidation of established routines.	AT, TCE, RBV. Directive or Transactional leadership.
8 DS2 (F5)	The franchiser demands strict compliance of all actions that contribute to the image of the brand name.	Control as a form of governance. Guides resources towards *exploitation*.	Alignment *ex post* of incentives. Consolidation of established routines.	AT, TCE, RBV. Directive or Transactional leadership.
9 DS2 (F5)	The franchiser demands strict compliance of all procedures related to the product or service.	Control as a form of governance. Guides resources towards *exploitation*.	Alignment *ex post* of incentives. Consolidation of established routines.	AT, TCE, RBV. Directive or Transactional leadership.
10 DS3 (F2)	The franchiser makes me rethink my productive activity in ways I had not previously considered.	Improves the agency rel. and transactions. *Exploitation*/*explora-tion* of resources.	Enables commitment, incentives *ex ante*. Improves the routines and capabilities of the franchise.	AT, TCE, RBV. Transactional or Transformational leadership.
11 DS3 (F1)	The franchiser enables conditions that allows for appropriate management of the employees in franchised outlets.	Improves the agency rel. and transactions. Guides resources towards *exploitation*.	Enables commitment, incentives *ex ante*. Improves the routines and capabilities of the franchise.	AT, TCE, RBV. Transactional or Transformational leadership.
12 DS3 (F2)	The franchiser informs me on aspects of my commercial activity or on my customers that I had not previously considered.	Improves the agency and transactions rel. Guides resources towards *exploitation*.	Enables commitment, incentives *ex ante*. Improves the routines of the franchise.	AT, TCE, RBV. Transactional or Transformational leadership.
13 DS4 (F4)	The franchiser makes me aware of how to avoid possible sanctions.	Improves the agency relationship if properly controlled. Makes transactions more expensive.	Hinders commitment, incentives *ex ante*. Consolidation of established routines.	AT, TCE. Strict use of Directive leadership.
14 DS1 (F1)	The franchiser bears in mind the needs and interests of franchisees.	Contributes to governing the agency relationship and transactions.	Alignment *ex ante* of incentives. Enables commitment to objectives.	AT, TCE. Transformational or Empowering leadership.
15 DS1 (F1)	The franchiser congratulates franchises with excellent performance.	Contributes to governing the agency relationship and transactions.	Alignment *ex ante* of incentives. Enables commitment to objectives.	AT, TCE. Transformational or Empowering leadership.

Abbreviations: rel. = relationship; org. = organization.

TABLE 2. Regression model 1

	Growth (β)	Financial performance (β)
Constant	0.053	0.434***
Importance of the environment 1	0.172	0.149
Importance of the environment 2	-0.022	0.188*
Dynamic nature of the environment	0.301**	0.321**
Complexity of the environment 1	0.033	-0.059
Complexity of the environment 2	-0.079	-0.060
Franchiser: businesses in Spain?	-0.034	-0.012
Does the franchiser charge royalties?	0.347***	0.156
Does the franchiser invest in advertising?	0.007	0.001
Franchisee: Is an initial payment made?	-0.119	-0.057
Year in which the firm became franchise	0.000	-0.034
R^2	0.242	0.208
Corrected R^2	0.149	0.110
Durbin - Watson	1.234	0.383
Snedecor F	2.591	2.128
Significativity F	0.009	0.031

TABLE 3. Regression model 2

	Growth (β)	Financial performance (β)
Constant	-0.234	0.361***
Form of management or leadership 1	0.321***	0.245**
Form of management or leadership 2	-0.120	-0.158
Form of management or leadership 3	0.205**	0.161
Form of management or leadership 4	0.107	-0.053
Form of management or leadership 5	0.162	0.281***
Importance of the environment 1	0.175	0.189*
Importance of the environment 2	-0.101	0.165
Dynamic nature of the environment	0.280**	0.229*
Complexity of the environment 1	0.104	-0.031
Complexity of the environment 2	-0.055	-0.027
Franchiser: businesses in Spain?	0.143	0.130
Does the franchiser charge royalties?	0.461***	0.284*
Does the franchiser invest in advertising?	-0.082	-0.111
Franchisee: Is an initial payment made?	-0.228*	-0.147
Year in which the firm became franchise	-0.051	-0.052
R^2	0.400	0.347
Corrected R^2	0.279	0.215
Durbin - Watson	1.361	0.620
Snedecor F	3.292	2.623
Importance of the environment 1	0.000	0.003

*p < .1; **p < .05; ***p < .01

DOES OUR WORK WITH TIME ALLOCATION IN SCHOOL ADMINISTRATION MATCH THE EXPECTATION

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ABSTRACT. *In many expositions of fuzzy methods, fuzzy techniques are described as an alternative to a more traditional statistical approach. In this paper, we present a class of fuzzy statistical decision process in which testing hypothesis can be naturally reformulated in terms of interval-valued statistics. We provide the procedure of testing hypothesis with fuzzy data. Empirical studies show that fuzzy hypothesis testing with soft computing for interval data are more realistic and reasonable in the social science research. Finally certain comments are suggested for the further studies. We hope that this reformation will make the corresponding fuzzy techniques more acceptable to researchers whose only experience is in using traditional statistical methods.*

Keywords: Testing Hypothesis; Efficient Performance; School Administration; Fuzzy Statistics

1. Introduction. How are people recognizing the efficiency of educational administration? Usually, administrators review the old efficient records to estimate the efficiency of a policy. They compare the work with others and if there are not many, they have to improvise and use some comparable cases from some similar work. If the evaluation really gets skewed, what the administration can do is to use comparable cases from recent sales as close to the likeness of the property as possible.

There have been numerous literatures in the methodology of educational administration valuation. Ekelid et al. (1997) have focused on the structure and arguments in appraisal reports and how these have changed over time and on the treatment of different types of uncertainty. Monte Carlo simulations were used to incorporate the uncertainty of valuation parameters by Hoesli et al. (2005). Chen et al. (2009) introduced a novel decision-making approach to risk assessment in commercial educational administration development based on the ANP (Analytic Network Process) model.

In this paper, we are proposing an alternative method which uses fuzzy logic to improve the traditional way of testing hypothesis by more accurately reflecting the real way of human thinking.

In practice, the price provided in the educational administration valuation report supplied by the valuation agency is an exact records. In order to work on the data, we need to provide an improved fuzzy-based methodology in the educational administration valuation which involves in the attributes of impreciseness and vagueness.

Fuzzy logic was introduced in educational administration appraisal by a great many of scholars. Fuzzy logic was introduced to deal with the risk and uncertainty which were poorly considered in educational administration analysis. Maurizio d'Amato (2002) applied fuzzy theory to appraise property and made a comparison between this method and the most common statistic instruments. Marco Aure´lio Stumpf Gonza´lez (2006) improved mass appraisal techniques using FRBS (Fuzzy Rule-Based System) to model the educational administration and compared it with traditional hedonic regression model. Pagourtzi et al. (2006) proposed a new methodology and discussed the architecture for a decision support system for educational administration analysis based on GIS (Geographic Information System) integrated with fuzzy theory and spatial analysis.

In this paper we focus on the testing hypothesis with fuzzy data in educational administration.

2. Fuzzy Data with Soft Computing. In the traditional statistical approach, we start with a collection of real numbers, i.e., in more precise terms, we used number-valued statistics. In an interval situation, we start with a collection of intervals instead of a collection of numbers. So, if we use statistical methods to process this collection, it is natural to call these statistical methods interval-valued.

Let us see what statistical characteristics we can naturally extract from this collection. In traditional statistical techniques, each expert presents a single number, and from this collection, we can extract the probabilities $p(x_i)$ and cumulative probabilities $F(x_i)$. In the interval case, each expert presents *two* numbers x^- and x^+. So instead of a single collection of numbers, we have two collections: a collection of the lower endpoints x^-, and the collection of upper endpoints x^+. It is therefore natural to apply the standard statistical procedure to each of these collections.

Fuzzy techniques were developed to describe and analyze the situation when an expert is not sure about the value of the estimated quantity x, and may consider several different values to be possible. Therefore, all we have to collect from the experts is these interval, i.e., to be more precise, their endpoints. As a result, we have a collection of intervals.

Since intervals have the diffusible property, we need to consider both location and scale of length, of dispersion. First of all, we may transform the interval data $[c_1, d_1]$, …, $[c_n, d_n]$, into an kind of representation $(a_1; r_1),\ldots,(a_n; r_n)$ where $a_i = (d_i + c_i)/2$, $r_i = (d_i - c_i)/2$. A well-defined statement with fuzzy sample variance is illustrated as below:

Definition 2.1. Let X={$(a_1; r_1)$, …, $(a_n; r_n)$} be a fuzzy sample of interval data, each data has center at a_i and radius r_i. The sample variance of the interval data Ivar(X) is defined as

$$\overline{FX} = (\frac{1}{n}\sum_{i=1}^{n} a_i; \frac{1}{n}\sum_{i=1}^{n} r_i)$$

Definition 2.2. Let X={$(a_1; r_1)$, …, $(a_n; r_n)$} be a fuzzy sample of interval data, each data has center at a_i and radius r_i. The sample variance of the interval data Ivar(X) is defined as

$$Ivar(X) = (\frac{1}{n-1}\sum_{i=1}^{n}(a_i - \bar{a})^2; \frac{1}{n-1}\sum_{i=1}^{n}(r_i - \bar{r})^2)$$

Remark: First term of Ivar(*X*) shows the diffusibility about sample center, while the second term represents the difusibility of the sample lenth.

Example 2.1. In a survey with the starting salary for the new undergraduate students' salary, we find the following 5 data as follows: (3,0.5), (3,1), (3.5;1), (2.8;0.4),(4,1.5). Then according to the definition 2.1 and 2.2 the fuzzy mean and variance becomes:

$$\overline{FX} = (\frac{1}{n}\sum_{i=1}^{n} a_i; \frac{1}{n}\sum_{i=1}^{n} r_i) = (3.26;0.88)$$

$$Ivar(X) = (\frac{1}{n-1}\sum_{i=1}^{n}(a_i-\overline{a})^2; \frac{1}{n-1}\sum_{i=1}^{n}(r_i-\overline{r})^2) = (0.24;\ 0.2)$$

3. Testing Hypothesis with Fuzzy Data. It is a new research topic about the hypothesis testing of fuzzy mean with interval values. First of all, we will give a brief definition about the defuzzification. Then under the fuzzy significant level δ, we make a one side or two side testing. These methods are a little different from traditional significant level α. In order to get the robustic properties, we will set up the rejection area level F_δ, according to the fuzzy population.

3.1. Testing Hypothesis for Fuzzy Equal. Let U be the universal set (a discussion domain), $L=\{L_1,L_2,\cdots,L_k\}$ a set of k-linguistic variables on U, and A={ $A_1,A_2,\cdots,A_m$ }and B={ $B_1,B_2,\cdots,B_n$ } be two sets of fuzzy sample drawn from categorical populations with numbers on U. For each sample we assign a linguistic variable L_j and a normalized membership $m_{ij}\,(\sum_{j=1}^{k} m_{ij}=1)$, and let $Fn_{Aj}=\sum_{i=1}^{m} Ln_{ij}$, $Fn_{Bj}=\sum_{i=1}^{n} Ln_{ij}$ $j=1,2,\cdots,k$ be the total memberships for each data set.. The following statements are process for testing hypothesis Testing hypothesis of fuzzy equal for discrete fuzzy mean

Consider a *k*-cell multinomial vector *n*={ $n_1,n_2,...,n_k$ } with $\sum_i n_i = n$. The *Pearson Chi-squared te st* ($\chi^2 = \sum_i\sum_j \frac{n_{ij}-e_{ij}}{e_{ij}}$) is a well known statistical test for investigating the significance of the differences between observed data arranged in *k* classes and the theoretically expected frequencies in the *k* classes. It is clear that the large discrepancies between the observed data and expected cell counts will result in larger values of χ^2.

However, a somewhat ambiguous question is whether (quantitative) discrete data can be considered categorical data, for which the traditional χ^2 *-test* can be used. For example, suppose a child is asked the following question: "how much do you love your sister?" If the responses is a fuzzy number (say, 70% of the time), it is certainly inappropriate to use the traditional χ^2-test for the analysis. We will present a χ^2-test for fuzzy data as follows:

Procedures for Testing hypothesis of fuzzy equal for discrete fuzzy mean

(1) Hypothesis: Two populations have the same distribution ratio.

(2) Statistics： $\chi^2 = \sum_{i\in A,B}\sum_{j=1}^{c}\frac{([Fn_{ij}]-e_{ij})^2}{e_{ij}}$. (In order to perform the Chi-square test for fuzzy data, we transfer the decimal fractions of Fn_{ij} in each cell of fuzzy category into the integer $[Fn_{ij}]$ by counting 0.5 or higher fractions as 1 and discard the rest.)

(3) Decision rule： under significance levelα, if $\chi^2 > \chi^2_\alpha(k-1)$,then we reject H_0.

Testing hypothesis of fuzzy index equal for discrete fuzzy mean

Let $\overline{FX}$ be the fuzzy sample mean, $\overline{X}_f$ be the *defuzzyfication* of $\overline{FX}$. Under the fuzzy significant level F_δ, and the corresponding critical value F_δ, we want to test H_0: $\overline{FX} = F\mu$, where $F\mu$ is the fuzzy mean of the underlying population. Let μ is the defuzzyfication value of $F\mu$, then the above hypothesis becomes H_0: $\mu = \mu_0$.

(1) Hypothesis: $H_0: F\mu = F\mu_0$ vs. $H_1: F\mu \neq F\mu_0$.

(2) Statistics: find $\overline{FX}$ from a random sample $\{S_i, i = 1,...,n\}$.

(3) Decision rule: under the fuzzy significant level F_δ, if $\left|\overline{X}_f - \mu_0\right| > \delta$, then reject H_0.

Note: for left side test H_0 : $\mu \le \mu_0$ vs. H_1 : $\mu > \mu_0$ under the fuzzy significant level F_δ, if μ_0 - $\overline{X}_f > \delta$, we reject H_0. The right hand side testing is similar.

Testing hypothesis with continuous fuzzy mean

(1) Hypothesis: H_0 : $F\mu =_F (c_0; r_0)$ vs. H_1 : $F\mu \neq_F (c_0; r_0)$.

(2) Statistics: find $\overline{FX} = (\frac{1}{n}\sum_{i=1}^{n} c_i; \frac{1}{n}\sum_{i=1}^{n} r_i) = (\bar{c}; \bar{r})$ from a random sample $\{S_i, i = 1,...,n\}$.

(3) Decision rule: under the significant level α, set up the critical region for $(c_0; r_0)$. If $\bar{c}$ and $\bar{r}$ falls on the critical regions $c_{\alpha/2}$ and $r_{\alpha/2}$, then reject H_0.

3.2. Testing Hypothesis for Fuzzy Belongs to.

Testing of fuzzy belongs to with bounded sample

(1) Hypothesis: H_0 : $F\mu \in_F (c_0; r_0)$ vs. H_1 : $F\mu \notin_F (c_0; r_0)$.

(2) Statistics: find $\overline{FX} = (\frac{1}{n}\sum_{i=1}^{n} c_i; \frac{1}{n}\sum_{i=1}^{n} r_i) = (\bar{c}; \bar{r})$ from a random sample $\{S_i, i = 1,...,n\}$.

(3) Decision rule: under the significant level α, set up the critical region for $(c_0; r_0)$. If $\bar{c}$ and $\bar{r}$ falls on the critical regions $c_{\alpha/2}$ and $r_{\alpha/2}$, then reject H_0.

Testing of fuzzy belongs to with unbounded below sample

(1) Hypothesis: H_0 : $F\mu \in_F (-\infty, b]$ vs. H_1 : $F\mu \notin_F (-\infty, b]$.

(2) Statistics: find $\overline{FX} = (-\infty, \bar{b})$ from a random sample $\{S_i, i = 1,...,n\}$.

(3) Decision rule: under the significant level α, set up the critical region for b. If $\bar{b}$ falls on the critical regions b_α then reject H_0.

Testing of fuzzy belongs to with unbounded above sample

(1) Hypothesis: H_0 : $F\mu \in_F [a, \infty)$ vs. H_1 : $F\mu \notin_F [a, \infty)$

(2) Statistics: find $\overline{FX} = [\bar{a}, \infty)$ from a random sample $\{S_i, i = 1,...,n\}$.

(3) Decision rule: under the significant level α, set up the critical region for b. If $\bar{a}$ falls on the critical regions b_α then reject H_0.

4. Empirical Study. In the questionnaire and sampling survey, we collect 35 school leaders reply the information. Ages from 30 to 60, sex is male 29, female 11. Most samples are collected at the Taichung area, Taiwan. In this sampling survey, we want to examine three assumptions: (a) H_0*:* School administrators' working hours in academic activity is equal to the expected one. (b) H_0 *:* School administrators' working hours in business activity is equal to the expected one. (c) H_0 *:* School administrators' working hours in student affairs is equal to the expected one. Table 1 illustrates the result of our survey.

TABLE 1. Result of our survey with 35 school leaders working time

	Expected interval	Observed data	
	$F\mu$	$\overline{FX}$	*Ivar(X)*
Academic activity	(12;2)	(11;0.8)	(2;0.2)
Business activity	(10;1)	(8*;1.1)	(2;0.3)
Student affairs	(15;2)	(12*;2.2*)	(3;0.5)

*p<0.1**

Under the significant level α =0.1, we can see that

(1) We accept (1) H_0 *:* School administrators' working hours/weekly in academic activity is equal to the expected one. Moreover, since the interval of $\overline{FX}$ falls within the expected ones. We can also say that $\overline{FX} \in_F F\mu = (c_0; r_0)$.

(2) We reject H_0: School administrators' working hours/weekly in student affairs is not equal to the expected one. Moreover, though we accept that the interval of length is equal to the expected one, we can not say $\overline{FX} \in_F F\mu = (c_0; r_0)$.

(3) We reject H_0 *:* School administrators' working hours/weekly in business activity is equal to the expected one. Though the center of $\overline{FX}$ falls within the expected interval, the radius of the $\overline{FX}$ is much larger than $F\mu$, We can not say that $\overline{FX} \in_F F\mu = (c_0; r_0)$

5. Conclusion. Fuzzy statistical analysis grows as a new discipline from the necessity to deal with vague samples and imprecise information caused by human thought in certain experimental environments. In this paper, we made an attempt to link the gap between the binary logic based on multiple choice survey with a more complicated yet precise fuzzy membership function assessment, such as fuzzy mode, fuzzy median, fuzzy weight and α -cut etc. We carefully revealed how theses factors can be properly and easily utilized in various fields to reveal the contradictory characteristics of human concepts. Through these processes, human ideas are no longer presented as discrete but as a natural and continuous flow. There are illustrated examples demonstrated to explain how to find the fuzzy mode and fuzzy median, and how to use the results to help people reaching their decisions.

However, there are still some problems we need to investigate in the future:

(1) We can further research on data simulation so that we can understand features of the fuzzy linguistic, multi-facet assessment, and the balance of the moving consensus. Moreover, the choice of different significant α-cut will influence the statistical result. An appropriate criterion for selecting significant α-level should be investigated in order to reach the best common agreement of human beings.

(2) There are other types of membership functions we could explore in the future. For the fuzzy mode of continuous type, we can extend the uniform and triangular types of membership functions to non-symmetric or multiple peaks types.

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INTRODUCTION OF TWAPS-A DECISION SUPPORT SYSTEM FOR AGRICULTURE IN TAIWAN

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ABSTRACT. *This article presents a decision support system, Taiwan Agricultural Policy System Model (TWAPS). TWAPS is developed for providing instantaneous decision-support for agricultural sector in Taiwan to solve various agricultural problems. It is a policy-oriented and production activities-based system, which is established based upon the characteristic of Taiwan agricultural sector. The system now is used to trace the historical development of agricultural economy in Taiwan, to do policy simulation for feasible policies in response to various agricultural problems, and also to predict the future developing trend of Taiwan agricultural economy as well for agricultural policy-maker in Taiwan. TWAPS includes three sub-systems, namely, TWAPS/BS, TWAPS/SFSS, and TWAPS/PS. TWAPS/BS with a complete time series data of the agricultural sector from 1990 to 2009 acting like a database of other sub-systems, TWAPS/SFSS makes a trend estimation to make up the time lag of official statistics and extends data to current year 2010, and TWAPS/PS conducts policy simulation or prediction based upon the complete time series data from TWAPS/BS and TWAPS/SFSS. An application of TWAPS on trade liberalization will be presented to show how it works with policy simulation.*
Keywords: Taiwan Agricultural Policy System Model; TWAPS, Decision Support System; Agricultural Policy Simulation

1. Introduction. In recent decades, the global environment has being gotten more and more complicate. Along with the increasing international trade, the agricultural issues in Taiwan are getting more complex. A large number of models have been developed for solving particular agricultural problems. A model designed for an individual event or a single production activity is not enough to solve the problems occurred under diversified and complicate environment. Besides, in order to reflect the growing interdependence in the world agriculture, most of the models are multi-country and multi-commodity models, such as the computable general equilibrium model (CGE) model (Wang . 2002; Dixon and Rimmer , 2002). It is not surprising, however, that for a long time most of these models tended to focus on the "major economic units", in particular the USA and the EU. A small country such as Taiwan was often only considered within regional aggregates. This has turned out to be problematic. Specific problems that may be important for some small countries are usually ignored.

Previous models used for decision support includes econometric model, mathematical programming, agricultural sector model (ASM), CGE and SPEL/EU (European Commission, 1996, 1998; Henrichsmeyer and Wolf, 1995; Burrell et al., 1995; Weber, 1995; Wolf et al., 1995, Wolf, 1995; Zintl and Greuel, 1995). In which the econometric model and mathematical programming might be easy to be used for policy simulation with some products, but could not link with the macro economic side because those models built without input-output flow. The ASM model (McCarl, et al., 2001; Taylor, 1996) is established based upon the concept that the prices are derived on the equilibrium of supply and demand. In practice, the optimum prices are not easy to reach, therefore the solutions from ASM model are usually far away from real economic situation. The CGE model is developed based on the theory of general equilibrium and is cored on a social accounting matrix (SAM) (Pyatt and Round, 1985). Because CGE model is a multi-country and multi-commodity model, it is usually lack of sensitivity used for agricultural policy simulation in Taiwan and the simulation results are sometimes far away from reality. Furthermore, the SAM in CGE can only reflect the identity balance between input and output from monetary side measured by value, but not from physical side measured by quantity. Moreover, CGE model built without time series data could not trace the developing economy in agricultural sector. SPEL/EU is a sector production and income model of agriculture used for the European Union (EU), which was developed in response to the demand of instantaneous decision-support in agricultural production and income in the EU from those departments of the European Commission responsible for the Common Agricultural Policy (CAP) (Wolf, et al., 1995). The SPEL/EU system is different from that of most econometric models, which is activity-based approach and characterized by mutual interaction or cooperation among model-builders, statisticians, and policy-makers. SPEL/EU system has ever played an important role for solving the agricultural problems in EU.

TWAPS, Taiwan Agricultural Policy System Model, is developed for providing instantaneous decision-support for agricultural sector in Taiwan to solve various agricultural problems, which tends to take the advantages of those models mentioned above into account and also make up their lack in practice as well. TWAPS (Chen, 1997-1999; Show, 2010; Hsu, 2001, 2005) adopts the idea of production activity-based approach from SPEL/EU and combines with Taiwan agricultural production structure to develop a policy-oriented system. This system covers the agricultural production activities related to all of Taiwan agricultural products, the foreign trade, and the domestic demand of agricultural products. Moreover, the model takes into account regional interrelationships of agricultural trade between Taiwan and other trade countries. In response to the special relationship between Taiwan and China, the system differentiated trade partners into three regions, namely China, USA, and the rest of the world. This system can be used for forecasting, policy analysis, and for simulating and explaining period of history (Hsu, 2002-2010). Due to the feature of activity-based model, this model can also directly present agriculture structure and interaction among production activities in physical measure. Therefore, simulation results could represent the quantitative, price, and monetary impacts of policy changes *via* the alternate use of various policy scenarios to evaluate the impact of implementing Taiwan's agricultural policy changes. The system now is used to trace the historical development of agricultural economy in Taiwan, to do policy simulation for feasible policies in response to various agricultural problems, to predict the future developing trend of Taiwan agricultural economy, and also to do the policy simulation for the new WTO agricultural trade negotiations as well to provide the policy implication for agricultural policy-maker in Taiwan (Hsu, 2002-2010).

This paper is organized into five main sections. It will start with a description of current WTO agricultural negotiations in section 2. Then an overview on domestic support and trade policies of Taiwan agriculture will follow in section 3. Section 4 will outline the theoretical structure of TWAPS. Finally an application of TWAPS on trade liberalization will be presented in section 5. This paper will finish with a short summary and concluding remarks.

2. Current WTO Agricultural Trade Negotiations. Taiwan‘s commitments in agricultural sector to WTO can be classified into three major categories, namely tariff reduction, market access and domestic support reduction. Current tariffs and tariff quotas for crops and livestock are shown in Table 1.

2.1. Tariff Reduction and Market Access: Tariffs and Tariff Quotas. For those tariff-only agricultural commodities average tariff rates would drop by more than 7% declined from around 20.02% in 2001 to 12.9% in 2004.

In the past, there are 43 commodities imported with non-tariff barriers, such as import controlled, area restriction, import licensing, and quota processes. All these non-tariff barriers have to be eliminated or converted to tariffs (known as “tariffication”) to comply with the access commitment.

(1) Rice was imported with maximum quota 144,720 tons in 2002 and imported with tariff rate quotas (TRQs) from 2003.

(2) 22 commodities including sugar, peanut, adzuki bean, garlic bulbs, dried shiitake, dried day lily, betel nut, coconut, pear, shaddock, longan pulp, banana, pineapple, mongo, persimmon, belly, meat of fowl, milk, edible offal of pig and poultry, and three fishery products are imported with TRQs, which have lower within-quota tariff and much higher tariff on out-of –quota volumes. The tariff quota will be phased out by January 1, 2005.

(3) In part (2), 14 sensitive products, namely sugar, peanut, adyuki bean, garlic bulbs, dried shiitake, dried day lily, betel nut, pear, shaddock, persimmon, belly, meat of fowl, milk, edible offal of pig and poultry are allowed to use special agricultural safeguard to add extra tariff on the products whose imported amount is over the base amount or the import price is lower than base price by 10%. Special agricultural safeguard can only be used on products that were tariffied – which amount to less than 20% of all agricultural products (as defined by “tariff lines”). But they could not be used on imports within the tariff quotas, and they can only be used if the government reserved the right to do so in its schedule of commitments on agriculture.

(4) For the rest of products, such as potato, papaya, and so on, have been converted to tariffs.

2.2. Domestic Support. Subsidies in WTO terminology are identified with “boxes”, green (permitted), amber (slow down – i.e. be reduced), and red (forbidden). The agriculture agreement has no red box, but there is a blue box for subsidies that are tied to programs that limits production**.**

(1) Amber box . Fo r agri culture, a ll d omestic support measures considered to dist ort production an d tra de fa ll int o the a mber b ox. T he to tal value of t hese measures m ust be reduced.

(2) Green box. All domestic support measures considered not to distort trade or at most cause m inimal dist ortion a re qualified f or " green box". The y include environment protection and regional development programs which are allowed without limits.

(3) Blue box. All subsidies linked to production fall in blue box must be reduced or kept within defined minimal levels.

TABLE 1. Current tariffs and tariff quotas for crops and livestock

	Quotas (Tons)	Under-quota tariff (%)	Over–quota tariff (%)
addy rice	144,720 12.5		300
Soft wheat		20	
Other cereals		20	
Soybean		22.5	
Peanut 5	,235 25		371
Adzuki Beans	2,500 22.5		164
Other beans		22.5	
Other potatoes		25	
Sugar cane	205,000 15		151
Oilseed		5	
Cabbage		20	
Garlic 3	,520 22.5		300
Banana 13	,338 12.5		111
Pineapple 23	,870 15		183
Orange		37.5	
Mangos 12	,755 25		64
Betel Nuts	8,824 17.5		1,710
Grapes		21.7	
Pears 9	,800 18		375
Milk 21	,298 15		97
Beef		15	
Pork		15	
Chicken		21.7	

The "Total Aggregate Measurement of Support (AMS)" was calculated on a product-by-product basis, it was the sum of those expenditures that have perceived abi lities to im pact on production and to d istort tra de f lows. To com ply with t he Taiwan's ac cess t o WTO domestic support expenditures (known as AMS) have to be reduced by 20% (around 14.185 billion) from an agreed base (1990~1992 base period). In principle, the agreed expenditure reduction applied only to those expenditures included in the amber box such as output price support and input subsidies. To qualify the WTO commitment some domestic support policies have been adjusted in Taiwan. Such as the overall level of domestic support has been reduced and thus reached the 20% reduction before entering WTO.

3. Domestic Support of Taiwan Agriculture. The domestic support instruments used in Taiwan can be categorize into (1) market intervention, (2) production related subsidies, and (3) direct income transfers, which are closely neutral for production and mainly social oriented. Table 2 shows the domestic agricultural policies used in Taiwan.

The “market intervention instruments” now are used only on the rice market. There are some small interventions planned for the future. A fixed percentage of the imports are taken by the government to support some social decisions, like food aid for less developed countries and so on. Also some part of public stock from plan of domestic rice production intervention to a fixed price will be used to support the state requests like food for soldiers, etc. Such intervention may have small impacts to food market. Therefore the model assumed that the intervention price and the intervention quantity would have a small impact on the retail prices by the difference to the retail prices without an intervention impact.

The “production related subsidies” usually have an effect to the productions decisions of the domestic farmers. Those subsidies will mainly increase the domestic production, which leads to an increase of the harvested area. The “direct income transfers” is assumed that these subsidies are only social based. There is only an income impact assumed, which is treated without any effects to production.

4. Taiwan Agricultural Policy System-TWAPS. TWAPS includes three sub-systems, namely, TWAPS/BS, TWAPS/SFSS, and TWAPS/PS. TWAPS/BS is a base system with a complete time series data of the agricultural sector from 1990 to 2009, which acts like a database of other sub-systems. The database in TWAPS/BS includes the whole production activities, input-output, demand-supply, export-import, previous and current agricultural policies of cropping and livestock sectors in Taiwan, as well as related macroeconomic variables. TWAPS/ SFSS is a short term forecast system, which makes a trend estimation to make up the time lag of official statistics and extends data to current year 2010. TWAPS/PS is a policy simulation system, which conducts policy simulation or prediction based upon the data from TWAPS/BS and TWAPS/SFSS. TWAPS adopts the idea of production activity-based approach from SPEL/EU[1] and combines with Taiwan agricultural production structure to develop a policy-oriented system. This system is as table 2.

4.1. TWAPS/BS and TWAPS/SFSS. TWAPS/BS, base system of TWAPS, constitutes the basis for other systems of TWAPS. This system integrates information from multiple sources (such as official statistics, farm sample data, calculation data, and so on) and represents the input/output flow of agricultural production activities. Base system of TWAPS is not only acting like a database but also providing functions like a model. TWAPS/BS consists of “Activity Based Table of Accounts (ABTA)” and “Matrix of

1 SPEL is an abbreviation of German -“Sectorales Produktions- und Einkommensmodell der Landwirtschaft”, that is “Sectoral Production and Income Model for Agriculture”. See [5-10] for the details of SPEL/EU.

Activity Coefficients (MAC)". Both of ABTA and MAC include four components, namely output generation (XG), output use (XU), input generation (YG), and input use (YU). It also covers supply component and demand component. The system works with a recursive algorithm to obtain consistent data from various sources. Thus it could represent the interaction relationship among ABTA, MAC, demand component, and supply component.[2] The ABTA consists of physical component and valued component shown as in Figure 1. The price acts as bridge to link value component with physical component. Both of physical and monetary valued components have identity structure (shown as in Figure 2) to fulfill a horizontal balance for both of physical and monetary valued components and a vertical balance for monetary valued components only. Figure 2 and Figure 3 show the identity equation system of the Activity-Based Table of Accounts (ABTA) and the Matrix of Activity Coefficients (MAC), respectively.

This system integrated production activities depending on (1) the weight of production value; (2) regional characteristic; (3) policy importance; (4) trade importance. Current ABTA distinguished crop and livestock sectors into 56 product items (33 for crop sector and 23 for livestock sector). In ABTA table, components XG and XU display the relationship between output and input as well as the interaction between agriculture and non-agriculture sectors. Similarly, components YU and YG display the relationship between input generation and input use, which can be presented with physical or monetary valued measures. The valued flow linked with macro economy can also display the relationship among production value, intermediate production value, and added value. The table 3 displays a simplified ABTA table with only some of the production activities.

TWAPS/SFSS, short-term forecast and simulation system, aims to update the data to current year to bridge the time lag for statistics based on trend analyses and expert forecast. Short-term forecast produces only one to two years forecast ahead.

TABLE 2. The domestic protective measures of agricultural products used in Taiwan

Policy Instruments	Important policies	Suitable products
Market intervention	Guarantee purchasing price	Rice, sugar, corn, soybeans, sorghum, wheat, mushroom, asparagus, banana, grape, pineapple, onion.
	Guarantee purchasing price of contract plant	Sugar, milk, pineapple, tobacco, tomato, ornamental plants.
	Marketing of guarantee price	Hog, fishery products.
	Export of united distribution	Ornamental plants, vegetables.
Direct income transfers	Subsidy of price margin	Hog, summer vegetables, fruit
	Subsidy of set aside and fallow land	Rice.
Production related subsidy	Livestock insurance	Cattle, hog, sheep.
	Political agricultural loan	All agricultural products.
	Electrification decrease	All agricultural products.

[2] See Wolf (1995) and Hsu (2005) for the details.

Designed to bring related players, namely economists, statisticians, model builders, and policy makers together. Thus it could reflect the mutual interaction among those four players, which is different from other models. The database of TWAPS covers whole agricultural production activities related to all of Taiwan agricultural products, the foreign trade, and the domestic demand for agricultural products. Thus it can be used for forecasting, policy analysis, and for simulating and explaining period of history.

4.2. TWAPS/PS. TWAPS/PS, policy simulation system, is designed for 10 years forecast of agricultural economy and policy simulation for policy instruments of agriculture including border (especially for the trade liberalization for WTO negotiations) and domestic support measures. TWAPS/PS is based on the ex-post and ex-ante data established by TWAPS/BS and TWAPS/SFSS. The whole structure of TWAPS/PS includes six components described as following:

(1) Policy scenarios. Policy instruments set up in this system including all the policy instruments used before or planned to be used in the future, for example, subsidies for set aside, guarantee purchasing price, tariff cut, import quota, tariff rate quota, AMS, and so on. Those policy instruments could be selected to represent various policy scenarios *via* the switch function in system.

(2) Main body of TWAPS. Main body of TWAPS including whole agricultural production activities integrated into some product items, output coefficients, input coefficients, and production level in ABTA and MAC tables are established by TWAPS/BS and TWAPS/ SFSS, which are used for TWAPS/PS.

(3) Output use. Output use covers all the output use of agricultural products in different sectors including sectoral interaction. The sectoral interaction is categorized into intrasectoral use activities (sales to non-agricultural sector) and an intersectoral use activity (agricultural sales) in agricultural sector. The output use has to satisfy the principle of supply balance, in which the total domestic resource is equal to the total domestic use.

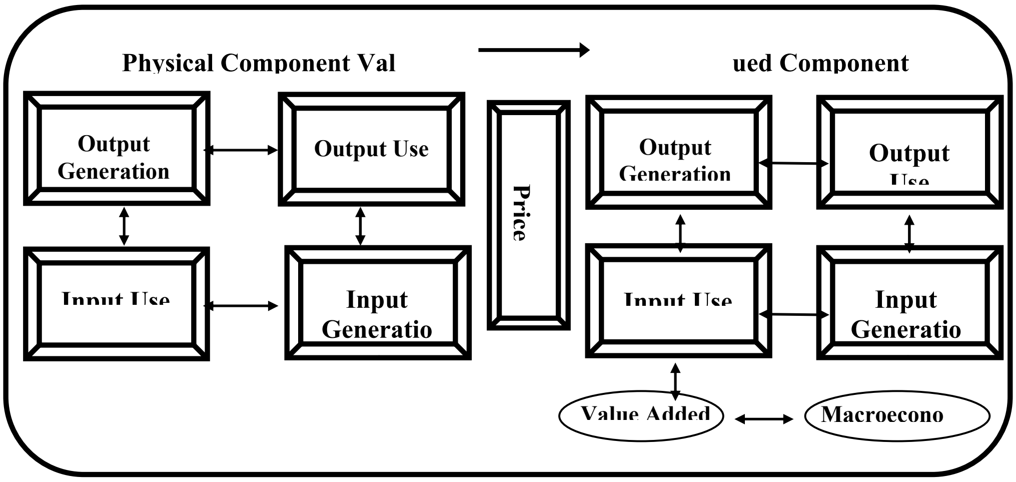

FIGURE 1. Structure of ABTA and MAC table

	Production activities		Use activities		
Output balances	$\sum_{i}\sum_{j} XG_{i,j}\,PG_{j}$ #	+	$\left\{-\sum_{i}\sum_{j} XU_{k,j}\,PU_{k,j}\right\}$	=	**0**
	+		+		
Input balances	$\left\{-\sum_{i}\sum_{h} YU_{i,h}\,QU_{h}\right\}$	+	$\sum_{i}\sum_{j} YG_{k,h}\,QG_{k,h}$	=	**0**
	=		=		
	0		**0**		

With:

$$PG_j = \frac{\sum_k XU_{k,j}\ PU_{k,j}}{\sum_i XG_{i,j}}$$

$$QU_h = \frac{\sum_k YG_{k,h}\,QG_{k,h}}{\sum_i YU_{i,h}}$$

XG : Output Generation, ABTA, physical component

XU : Output Use, ABTA, physical component

YG : Input Generation, ABTA, physical component

YU : Input Use, ABTA, physical component

PG : Unit value producer prices for Output Generation

PU : Producer prices for Output Use

QG : Purchase prices for Input Generation

QU : Unit value purchase prices for Input Use

i : Subscript, production activity, ABTA,(i=(1,⋯,n))

j : Subscript, products, ABTA, (j=(1,⋯,m))

k : Subscript, use activity, ABTA, (k=(n+1,⋯,N))

h : Subscript, input items, ABTA, (h=(m+1,⋯,M))

FIGURE 2. Identity equation system of the activity-based table of accounts (ABTA)

	Production activities
Output coefficients	$\sum_{i}\sum_{j}\frac{XG_{i,j}}{Level_i} PG_j$ #
	+
Input coefficients	$\left\{-\sum_{i}\sum_{h}\frac{YU_{i,h}}{Level_i} QU_h\right\}$
	=
	0

With:

$$PG_j = \frac{\sum_k XU_{k,j}\ PU_{k,j}}{\sum_i XG_{i,j}}$$

$$QU_h = \frac{\sum_k YG_{k,h}\ QG_{k,h}}{\sum_i YU_{i,h}}$$

XG : Output Generation, ABTA, physical component

XU : Output Use, ABTA, physical component

YG : Input Generation, ABTA, physical component

YU : Input Use, ABTA, physical component

PG : Unit value producer prices for Output Generation

PU : Producer prices for Output Use

QG : Purchase prices for Input Generation

QU : Unit value purchase prices for Input Use

i : Subscript, production activity, ABTA, (i=(1,⋯,n))

j : Subscript, products, ABTA, (j=(1,⋯,m))

k : Subscript, use activity, ABTA, (k=(n+1,⋯,N))

h : Subscript, input items, ABTA, (h=(m+1,⋯,M))

FIGURE 3. Identity equation system of the matrix of activity coefficients (MAC)

TABLE 3-1. A simplified ABTA table in 2008

2008		Production activities(1)				Use of production(2)					
		Rice H	ogs	Sows, matted	R Sows	Consump-tion	Process-ing	Feed use	Seed use	Other use	Losses
Final products(a)	Rice	4669.87				1310.3	49.6	4.37	14.53		13.04
	Pork		98.51	27.05		818.91	123.89				18.18
Intermediate products(b)	Sows, matted			0.49	1						183.94
	Piglets			14.84							2091.57
	Manure		3.71	28.5	8.55						
Input(c)	Seed	9882.99							625.56	11111.42	
	N fertilizer	245.43								244.71	
	P fertilizer	46.35								111.46	
	K fertilizer	96.16								156.09	
	Fertilizer(other)	548.36									-17.24
	Pesticides	5343.12								8230.6	
	Cereal and rice feeding			222.24	83.3			5018.97		853.04	
	High energy feeding stuff		108.89	355.84	78.46					2166.01	
	High protein feeding stuff		181.06	801.67	201			95.41		8623.53	
	Other feeding stuff		129.72	22.37				1725.73		692.43	
	Veterinary and medicine		172.57	258.86	215.71					4211.85	
	Piglets			1							
	Sows		1		1						
	Energy	803.95								362.34	
	Materials	220.92	6.87	10.31	8.59					6496.23	
	Repair costs	303.2								136.65	
	Contract labor	50								31.36	
	Own labor	28.06	0.25								
	Employee labor	100.23									
	Others inputs		24.79	7292.45	25.31					17465.06	
Macro-economic variables(d)	Gross production value	115166.4	10869.52	38994.87	6624.32	421538.4	98260.2	91336.49	726.29	18994.89	51230.19
	Total intermediate inputs	52094.89	1885.92	15539.14	2076.58			20561.79	726.29	134016.1	-45.52
	Total variable inputs	28818.15	1847.44	6664.1	2035.38			20561.79	726.29	90704.05	-45.52
	Gross value added	63071.55	8983.59	23455.73	4547.74	421538.4	98260.2	70774.7		-115021	51275.71
	Subsidies	2899.44	6.27	4.4	26.89						
	Depreciation	446.31	240.2	283.04	593.66						
Aggregates(e)	Harvested area	252.29									
	Animal activity in heads		8542.44	751.44	515.77						
	Main area	148.33									

Note：the units are as following:(1a)：kg/ha、kg/head、head/head; (2a)：1000mt、million; (3a) ：1000mt、1000 heads; (4a) ：NT$/mt、NT$/1000heads; (5a)：million NT$; (1b)：head/head、piece/head; (2b)：1000mt、million pieces ; (3b)：1000 mt、million pieces; (4b) ：NT$/1000heads、NT$/1000pieces; (5b)：million NT$; (1c)：NT$/ha、NT$/head、head/head; (2c)：1000mt、million pieces、million NT$; (3c)：1000 mt、million NT$、1000 head、million NT$(4c) ：NT$/1000 heads、NT$/1000 pieces、NT$/mt; (5c)：million NT$; (1d)：NT$/ha、NT$/head; (1e)：1000ha、1000 heads.

TABLE 3-2. A simplified ABTA table in 2008

2008		Physical aggregates(3)					Prices(4)			
		Production	Slaugh-terings	Domestic use	Import	Export	Farm price	Retail price	Import price	Export price
Final products(a)	Rice	1178.17		1378.8	180.58	8.48	24492.04	33970	14000	47000
	Pork	861.84		942.81	100.57	1.43	110316.7	173070	46000	210000
Intermediate products(b)	Sows, matted	885.36	184.79	764.55			6619000			
	Piglets	11149.78	8542.44	9058.21			2206333			
	Manure	585.16					622.63			
Input(c)	Seed	11736.98		11736.98			1161.03			
	N fertilizer	244.71		244.71			26049.94			
	P fertilizer	111.46		111.46			28771.93			
	K fertilizer	156.09		156.09			17422.2			
	Fertilizer(other)	567.92		567.92			2640.34			
	Pesticides	8230.6		8230.6			1215.3			
	Cereal and rice feeding stuff	5872.01		5872.01			3352.61			
	High energy feeding stuff	2166.01		2166.01			225.12			
	High protein feeding stuff	8718.94		8718.94			5303.85			
	Other feeding stuff	2418.17		2418.17			1871.16			
	Veterinary and medicine	4211.85		4211.85			1215.3			
	Piglets	751.44		751.44			1230538			
	Sows	9058.21		9058.21			410179.5			
	Energy	362.34		362.34			1215.3			
	Materials	6496.23		6496.23			1215.3			
	Repair costs	136.65		136.65			1215.3			
	Contract labor	31.36		31.36			433255			
	Own labor	749.01					488237.3			
	Employee labor	154.39					559826.4			
	Others inputs	17465.06		17465.06			1215.3			
Macro-economic variables(d)	Gross production value	469943.4					1362.28			
	Total intermediate inputs	146559					1218.81			
	Total variable inputs	107819.5					1255.02			
	Gross value added	323384.4					1427.29			
	Subsidies	3623.8					1215.3			
	Depreciation	3852.14					1215.3			
Aggregates(e)	Harvested area	1013								
	Animal activity in heads									
	Main area	822								

Note：the units are as following:(1a)：kg/ha、kg/head、head/head; (2a)：1000mt、million; (3a)：1000mt、1000 heads; (4a)：NT$/mt、NT$/1000heads; (5a)：million NT$; (1b)：head/head、piece/head; (2b)：1000mt、million pieces; (3b)：1000 mt、million pieces; (4b)：NT$/1000heads、NT$/1000pieces; (5b)：million NT$; (1c)：NT$/ha、NT$/head、head/head; (2c)：1000mt、million pieces、million NT$; (3c)：1000 mt、million NT$、1000 head、million NT$(4c)：NT$/1000 heads、NT$/1000 pieces、NT$/mt; (5c)：million NT$; (1d)：NT$/ha、NT$/head; (1e)：1000ha、1000 heads.

TABLE 3-3. A simplified ABTA table in 2008

2008		Trade			Values aggregates(5)
		Tariff up the quota	Tariff rate	Quota	Production values
Final products(a)	Rice	300	12.5	144.72	28855.79
	Pork	15			95074.88
Intermediate products(b)	Sows, matted				5860.22
	Piglets				24600.13
	Manure				364.34
Input(c)	Seed				13626.98
	N fertilizer				6374.71
	P fertilizer				3206.82
	K fertilizer				2719.38
	Fertilizer(other)				1499.51
	Pesticides				10002.65
	Cereal and rice feeding stuff				19686.55
	High energy feeding stuff				487.61
	High protein feeding stuff				46244
	Other feeding stuff				4524.77
	Veterinary and medicine				5118.66
	Piglets				924.67
	Sows				3715.49
	Energy				440.35
	Materials				7894.87
	Repair costs				166.08
	Contract labor				13585.44
	Own labor				365696.1
	Employee labor				86431.1
	Others inputs				21225.29
Macro-economic variables(d)	Gross production value				640192.4
	Total intermediate inputs				178628
	Total variable inputs				135316
	Gross value added				461564.3
	Subsidies				4404
	Depreciation				6378
Aggregates(e)	Harvested area				
	Animal activity in heads				
	Main area				

Note：the units are as following:(1a)：kg/ha、kg/head、head/head; (2a)：1000mt、million; (3a) ：1000mt、1000 heads; (4a) ：NT$/mt、NT$/1000heads; (5a)：million NT$; (1b)：head/head、piece/head; (2b)：1000mt、million pieces ; (3b)：1000 mt、million pieces; (4b) ：NT$/1000heads、NT$/1000pieces; (5b)：million NT$; (1c)：NT$/ha、NT$/head、head/head; (2c)：1000mt、million pieces、million NT$; (3c)：1000 mt、million NT$、1000 head、million NT$(4c) ：NT$/1000 heads、NT$/1000 pieces、NT$/mt; (5c)：million NT$; (1d)：NT$/ha、NT$/head; (1e)：1000ha、1000 heads.

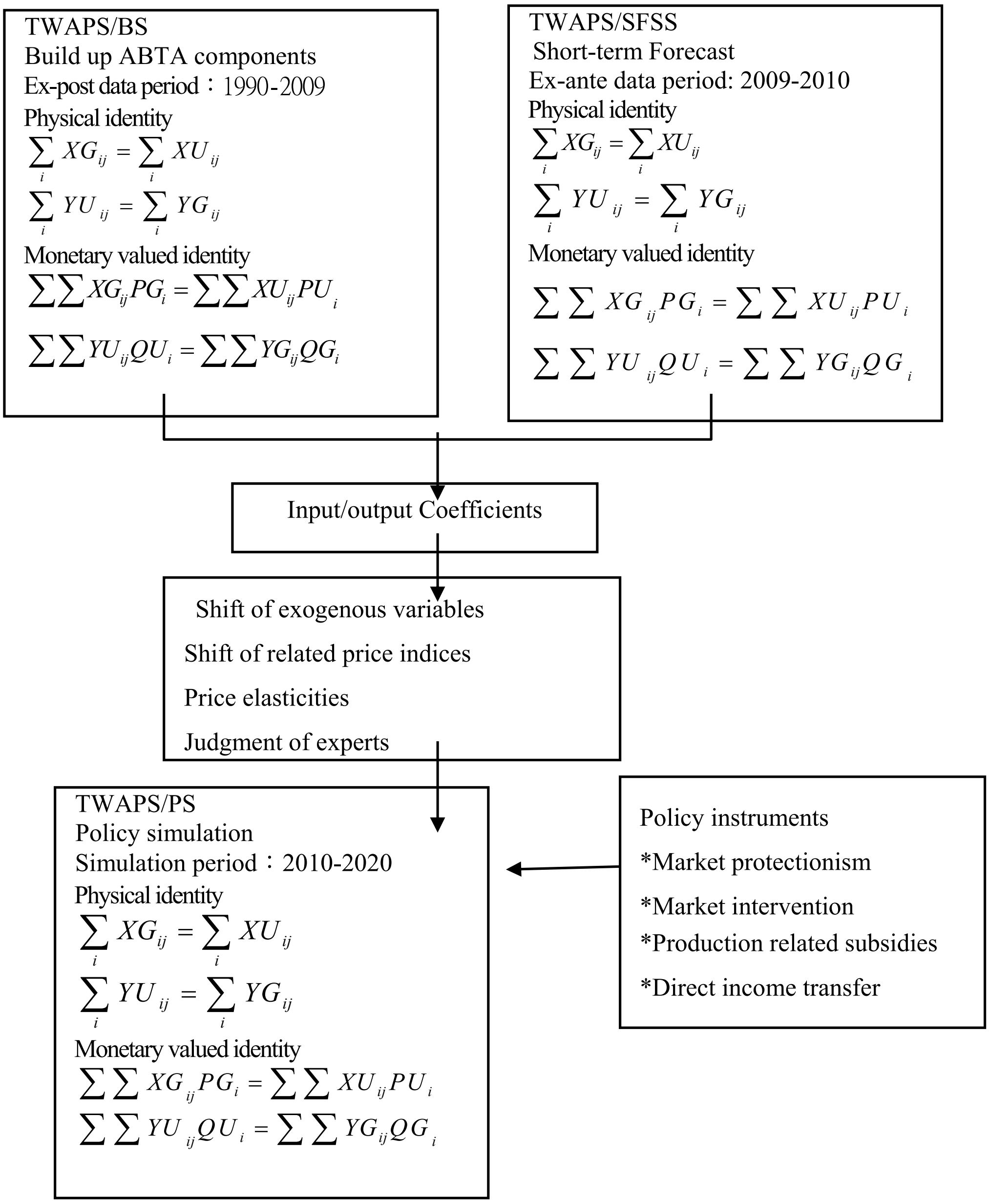

FIGURE 4. Simulation process of TWAPS

(4) Input generation. Input generation covers various agricultural inputs from agricultural sector and non-agricultural sector.

(5) Market and demand component. This component includes import, export, domestic consumption, input purchase, stock, etc.

(6) Identity system. This system includes some identity equations, such as equality between total production and total product use in both of physical flow and monetary valued flow, balance with national account, and so on.

TWAPS/PS first forecast ahead to year 2020 for exogenous variables. The exogenous variables include input coefficients, output coefficients, world market price, total land use for agricultural se ctor, and s ome re lated m acro e conomic v ariables (suc h as people, wholesale price index, consumer price index, index of price received by farmers, index of price paid by f armers, a nd national in come). T he f orecast of s ome pa rameters a nd exogenous v ariables wil l b e p rovided by TWAPS estimation, o ther stud ies, a nd exp ert suggestion. Fu rther, TWAPS/ PS use s rel ated price el asticities a nd keeps t he policy instruments at current level (including border control and domestic support) to obtain base simulation from 2010 to 2020.

Then TWAPS takes combinations of various policy instruments in different support level to get poli cy scenarios and does the policy simulation for tho se policy s cenarios. Th e algorithm used in TWAPS/PS fo r policy si mulation fo llows th e simulation flow chart shown as in Figure 5. The simulation process has to fulfill the requirement of physical and monetary va lued id entities. Th e imp act on agriculture from implementation o f v arious policy ins truments would be c arried o ut b y c omparing th e po licy s imulation results and with base sim ulation. Si mulation res ults w ill cont ain impacts on each of individual production activities and the whole agricultural sector and macro economy of agricultural sector as well.

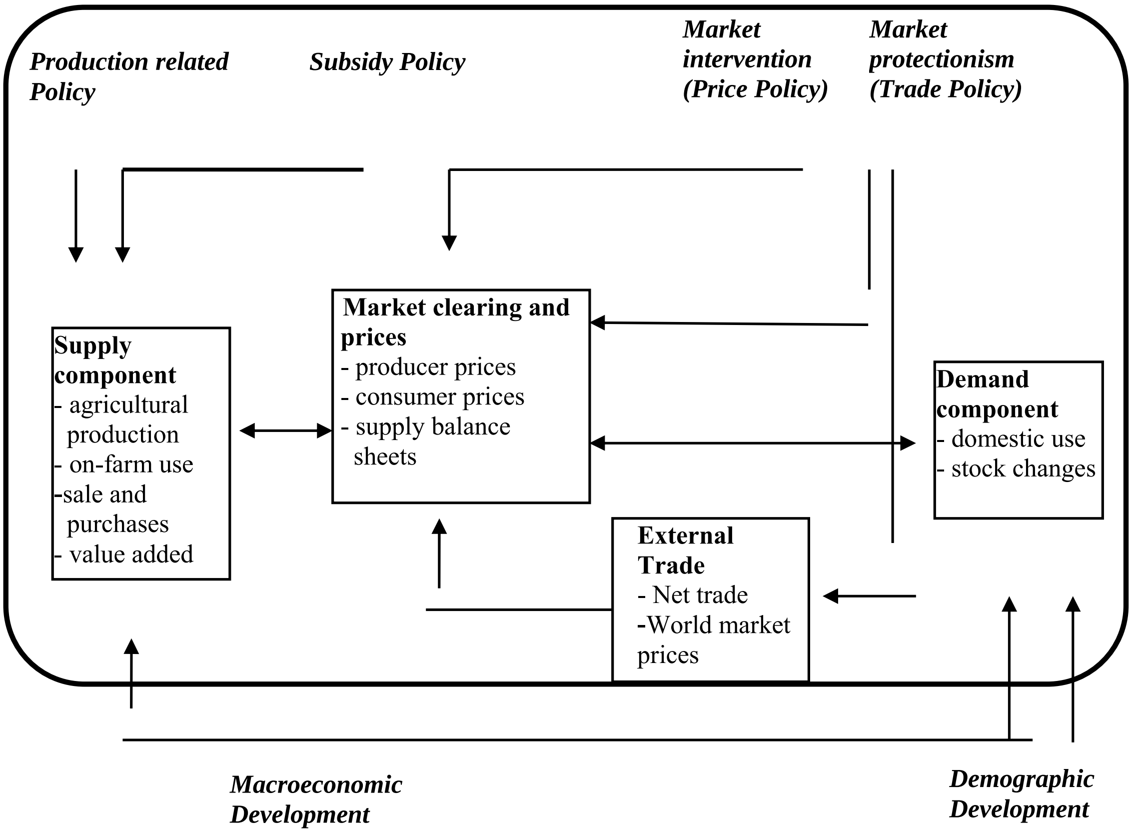

FIGURE 5. Flow chart of policy simulation with policy instruments

4.3. General Me thodology of P olicy S imulation w ith TWAPS/PS. TWAPS/PS i s a demand oriented model. T he engine fo r ch anges on the m arket is lo cated at the demand side (ret ail prices a nd dom estic demanded quantities). The retail pri ces (CPRI) are depending on (1) Domestic market cost prices of imports (CP), which is defined as function of the world market prices (WP) and which is depending on other than price impacts, so called "shifts"(shift), (2) Border protectionism regulations (quota, tariffs), (3) Share of foreign trade on the domestic demand (εptr), (4) Producer prices changes (PP) of the year before, (5) The other impacts except price are collected by "shifts", (6)Indirect impacts of production related subsidies to domestic farmers (sdive). The domestic retail prices can be formulated like a function as following:

$$CPRI_{j,r,t} = f\left\{\begin{matrix} CP_{j,r,t}\left[WP_{j,r,t}\left(sht^{WP}_{j,r,t}\right)\right], tariff_{j,r,t}, quota_{j,r,t}, \\ \varepsilon ptr_{j,r,t}(t-1);\ SUBP_t;\ PP_j(t-1);\ shift_{j,t} \end{matrix}\right\} \qquad (1)$$

Where *CPRI* : domestic retail price, *CP*:domestic market cost price of imported products, WP: world market prices (cif-prices), ΔP: producer prices change, tariff: tariff over and under quota, quota: import quota, *εptr*: price transmission elasticities, (*ΔCP* transmit to ΔRetail price), *SUBP*: subsidies, production related, *shift*:"shifts", other than price impacts, IIps: indirect impacts of production related subsidies, *r*: index trading region (MC, LT, RoW), *j*: index commodities, t: calendar year index (*1,…,T*), simulation period, *tb*: base year of simulation (*tb* ∉ t).

Moreover, PS is handling three groups of protagonists for the domestic Taiwan market of agricultural products. The retail consumer group is contrasting with the group of foreign producers (farmers, exporters) and domestic farmers. Additionally, the model handled in an indirect point of view, a fourth group of protagonists by the exports of Taiwan, the foreign retail consumers. The retail prices, the engine of PS, steers endogenously the domestic demand, the domestic production and imports of agricultural products. The usual theoretical dependencies with PS have following implication. If the retail prices (*CPRI*) decrease, the domestic demand and imports will increase, whereas the domestic production and producer prices will decrease. The harvested area will change depending on the yield development per hectare, which is exogenous determined. Besides this differentiated demand part, the PS model contains a differentiated supply part, which depends on the consumer decisions. This supply part is simulating a consistent "Output Generation" and "Input Use", so that the value added (farmers income) are carried out for each production activity.

The government, like an exogenous player, who is taking influence to market decision by a set of policy instruments which are taken into account by the model specification. These policy instruments can be roughly grouped into (1) market protectionism, (2) market intervention, (3) production related subsidies and (4) direct income transfers, which are closely neutral for production and mainly social oriented. The support instruments can be categorized into various “boxes” in response to WTO commitment of the AMS deduction.

The “market protectionism instruments” are quota regulations for imports, tariffs under and over quota, which are showing direct impacts to "market cost prices" (CP). In order to treat with model possible for different negotiated trade agreement under the WTO - regulation, PS is distinguishing foreign trade with "major trade countries" like the USA, China and the "Rest of the world", which are treated by the protectionism instruments. The “market intervention instruments” will not be used in the future so intensive like it in the past. Only on the rice market, there are some small interventions planned for the future. A fixed percentage of the imports are taken by the government to support some social decisions, like food help for less developed countries and so on. Also domestic rice production intervention to a fixed price should support the state requests like food for soldiers, etc. Therefore the model assumed that the intervention price and the intervention quantity would have a small impact on the retail prices by the difference to the retail prices without an intervention impact.

The "production related subsidies" usually have an effect to the productions decisions of the domestic farmers. Those subsidies will mainly increase the domestic production, which leads to an increase of the harvested area. Since the model is demand oriented (driven by retail prices), are these impacts treated only indirectly. The assumed increase in production only can be put on the market by decreasing the producer prices and will have an effect to the market cost prices. This indirect impact to retail prices (domestic market cost prices) will give incentives to decrease the retail prices of model, which leads finally to increase demand and soon. The "direct income transfers" is assumed that these subsidies are only social based. There is only an income impact assumed, which is treated without any effects to production (decoupled of production).

4.4. Simulation Algorithms for Trade Liberalization. PS assumes that the retail prices are depending on the world market price changes. First, the world market prices are corrected by all the negotiated protection instruments, like tariffs, quota, etc., which are not differentiated for the different trading regions (Mainland China and Rest of the World).

4.4.1. Trade under Protection and Trade Liberalization. For the imports under protection:

$$CP_{j,r,t} = \frac{IWMP_{j,r,t} \times \left(UQU^{protected}_{j,r,t} \times qta_{j,t} + OQU^{protected}_{j,r,t} \times tar_{j,t}\right)}{IMPO^{protected}_{j,r,t-1}} \tag{2}$$

Where

$$QUO^{protected}_{j,r,,t} = \frac{IMPO^{protected}_{j,r,t-1}}{\sum_r IMPO^{protected}_{j,r,t-1}} \times QUO_{j,t} \tag{3}$$

$$OQU^{protected}_{j,r,t} = IMPO^{protected}_{j,r,t-1} - QUO^{protected}_{j,r,t} \tag{4}$$

$$If: \quad OQU^{protected}_{j,r,t} \le 0; \quad then \quad UQU^{protected}_{j,r,t} = IMPO^{protected}_{j,r,t-1}, \text{ and } OQU^{protected}_{j,r,t} = 0$$

$$If: \quad OQU^{protected}_{j,r,t} > 0; \quad then \quad UQU^{protected}_{j,r,t} = QUO^{protected}_{j,r,t}$$

so that the following identity is fulfilled:

$$\sum_r IMPO^{protected}_{j,r,t-1} = \sum_r \left(UQU^{protected}_{j,r,t} + QUO^{protected}_{j,r,t}\right)$$

PS assumed that the quota is only given for the "protected" imports. For the liberalized imports the "regional" differentiated world market prices (cif-prices) are representing the market cost price:

$$CP_{j,LT,t} = IWMP_{j,LT,t} \tag{5}$$

These calculations are simultaneously done (equations (2) ~ (5)) for the last available year of the reference period (*tb*). This year is the starting year for the simulations, so that the "cost price" changes (*scp*) for the "regional" differentiation are given by:

$$scp_{j,r,t} = \frac{CP_{j,r,t}}{CP_{j,r,tb}} - 1 \tag{6}$$

The second supply market resource, the domestic production, is taken into account also in the retail price change calculation. The first supply resource, the foreign trade, represents the most important one for the WTO-accession and the demanded adaptation to the world standard of the policy protection instruments. The producer price change of previous year determines the retail price changes in the current year, too. Such a lagged effect makes meaning for example, one considers that the prices of the current year have influence on the production structure of the next year and therefore also on the quantitative market supply. The relative effect to the retail prices are calculated by PS as follows:

$$\Delta FPRI_{j,t-1} = FPRI_{j,t-1} - FPRI_{j,tb} \tag{7}$$

$$\Delta Q_{j,t} = GPRO_{j,tb} \times \varepsilon ppr_j \times \frac{\Delta FPRI_{j,t-1}}{FPRI_{j,tb}} \tag{8}$$

$$\Delta P_{j,t} = \frac{\Delta Q_{j,t}}{\varepsilon rpr_{j,j}} \times \frac{\left(CPRI_{j,tb} - PM_{j,tb}\right)}{DOMU_{j,tb}} \tag{9}$$

$$cpp_{j,t} = \frac{\Delta P_{j,t}}{CPRI_{j,tb} - PM_{j,tb}} \tag{10}$$

As a rule, the retail own price elasticities are negatively predefined; therefore a producer price reduction leads to a reduction of market supply, which leads to a raise of the retail prices. This lagged producer price change will affect the retail prices of the current year, combined with the other distinguished price based impacts.

4.4.2. Retail Price Changes. For the PS-simulations it is assumed that the market profit margins (in NT$) are not affected by the market cost prices. This profit margin is representing the distribution and processing costs inside Taiwan's domestic retail market. For the ex-post period, these profit margins are calculated by subtracting the distinguished weighted market cost prices from the retail prices. The retail price changes then given by:

$$PM_{j,tb} = \frac{DOMU_{j,tb} \times CPRI_{j,tb} - \sum_r CP_{j,r,tb} \times IMPO_{j,r,tb} - GPRO_{j,tb} \times FPRI_{j,tb}}{DOMU_{j,tb}} \tag{11}$$

$$\Delta CPRI_{j,t} = \left(CPRI_{j,tb} - PM_{j,tb}\right) \times \left(\sum_r \varepsilon ptr_{j,r,t} \times scp_{j,r,t} + corr_{j,t} + cpp_{j,t} \right) \tag{12}$$

The "retail prices" then given by:

$$CPRI_{j,t} = CPRI_{j,tb} + \Delta CPRI_{j,t} \tag{13}$$

Where *IWMP*: world market price (cif-price), *DOMU*: total domestic use, *GPRO*: gross domestic production, *CPRI*: domestic retail price, *FPRI*: producer prices, *PM*: domestic market profit margin, *CP*: domestic market cost price of imported products, *corr*: retail price correction, indirect effect, *cpr*: producer price correction, *scp*: market cost price changes (imports), *cpp*: market cost price changes (domestic production), *qta*: tariff under quota, administrative, *tar*: tariff over quota, *quo*: import quota, *uqu*: import quantities under quota, *oqu*: import quantities over quota, *sdive*: subsidies, diversification, *εrpr*: retail price elasticities (*ΔCPRI* → *ΔDOMU*), *εppr*: producer price elasticities (*ΔFPRI* → *ΔGPRO*), *εptr*: price transmission elasticities, (*ΔCP* → *ΔRetail*), *r*: index trading region or kind of import, *j*: index commodities, *t*: calendar year index (*1,…,T*) for simulation period, *tb*: base year of simulation (tb ∉ t).

4.4.3. Total Domestic Dem and Changes. The total domestic demand (*DOMU*) for agricultural products depends on an autonomous shift factor (exogenously estimated) and the retail price changes (endogenously calculated). The relative retail price changes are calculated using the own and cross elasticities, as following:

$$qcor_{j,t} = \sum_{l} \varepsilon rpr_{j,l} \times \frac{\Delta CPRI_{l,t}}{CPRI_{l,tb} - PM_{l,tb}} \tag{14}$$

This price change and the "shift" are justifying the total domestic demand, which is calculated using the following equation:

$$DOMU_{j,t} = DOMU_{j,tb} + DOMU_{j,tb} \times \left(shift_{DOMU,j,t} + qcor_{j,t}\right) \tag{15}$$

4.4.4. Foreign Trade Dependency. The import quantities (*IMPO*) of agricultural products depend in general on the same variables like the total domestic demand. The estimated long time "shifts" of domestic demand are the only movement of imports. As long as the world market prices has such a significant difference to the domestic producer prices like today PS will give an additional push for the imports.

$$IMPO_{r,j,t} = IMPO_{r,j,t} + \Delta IMPO_{r,j,t} \times \left(1 - \varepsilon str_{r,j,t}\right) \tag{16}$$

This additional correction should force the imported products and should work like substitution elasticity between the domestic and foreign production. Due to some great price differences between world market price and producer price of the previous years (small quotient "εstr") for some products, the additional import change is forcing the increase of imports. Due to an expected decrease of the related producer prices, this additional push will decrease over time and will take care that the prices develop towards each other.

The export quantities (*EXPO*) of agricultural products depend in general on the same variables like the total domestic demand, but in the opposite and are calculated using the following equations.

$$EXPO_{j,t} = EXPO_{j,tb} + EXPO_{j,tb} \times \left(\left[shift_{DOMU,j,t} + qcor_{j,t}\right] \times [-1]\right) \tag{17}$$

Equation (17) assumed that the foreign consumer does have a comparable benefit (utilization function) like the domestic consumers. On the other hand, the domestic producer will force the export of products, if the domestic demand will decrease and the opposite.

4.4.5. Domestic Agricultural Production. The physical domestic productions (*GPRO*) of agricultural products are calculated as a residual with the following definition equations:

$$sdo_{j,t} = \frac{\Delta DOMU_{j,t}}{DOMU_{j,t-1}} \tag{18}$$

$$MLOS_{j,t} = MLOS_{j,t-1} + MLOS_{j,t-1} \times sdo_{j,t} \tag{19}$$

$$TOST_{j,t} = TOST_{j,t-1} + TOST_{j,t-1} \times sdo_{j,t} \tag{20}$$

$$CSTO_{j,t} = TOST_{j,t} - FRST_{j,t-1} \tag{21}$$

$$GPRO_{j,t} = DOMU_{j,t} + MLOS_{j,t} + CSTO_{j,t} + EXPO_{j,t} - \sum_{r} IMPO_{r,j,t} \tag{22}$$

With this definition equation (22) a market clearing is ensured. The market clearing of agricultural are be based on the following resources and uses identity

$$FRST_{j,t} + IMPO_{j,t} + GPRO_{j,t} = DOMU_{j,t} + MLOS_{j,t} + EXPO_{j,t} + TOST_{j,t} \tag{23}$$

The producer prices (farm gate price) (*FPRI*) for agricultural products depend on the difference of the gross production of the current year and year before and the producer price elasticities. The elasticities are positive defined, constant over time and exogenous. An increase of production will lead to an increase of producer prices. The producer price change is calculated using the following equations.

$$\Delta GPRO_{j,t} = GPRO_{j,t} - GPRO_{j,t-1} \tag{24}$$

$$\Delta FPRI_{j,t} = \frac{\Delta GPRO_{j,t}}{\varepsilon ppr_j} \times \frac{FPRI_{j,t-1}}{GPRO_{j,t-1}} \tag{25}$$

$$FPRI_{j,t} = FPRI_{j,t-1} + \Delta FPRI_{j,t} \tag{26}$$

where *CPRI* : retail price, *FPRI*: producer price, *DOMU*: domestic use, *IMPO*: imports, physical, *EXPO*: exports, physical, *GPRO*: gross domestic production, *FRST*: stocks, *TOST*: total stocks, *MLOS*: domestic losses, εpp: producer price elasticities, *shift*: shift domestic use, autonomous, constant over time, *j*: index commodities, *l*: index commodities, *t*: calendar year index (1,…,T) of simulation period, *tb*: base year of simulation (tb $\notin$ t).

5. An Application of TWAPS on Trade Liberalization. In this paper, TWAPS was used to conduct the impact on agricultural sector from agricultural trade liberalization. The trade liberalization is defined as taking off all the border protection instruments, like tariffs and quota and free trading with other countries without trade barriers, but keeping current domestic protection policy as described in Table 2. The scenario for trade liberalization is setting all the tariff rates of the cropping and livestock products to be zero that means the tariff in Table 1 will be reduced to zero. The operating process with TWAPS is shown in Figures 6~9. Some simulation results in percentage changes are selected and presented in Table 4 to Table 8. Table 4 summarizes the simulation results of some macro economic variables in agricultural sector. As expected, simulation results reveal big loss in Taiwan agriculture sector after trade liberalization, compared with the figure in based year 2009, the production value of agricultural sector that includes crop and livestock will be sharply reduced by 36.20%, and the nominal GDP of crops and livestock will be reduce by 20.97% in 2013. The trade liberalization would make strong impact on agricultural sector.

Table 5~7 presents the impact on domestic production, production value, and farm gate price by commodities, respectively. The results show that domestic production, price, and production value would deeply drop for most of crops and livestock in response to trade liberalization. It can be seen from Table 4 that the most effect, as expected, is on those products with less competitiveness, such as beans and sugar. Rice is the most important crop in Taiwan. The trade liberalization would significantly decline rice production by 16.30% from 2009 (base year) to 2013, and decrease production value by 35.31% due to sharp increase of import and price deflation. By the end of 2013 the rice price will be 24.03% lower than the 2009 (base year) level. This implies that rice farmers will largely suffer from trade liberalization.

Most of other crops will suffer from trade liberalization with negative impacts on production value, price, and production amount. Only very few of local fruits planted in Taiwan with special tastes would increase production due to increasing demand from export. The local fruits, such as guavas and wax apple might increase production but their production values are expected to be reduced due to large decrease in prices. The whole livestock sector will have loss from trade liberalization with large drop in price. The decrease in production for live stock will bigger than the reduction in their prices. Consequently, the production value of livestock sector will be reduced deeply.

The simulation results also provide useful information for evaluating the impact of trade liberalization on agriculture sector. Results from scenarios of trade liberalization reveal that agricultural sector in Taiwan would have a significant loss as a result of trade liberalization. Especially, those products with less competitiveness would suffer more. In response to WTO accession, Taiwan government has launched lots of plans to change the agricultural structure to adapt to the trade liberalization and to comply with the WTO negotiations, but the agricultural reform is not good enough. Partly due to relative low world market price and partly due to the sharply increase of import which replaces domestic production, as a result, implementation of trade liberalization would cause seriously price deflation and decrease of agricultural production. Indeed, not all of agricultural activities are in bad situations; some of local fruits could gain from trade liberalization. The results suggest that policy reform have to be done to encourage farmers to switch their farming work into those production activities with better competitiveness.

6. Summary and Conclusions. TWAPS system is a policy-oriented and production activities-based system which is established based upon the characteristic of Taiwan agricultural sector and is developed for providing instantaneous decision-support for agricultural sector in Taiwan to solve various agricultural problems. The system now is used to predict the future developing trend of Taiwan agricultural economy, and to do policy simulation for policy adjustment in response to various agricultural problems.

This paper takes trade liberalization as a case to introduce the application of TWAPS on policy simulation. The simulation results provide policy implications to Council of Agriculture (COA) in Taiwan for future policy reform. TWAPS is also used to conduct forecasting by taking fluctuation of macro-economy, policy adjustment in respond to international trade, and changing strategy of domestic production-marketing into account to make short-term forecast for cropping and livestock sectors in Taiwan agricultural industry. In order to increase forecast performance, TWAPS has to be maintained and extended yearly to meet the reality of the real world. Currently, TWAPS provides Taiwan agricultural economic forecasts semiyearly to COA in Taiwan for their decision making of agricultural policy in the following year.

Besides, TWAPS also conducts scenario simulations to evaluate the impact on agricultural sector from occasional events like disease (Bird flu, SARS, Foot and mouth disease, Mad cow disease, etc.) and storm. A good decision support system has to be upgraded and extended continuously to comply with the changing global environment to raise its performance. The agricultural trade across the Straits is getting hot following with the ECFA signing in recent years. A developing sub-system of TWAPS for cross-strait agricultural trade is established for policy simulation to evaluate the potential impact on agricultural sector from increasing agricultural trade across the Straits. The maintenance and development work on TWAPS is still on going.

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Appendix.

TABLE 4. Simulation results of macro economy for trade liberalization

Variables	Change Rate (%)			
	year			
	2010	2011	2012	2013
Production value of crops and livestock	-16.39	-23.07	-29.70	-36.20
Nominal GDP of crops and livestock	-7.37	-12.04	-16.63	-20.97

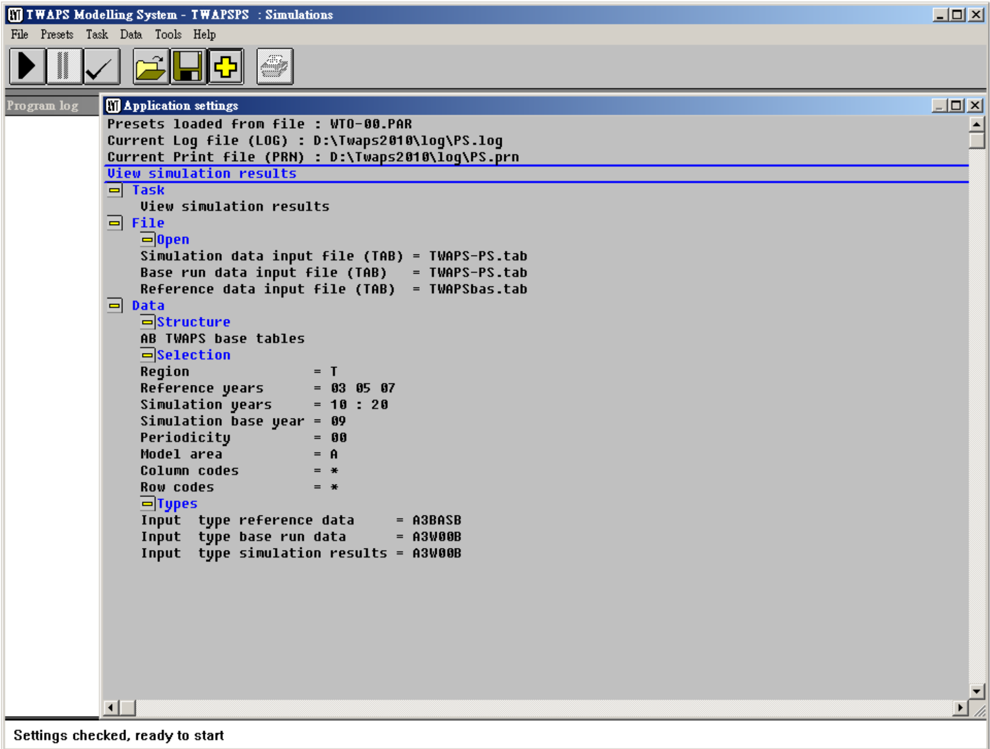

FIGURE 6. The TWAPS system

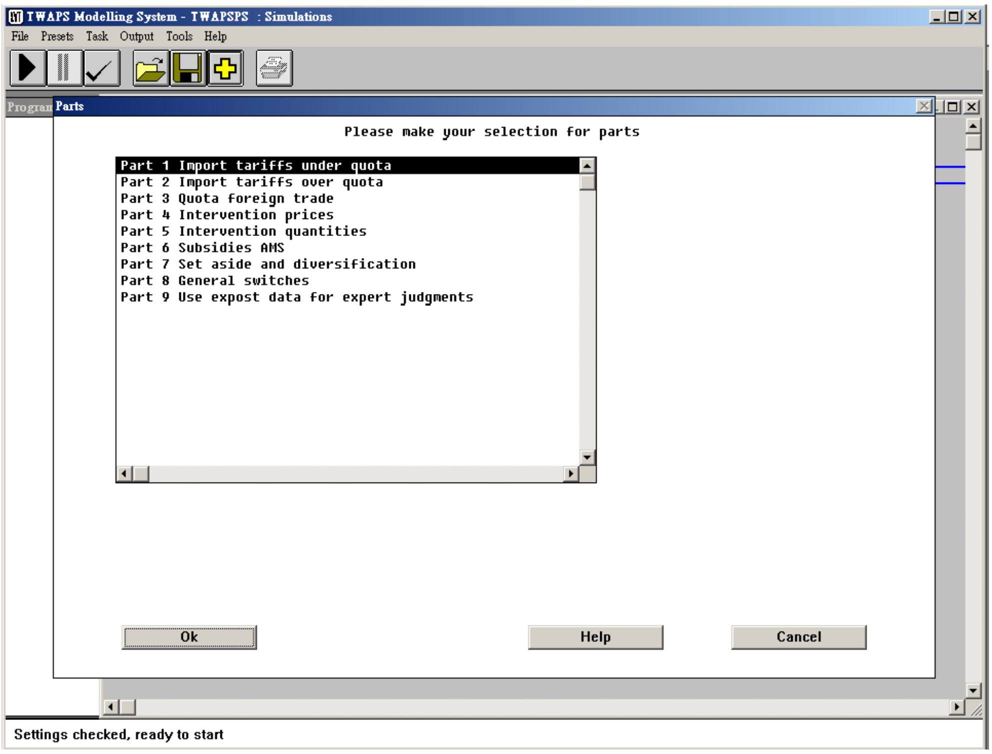

FIGURE 7. Setting scenarios for trade liberalization

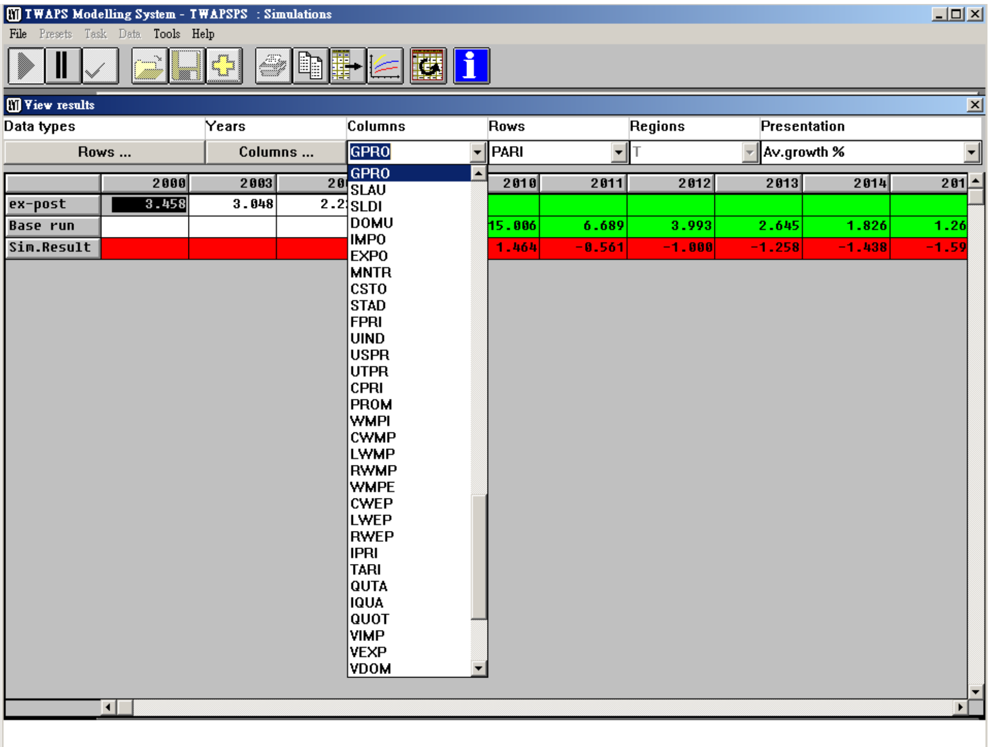

FIGURE 8. The simulation results for trade liberalization by variables

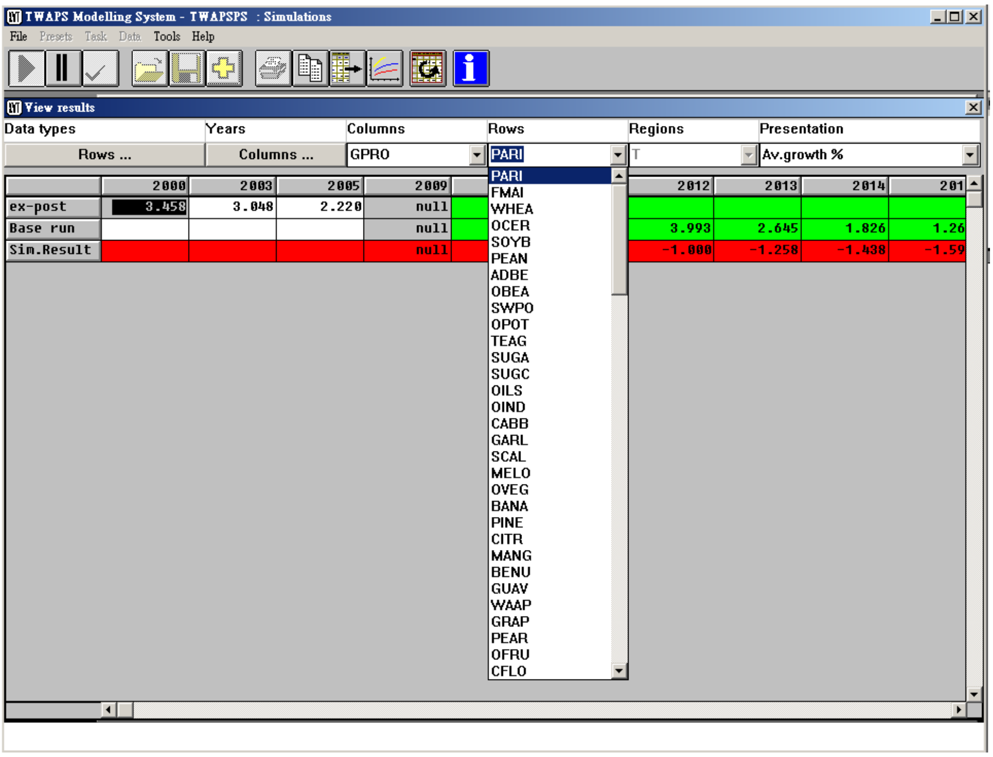

FIGURE 9. The simulation results for trade liberalization by products

TABLE 5. Impact on production by commodity for trade liberalization

Items	2010 201 Change (%)	1 Change (%)	2012 Change (%)	2013 Change (%)
Rice -7.5	9	-10.41	-13.59	-16.30
Peanut -25.83		-36.78	-36.14	-39.34
Adzuki beans	-21.54	-31.20	-41.73	-52.10
Tea 0	.52	0.53	0.55	0.58
Sugar -34.18		-43.63	-53.04	-41.09
Fresh sugar can	-2.67	-5.14	-7.59	-10.05
Oil seeds	-6.03	-8.32	-9.45	-12.99
Other crops	5.79	-5.90	-8.60	-10.13
Cabbages -1.3	9	-2.37 -	3.28	-4.17
Garlic bulbs	-14.90	-22.34	-30.00	-37.52
Onions 0	.17	0.22	0.29	0.41
Melons 0	.52	0.59	0.72	0.88
Other vegetables	-1.59	-2.29	-3.04	-3.81
Bananas -8.0	3	-11.80	-15.48	-19.16
Pineapples -14.59		-21.56	-28.49	-34.19
Oranges -3.7	9	-5.51	-7.22	-8.97
Mangos -3.8	6	-5.61	-7.55	-9.20
Betel nuts	-1.67	-2.43	-3.16	-3.85
Guavas 1	.09	0.45	-0.18	-0.83
Wax apples	0.15	0.14	0.13	0.11
Grapes -9.4	5	-15.10	-20.73	-26.38
Pears -9.6	9	-16.28	-21.70	-27.00
Other fruit	-6.11	-12.38	-18.51	-24.59
Cut flowers	0.29	0.41	0.52	0.61
Other flowers	0.30	0.26	0.21	0.14
Milk -14.81		-22.25	-29.93	-37.50
Beef -17.75		-28.62	-39.65	-49.71
Pork -19.20		-25.01	-30.91	-36.88
Chicken -2.9	2	-4.47	-6.26	-7.97
Color chicken	-2.46	-3.11	-3.76	-4.42
Other poultry	-0.03	0.01	0.05	0.11
Other eggs	0.09	0.10	0.11	0.13

Source: From TWAPS's simulations

TABLE 6. Impact on production value by commodity for trade liberalization

Items	2010 201 Change (%)	1 Change (%)	2012 Change (%)	2013 Change (%)
Rice -13.70		-19.60	-27.90	-35.31
Peanut -39.30		-53.06	-53.23	-57.14
Adzuki beans	-38.38	-54.11	-69.70	-83.92
Tea -6.1	4	-9.71	-13.09	-16.40
Sugar -23.32		-29.94	-35.60	-29.02
Fresh sugar cane	-12.84	-19.89	-26.36	-32.39
Oil seeds	-15.45	-21.81	-28.15	-34.42
Other crops	0.27	-15.26	-21.68	-26.57
Cabbages -9.0	9	-13.87	-18.47	-22.87
Garlic bulbs	-28.69	-41.98	-54.80	-66.75
Onions -6.5	3	-9.82	-13.08	-16.38
Melons -6.1	6	-9.47	-12.69	-15.83
Other vegetables	-9.54	-13.86	-18.02	-22.36
Bananas -18.86		-27.13	-35.15	-42.89
Pineapples -28.53		-41.04	-52.74	-62.34
Oranges -13.10		-18.84	-23.01	-29.58
Mangos -12.39		-18.30	-22.69	-29.54
Betel nuts	-9.74	-14.06	-18.47	-22.58
Guavas -6.8	2	-10.07	-16.25	-20.95
Wax apples	-6.36	-9.44	-12.44	-15.32
Grapes -20.37		-31.33	-42.15	-52.49
Pears -23.14		-33.74	-43.77	-53.19
Other fruit	-15.40	-27.65	-39.15	-49.92
Cut flowers	-7.28	-9.31	-13.83	-16.75
Other flowers	-6.63	-10.36	-14.07	-18.06
Total for cropping products	-13.55 -	19.88	-25.96	-32.10
Milk -22.48		-33.44	-44.04	-54.29
Beef -27.35		-43.95	-60.55	-76.41
Pork -28.65		-36.49	-47.05	-56.32
Chicken -7.3	4	-9.89	-15.14	-19.12
Color chicken	-6.61	-9.03	-10.09	-13.77
Total for livestock products	-21.06 -	28.32	-35.64	-42.93
Total -16.39		-23.07	-29.70	-36.20

Source: From TWAPS's simulations

TABLE 7. Impact on farm gate prices by commodity for trade liberalization

Items	2010 201 Change (%)	1 Change (%)	2012 Change (%)	2013 Change (%)
Rice -5.8	6	-10.70	-16.03	-24.03
Peanut -16.11		-23.87	-24.80	-28.03
Adzuki beans	-16.64	-24.47	-32.80	-40.75
Other beans	15.43	25.13	18.28	8.81
Sweet potatoes	-10.83	-10.74	-12.95	-15.57
Other potatoes	-4.37	-7.86	-12.27	-15.54
Tea -6.7	4	-11.57	-13.73	-17.20
Fresh sugar cane	4.10	8.86	12.80	8.05
Oil seeds	-10.58	-15.68	-20.80	-25.56
Other crops	-8.96	-12.95	-16.83	-20.80
Cabbages -6.6	2	-11.29	-13.61	-15.68
Garlic bulbs	-7.64	-11.54	-15.27	-19.08
Onions -13.13		-19.61	-26.09	-32.15
Melons -6.5	4	-11.19	-13.19	-16.58
Other vegetables	-6.59	-11.32	-13.37	-16.87
Bananas -7.8	1	-11.61	-15.53	-19.13
Pineapples -11.60		-14.92	-19.65	-24.31
Oranges -13.58		-20.05	-26.39	-32.73
Mangos -10.54		-13.62	-17.98	-22.27
Betel nuts	-8.10	-12.11	-16.07	-19.95
Guavas -7.9	3	-11.81	-15.64	-19.53
Wax apples	-7.85	-11.86	-15.85	-19.85
Grapes -6.5	5	-11.19	-13.17	-16.44
Pears -11.53		-15.50	-20.80	-26.13
Other fruit	-11.89	-17.72	-24.77	-29.11
Cut flowers	-8.60	-14.55	-20.32	-26.11
Other flowers	-7.69	-11.62	-15.23	-18.91
Milk -4.2	7	-6.76	-10.70	-12.07
Beef -6.5	8	-11.52	-13.61	-17.24
Pork -7.1	5	-11.12	-15.07	-18.79
Chicken -7.6	6	-10.51	-13.52	-16.51
Color chicken	-3.93	-5.98	-8.05	-11.56
Other poultry	-3.81	-5.62	-7.58	-10.59
Other eggs	-3.28	-4.98	-6.66	-8.35

Source: From TWAPS's simulations

TABLE 8. Impact on farming income by commodity for trade liberalization

Items	2010 201 Change (%)	1 Change (%)	2012 Change (%)	2013 Change (%)
Rice -10.33		-16.34	-28.29	-40.32
Peanut -23.38		-33.06	-36.71	-41.87
Adzuki beans	-41.83	-48.02	-77.61	-96.38
Sweet potatoes	-12.21	-11.63	-16.20	-19.20
Tea -7.8	8	-12.03	-16.03	-20.03
Oil seeds	19.42	19.66	18.70	4.01
Other crops	-8.53	-12.21	-15.89	-19.52
Cabbages -7.1	3	-10.78	-14.81	-17.25
Garlic bulbs	-10.44	-15.97	-21.30	-26.64
Onions -17.28		-27.92	-37.41	-46.96
Melons -7.2	9	-10.85	-14.43	-16.89
Other vegetables	-9.99	-15.06	-20.12	-25.16
Bananas -9.6	4	-14.06	-18.70	-23.17
Pineapples -13.85		-19.90	-25.63	-31.05
Oranges -15.28		-22.46	-29.28	-35.86
Mangos -16.87		-25.15	-33.60	-40.94
Betel nuts	-9.93	-14.47	-18.76	-22.69
Guavas -9.0	0	-13.03	-16.87	-20.49
Wax apples	-13.58	-20.00	-26.20	-32.17
Grapes -11.96		-16.35	-22.94	-28.08
Pears -11.40		-16.41	-23.92	-29.04
Other fruit	-22.66	-33.77	-45.15	-44.12
Total of cropping	-9.15	-13.78	-18.91	-23.89
Dairy cows	-9.85	-15.19	-18.06	-19.81
Heifers -9.5	3	-15.19	-20.76	-25.39
Male adult cattle	-8.17	-13.05	-17.95	-22.82
Hogs -7.7	2	-10.74	-13.67	-16.89
Laying hens	-1.19 -	1.51 -	2.32	-2.74
Fatten chicken	-3.68 -	5.80 -	7.84	-10.03
Color chicken	-3.49 -4.	10 -6	.81	-8.46
Fatten goat	-3.12 -	3.57 -	6.17	-7.72
Sows -11.46		-15.14	-20.82	-25.50
Raising Piglets	-9.70	-13.41	-16.99	-20.72
Total of livestock	-7.06	-11.47	-15.34	-20.46
Total -7.3	7	-12.04	-16.63	-20.97

Source: From TWAPS's simulations

TECHNICAL PROGRESS AND EFFICIENCY IMPROVEMENT ON PUBLIC HOSPITAL: EVIDENCE FROM GOVERNMENTAL INPUT-DRIVEN IDENTIFICATION

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ABSTRACT. *The technical progress and efficiency improvement with governmental financial inputs is of crucial importance to realize commonweal return for public hospitals in China. Based on the monthly data of provincial hospitals in Zhejiang Province during 2005-2008, the research finds out the classical Malquist index and linear regression estimation are unable to identify the technical progress and efficiency improvement due to governmental inputs. Therefore, the research applies an innovative path design approach to explore how governmental inputs contribute to the technical progress and technical progress. First of all, the governmental input pushes the productivity improvement in public hospitals mainly through technical progress rather than efficiency improvement. Secondly, governmental financial input contributes to technical progress of public hospital decisively. Thirdly, governmental inputs are not effective in promoting technical progress all the time, with periods 200505-200610 and 200807-200812 effective while period 200610-200807 ineffective.*

Keywords: Governmental Inputs; Public Hospital; Technical Progress; Efficiency Improvement; Sustainability

1. Introduction. Being confronted with the problems of commonweal deficiency and supporting the medical care service by drug for the medical service system in China, "The Guidelines on the Experimental Reform of Public Hospitals" is formulated on February 2nd 2010 jointly by Ministry of Health, National Development and Reform Commission, the State Commission Office for Public Sector Reform, Ministry of Finance, and Ministry of Human Resource and Social Security. The guidelines aim to realize the commonweal return for public hospitals with abolishing Drug Addition Policy, increasing Governmental Financial Compensation and setting Medicine Service Fee.

However, the income of Drug Addition accounts for almost 50 percents of total revenue in most public hospitals. The abolishment of Drug Addition will inevitably incur enormous output gap for public hospitals. A research report in 2007 by China Association of Pharmaceutical Commerce pointed out the minimum annual financial inputs to compensate the drug income for hospitals is 89.6 billion Yuan (Zeng and Lu, 2007), while the proportions of actual governmental financial input to total revenue in public hospitals are rather few. Take the provincial hospitals in Zhejiang Province for instance; the proportion is merely 3.82 percents during period 2005-2008 (Fig.1). Similarly, if the quantity of medicine service fee equals to the output gap caused by the abolishment of Drug Addition, the reform is doomed to fail in reducing the financial burden for patients. In this sense, scholars have come to unanimous agreement (Gu, 2010, Zhu, 2009, Shen 2010) that the only solution to fill the output gap is to improve output productivity of public hospitals rather than the plan of solely increase in governmental compensation or solely increase in medicine service fee.

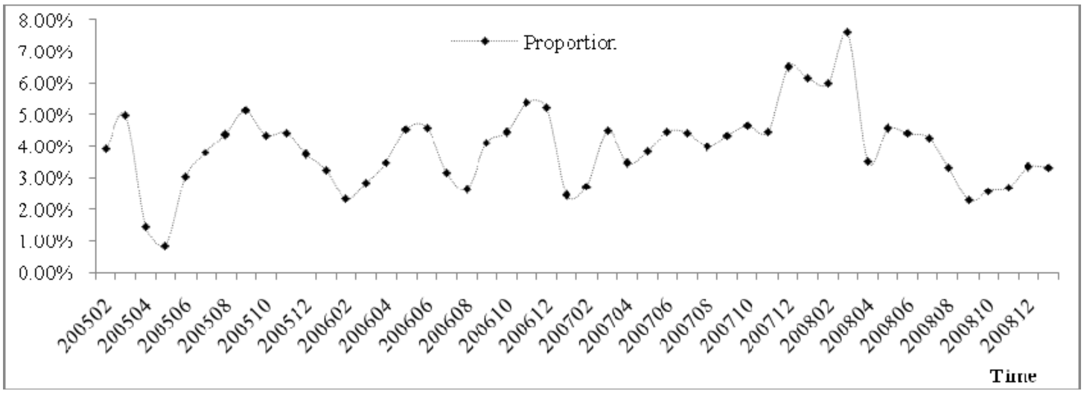

FIGURE 1. The proportion of governmental financial inputs to total revenue for provincial public hospitals in Zhejiang province during 200501-200812

The new financial compensation mechanism presented in 2010 puts more emphasis on encouraging compensation and special compensation. The encouraging compensation policies focus on the compensation on hospitals who realizes significant improvement in cost efficiency; the special compensation policies focus more on renewal of equipment and support in key built disciplines. The purpose of both compensations is to promote the technical progress and efficiency improvement for public hospitals. In order to realize the commonweal return for public hospitals with the comparatively few governmental financial inputs, the identification of technical progress and efficiency improvement with governmental inputs is of crucial importance to the reform of public hospitals in China.

The Data Envelope Analysis (DEA) is widely applied to evaluate the efficiency levels for hospitals. On the one hand, reviewing researches are developed based on considerable similar studies, for instance, Gattoufi et al. (2004), Neill et al. (2008), Cook and Seiford (2009). On the other hand, domestic studies on efficiency evaluation in China mainly implement the DEA approach to hospitals with different type or single given hospital for analysis (Pang, 2006; Liu, 2009). Besides the evaluation of efficiency level for hospital sector, Lin and Jin (2007) attempts to fit a linear regression model between hospital efficiency level and governmental input to indicate their relationship.

Malquist index approach is now widely applied to decompose the total factor productivity (TFP) into technical progress and efficiency improvement. The existing researches on TFP change involve the researches at national level (Zhang and Gui, 2008; Tao and Qi, 2010; Shao and Xu, 2010), at regional level, and at particular industry level (Zhao and Yuan, 2009; Li, 2010; Cai and Guo, 2009). Generally, the researches apply the Malquist index approach to data at different periods and different level to explore the major contribution to productivity change is technical progress or efficiency improvement. Taken the research on hospital efficiency for instance, Pang and Wang (2010) find out technical progress majorly contributes to the productivity change for comprehensive hospitals at large scale in China.

First of all, to identify technical progress and efficiency improvement, the four main approaches to the measurement of total factor productivity (TFP)-growth and its decomposition are (i) Solow's residual analysis, (ii) the Index Number Approach, (iii) Input-Output Analysis (IO), and (iv) Data Envelopment Analysis (DEA). Raa and Shestalova (2006) consolidate the four alternative measures in a common framework of Solow Residual model. Secondly, Xu (2010) puts forward a data-oriented path converged design based on Cobb-Douglas production model. Thirdly, following the research of Xu(2010) with the framework of Solow Residual approach, Zeng et al. (2010) further decompose the change of total factor productivity (TFP) into technical progress and efficiency improvement, and explore how the different path contributes to technical progress and efficiency improvement.

The existing studies on hospital efficiency mostly focus on sole analysis of efficiency level, while fail to present a combination investigation of governmental financial inputs, technical progress and efficiency improvement for public hospitals. Different from previous studies, the research puts its emphasis on exploration of how governmental financial inputs contributing to technical progress and efficiency improvement of public hospitals, which aims to provide strong decision making support in formulating investment plan for medical reform.

Taken the perspective of method, rather than classical Malquist index approach or linear regression model (Lin and Jin, 2007), the research applies an innovative path converged design to explore how governmental financial input impacts on the productivity for public hospitals, which can avoid the problems of model selection and mutual correlation between variables. Taken the perspective of research contents, the research attempts to answer the following questions with thethe monthly data of provincial hospitals in Zhejiang Province during 2005-2008. First, does governmental financial input promote the output productivity of public hospitals through technical progress or efficiency improvement? Second, does governmental financial input keep exerting effective role in promoting output productivity all the time?

2. Data Description. According to the Guidelines on the Experimental Reform of Public Hospitals, the governmental financial compensation is a primary source to support the hospital operation. The research tries to build the governmental financial input as an innovative path with nonparametric path-converged design for analysis.

The research takes 13 provincial hospitals in Zhejiang Province as a whole for empirical study; the number of each index for the whole system is obtained by the sum of each index for each provincial hospital. The investigated indexes in this research are: total output, capital input, labor input and the governmental input path. The monthly data for 13 provincial hospitals during period 200501-200812 is collected from "Hospital's Accounting Statement in Zhejiang Province", which is built by both Health Bureau of Zhejiang Province and its subordinate hospitals.

The specific indicators for each hospital are presented as follows. 1. The output index is denoted by the total revenue of hospital. 2. Since the number of doctors in each hospital shows no significant variance during period 2004-2008, and actual labor input in hospital is mostly embodied by medical service, the labor input index in this research is denoted by the total number of outpatients visits, emergency visits, and discharge inpatients. 3. The general capital input index in production function is measured by capital stock, however, the benchmark capital stock for is hard to be identically set because of their different history. The research employs the total fee of the purchase and maintainee expenses of fixed asset, and the cost for appropriative material (including hygiene materials, low cost of consumables and medical drugs) as a proxy of capital input. 4. The governmental financial input path is designed by the monthly data of governmental financial input for 13 provincial hospitals.

Since the labor inputs of inpatients attendees varies from the ones of discharged inpatients, the research unifies the two indexes into a generalized labor index by a discount coefficient, which is the dividing value of total revenue of discharged inpatients to total revenue of inpatients and emergency visits attendees. In this sense, the medical service visits (ten thousand time) = number of inpatients and emergency attendees (ten thousand time) + number of discharged inpatients × average inpatients days attendees(day) ×discount coefficient. Secondly, the designed approach for the governmental financial input path is presented by $fe(t) = \sum_{k=1}^{t} PE(k) \Big/ \sum_{i=1}^{n} PE(i)$, which satisfies $fe(n) = 1$.

3. Malquist Index of Governmental Financial Inputs.

3.1. Estimation Approach. Malquist index is firstly proposed by Malquist (1953), and then applied as productivity index by caves et al. (1982) and Fare et. al (1994). Farrell (1957) pointed out that, providing given technical structural features and factor inputs, the technical efficiency for a given period is given by the ratio of real output $Y^t(X^t)$ of DMU to the maximum output $\bar{Y}^t(X^t)$ of DMU with same inputs, which is defined by:

$$e^t = Y^t(X^t) \big/ \bar{Y}^t(X^t) \tag{1}$$

According to the original definition of technical efficiency, Tao and Qi (2010) present a detailed decomposition of the Malquist index on total factor productivity change (TFPC) into the following form:

$$M_0(x^{t+1}, y^{t+1}, x^t, y^t) = TFPC = \sqrt{\frac{D_0^{t+1}(x^{t+1}, y^{t+1})}{D_0^{t+1}(x^t, y^t)} \times \frac{D_0^t(x^{t+1}, y^{t+1})}{D_0^t(x^t, y^t)}}$$
$$= \frac{D_0^t(x^{t+1}, y^{t+1})}{D_0^t(x^t, y^t)} \times \left[\frac{D_0^t(x^{t+1}, y^{t+1})}{D_0^{t+1}(x^{t+1}, y^{t+1})} \times \frac{D_0^t(x^t, y^t)}{D_0^{t+1}(x^t, y)}\right]^{1/2} \quad (2)$$
$$= EFFCH \times TECH$$

where $D_0^t(x^t, y^t)$ and $D_0^t(x^{t+1}, y^{t+1})$ are the production distance functions at period t and $t+1$ with the production frontier at period t as the reference set; $D_0^{t+1}(x^{t+1}, y^{t+1})$, $D_0^{t+1}(x^t, y^t)$ are the production distance functions at period t and $t+1$ with the production frontier at period $t+1$ as the reference set.

If Malquist index is greater than 1, the total factor productivity at period $t+1$ realizes growth relative to period t; if Malquist index equals to 1, the total factor productivity at period $t+1$ keeps unchanged relative to period t. Simultaneously, equation (2) indicates that Malquist index can be decomposed into two parts: efficiency improvement index (EFFCH) and technical change index (TECH). EFFCH measures the relative efficiency change of each Decision Making Unit (DMU) from period t to period t+1, illustrating the moving degree of DMU to the optimal frontier, which can be taken as a catch-up effect. EFFCH>1 indicates efficiency improvement, otherwise, efficiency decline. TECH measures the relative change of production frontiers at period t and period $t+1$, TECH>1indicates technical progress, otherwise, technical decline.

3.2. Estimation Results. The study in this section focuses on the measurement of how governmental financial input impacts on technical progress index and efficiency improvement index under the framework of Malquist index. With reference to the idea of path identification, the research builds a benchmark model and a governmental input path model for comparison analysis. The benchmark Malquist model measures the technical progress index and efficiency improvement index with the output index being the total revenue, the input indexes being capital input and labor input. The path Malquist model is the measurement of technical progress and efficiency improvement when the governmental financial input path is added into benchmark model.

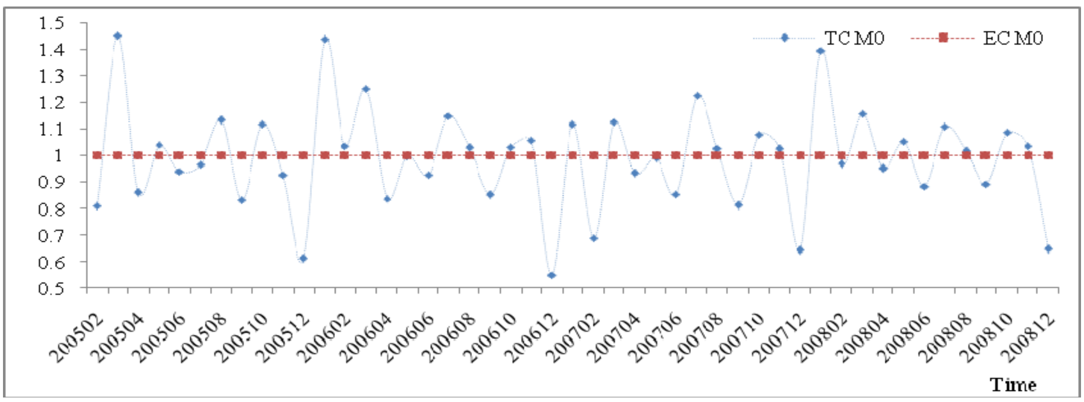

FIGURE 2. Technical progress and efficiency improvement indexes of benchmark Malquist model for provincial public hospitals in Zhejiang province during 200501-200812

Under the framework of Malquist index approach, TC M0 and EC M0 in Figure 2 refer to the average technical progress and efficiency improvement curves with benchmark Malquist model. And TC M1 and EC M1 in Figure 3 are the average technical progress and efficiency improvement curves with governmental financial input path Malquist model. 1. Technical progress curve fluctuates strongly than efficiency improvement curve and displays a feature of disorder. 2. The efficiency improvement curve surprisingly keeps unchanged and is the constant 1. 3. Few differences are observed between TC M0 and TC M1; the two curves display a feature of convergence during whole period. Both facts reveals that governmental financial inputs exerts no significant role on productivity promotion.

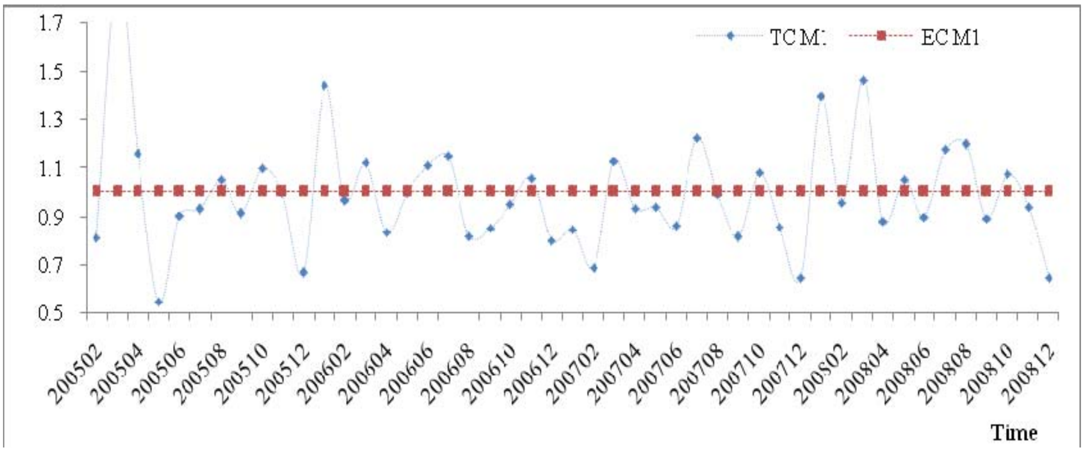

FIGURE 3. Technical progress and efficiency improvement indexes of governmental input path Malquist model for provincial public hospitals in Zhejiang province

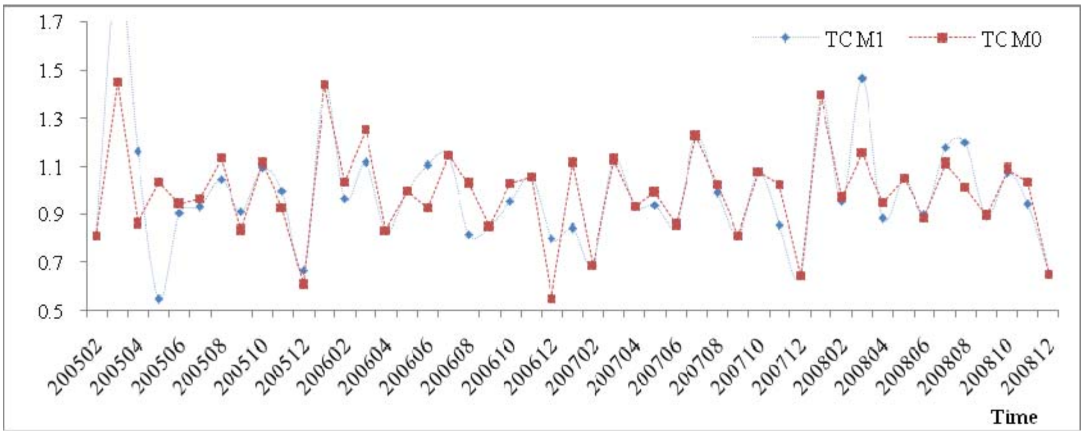

FIGURE 4. Technical progress index comparison with benchmark and path Malquist model for provincial public hospitals in Zhejiang province during 200501-200812

Table 1 is the decomposition of average Malqusit index under the framework of Malquist Index. The information in Table 1 is consistent with the results in Figures 2 -4. No significant difference can be observed between the average Malquist index of benchmark model and the one of path model at each period, which validates that the framework of

Malquist index approach fails to identify the role of governmental financial inputs on technical progress and efficiency improvement for public hospitals in China.

TABLE 1. Average Malquist index and its decomposition for provincial public hospitals in Zhejiang province during different periods

Benchmark Malquist Model				Governmental Input Path Malquist Model			
Period	EC M0	TC M0	TFPC M0	Period	EC M1	TC M1	TFPC M1
200501-200512	1.0000	0.9497	0.9497	200501-200512	1.0000	0.9506	0.9506
200601-200612	1.0000	0.9874	0.9874	200601-200612	1.0000	0.9926	0.9926
200701-200712	1.0000	0.9428	0.9428	200701-200712	1.0000	0.9017	0.9017
200801-200806	1.0000	1.0771	1.0771	200801-200806	1.0000	1.1037	1.1037
200807-200812	1.0000	0.9489	0.9489	200807-200812	1.0000	0.9676	0.9676

Note: EC M、TC M、TFPC M are the efficiency improvement index, technical progress index, and the total factor productivity change index respectively. The index at each period is the average index, which can be obtained by $\prod_{t=200501}^{200512} TC\,M0_t$, $\prod_{t=200501}^{200512} EC\,M0_t$.

4. Linear Regression Model of Governmental Financial Inputs. Substituting the governmental inputs by the proportion of health expenditure to national fiscal expenditure, Lin and Jin (2007) implement OLS regression approach between it and efficiency values of hospital at different levels to depict relationship between governmental inputs and hospital efficiency. Let the dependent variable be technical progress index of path Malqusit model (TC M1), the study in this section attempts to apply the linear regression to measure the role of governmental inputs on technical progress for public hospitals.

Case 1. Let the independent variable be the proportion of the total values of governmental financial input to total revenue of hospital for 13 provincial public hospitals in Zhejiang Province during period 200501-200812, the estimated OLS regression equation is as follows.

$$\begin{array}{c} y = 1.2183 - 5.7237x \\ (0.000) \quad (0.0366) \end{array} \qquad R^2 = 0.0935$$

Note: The value in bracket is concomitant probability.

Case 2. Let the independent variable be the total values of governmental financial input for 13 provincial public hospitals in Zhejiang Province during period 200501-200812, the estimated OLS regression equation is as follows.

$$\begin{array}{c} y = 1.1196 - 0.0046x \\ (0.000) \quad (0.1750) \end{array} \qquad R^2 = 0.0405$$

Case 3. Let the independent variable be the designed governmental financial input path, and obtain the OLS regression equation as follows.

$$\begin{array}{c} y = 1.0047 - 0.0286x \\ (0.000) \quad (0.8123) \end{array} \qquad R^2 = 0.0013$$

Observe the above equations and find out the following results. 1. The values of R^2 are very small, with the maximum value only 0.09 in case 1. 2. The concomitant probabilities of correlation coefficients for case 2 and case 3 both exceed 0.05. The above information explains the correlation coefficients and estimated equations of the three linear regression equations are insignificant. In this sense, general OLS regression approach can't identify the role of governmental financial inputs on technical progress for public hospitals statistically.

5. Path Converged Design of Governmental Financial Inputs Path.

5.1. Governmental Financial Inputs Path Design. The governmental financial input path converged design is established with reference of Xu's study (Xu, 2010). Specifically, the design is given with three steps as follows.

Step 1. Suppose the general underlying structure in equilibrium is presented by S_0 as follows :

$$Y(t) = A_0(t)K(t)^{\alpha} L(t)^{\beta} \tag{3}$$

where Y is the output, K is capital input, and L indicates labor input, α and β are the output elasticities of capital and labor, respectively, A_0 indicates the technical level.

Step 2. Benchmark Model S_1 :

$$Y_1(t) = K(t)^{\alpha(t)} L(t)^{\beta(t)} \tag{4}$$

S_1, a time-varying production function, is employed to estimate the underlying structure S_0. $\alpha(t)$ and $\beta(t)$ are the time-varying output elasticities of capital and labor at time *t*.

Step 3. Path Model S_2

$$Y_2(t) = FE(t)^{\lambda(t)} K(t)^{\alpha(t)} L(t)^{\beta(t)} \tag{5}$$

where $\lambda(t)$ is the time-varying elasticity of path FE.

Path model S_2 is obtained when the governmental financial input path FE enters into the initial equilibrium system S_0. The change effect due to the governmental financial input path can be measured by the comparison between benchmark model S_1 and path model S_2.

Path model S_2 aims to measure the change effect of governmental financial path when path FE enters into the initial equilibrium system S_0. And $\lambda(t)$ is the time-varying elasticity of Path FE.

According to the research of Xu (2010), along with the path variation of $FE(t)$, the research can realize the identification of the underlying production structure through the relative differences between S_1 and S_2.

Equations (4) and (5) can be estimated by the nonparametric local polynomial regression method, and the total factor productivities of benchmark model(4) and path model (5) can be defined respectively as follows (Zeng et al. , 2010).

$$A_1(t,t_0) = K(t)^{\alpha_1 t-\alpha_1 t_0} L(t)^{\beta_1 t-\beta_1 t_0} \left(K(t)L(t)\right)^{o(t)} \tag{6}$$

$$A_2(t,t_0) = FE(t)^{\lambda_1 t-\lambda_1 t_0} K(t)^{\alpha_1 t-\alpha_1 t_0} L(t)^{\beta_1 t-\beta_1 t_0} \left(FE(t)K(t)L(t)\right)^{o(t)} \tag{7}$$

With reference to the measurement of Malquist index, the technical progress index of TFPC from period t_0 to period t for benchmark model is given as follows:

$$TC_0 = \left(K(t)^{\alpha_1 t-\alpha_1 t_0} L(t)^{\beta_1 t-\beta_1 t_0} K(t_0)^{\alpha_1 t-\alpha_1 t_0} L(t_0)^{\beta_1 t-\beta_1 t_0}\right)^{1/2} \tag{8}$$

The technical progress index of TFPC from period t_0 to period t for path model is given as follows:

$$TC_1 = \left(FE(t)^{\lambda_1 t - \lambda_1 t_0} K(t)^{\alpha_1 t - \alpha_1 t_0} L(t)^{\beta_1 t - \beta_1 t_0} FE(t_0)^{\lambda_1 t - \lambda_1 t_0} K(t_0)^{\alpha_1 t - \alpha_1 t_0} L(t_0)^{\beta_1 t - \beta_1 t_0} \right)^{1/2} \quad (9)$$

TC, shown as a geometric average, measures the technical change from period t_0 to period t. If TC <1, technical level declines; TC =1, technical level keeps unchanged; TC > 1, technical level upgrades.

Similarly, according to the definition of relative efficiency, the efficiency improvement index of TFPC from period t_0 to period t for benchmark model is defined as follows:

$$EC_0 = \left(K(t)L(t)\right)^{o(t)} / \left(K(t_0)L(t_0)\right)^{o(t_0)} \quad (10)$$

The efficiency improvement index of TFPC from period t_0 to period t for path model is:

$$EC_1 = \left(FE(t)K(t)L(t)\right)^{o(t)} / \left(FE(t_0)K(t_0)L(t_0)\right)^{o(t_0)} \quad (11)$$

EC > 1, EC = 1 and EC < 1 refer to improved efficiency, unchanged efficiency, and declined efficiency respectively.

Considering the relativity of path converged design, the technical progress index and efficiency improvement index due to governmental financial input path FE are presented as follows:

$$TC_1 / TC_0 \quad (12)$$

$$EC_1 / EC_0 \quad (13)$$

If $TC_1 / TC_0 \geq 1$, governmental financial input promotes technical progress; otherwise, $TC_1 / TC_0 < 1$, governmental financial input does not contribute to technical progress

The research uses equation (14) to identify the technical progress due to governmental financial input in public hospitals, which is extracted from equation (9).

$$\Delta PTC = \left(FE(t)^{\lambda_1 t - \lambda_1 t_0} FE(t_0)^{\lambda_1 t - \lambda_1 t_0} \right)^{1/2} \quad (14)$$

The parameter λ_1 in equation (14) synthesizes the information of capital input K and Labor input L, it reflects the integrated information on how governmental financial input impacts on the production system. If $\Delta PTC > 1$, the cumulative effect of governmental input increases at period t relative to period t_0 on technical progress for public hospital, it reflects sustainability of governmental input in promoting output productivity for public hospitals.. Otherwise, $\Delta PTC < 1$, the cumulative effect of governmental input decreases at period t relative to period t_0 on technical progress for public hospital, and it reflects the failure in sustainability of governmental input in promoting output productivity for public hospitals.

If $TC_1 > TC_0$, and $\Delta PTC \geq 1$, the governmental financial input promotes technical progress and it is sustainable in productivity change for public hospital; if $TC_1 > TC_0$, and $\Delta PTC < 1$, the governmental financial input promotes technical progress, however it is unsustainable in productivity change for public hospital.

On the other hand, the efficiency improvement and its sustainability due to governmental financial input can be obtained similarly.

5.2. Identification Results of Governmental Input Path. Under the framework of path converged design, the research attempts to identify how governmental financial input contributes to technical progress and efficiency improvement for public hospitals through comparison the technical progress and efficiency improvement curves of benchmark model and the ones of path model.

Under the framework of path converged design, TCP0 and ECP0 in Figure 5 are the technical progress and efficiency improvement curves of benchmark model for 13 provincial public hospitals in Zhejiang Province during period 200501-200812. Firstly, Figure 5 displays that ECP0 curve is always higher than TCP0 curve, implying the change of total factor productivity is mainly due to efficiency improvement rather than technical progress during the whole investigated period. Secondly, on the one hand, the value of ECP0 is greater than 1 during almost the whole period, indicating the efficiency improvement for public hospitals; on the other hand, the value of TCP0 exceeds 1 only after April 2008, indicating the decline in technical level has handicaps the TFP growth during period 200501-200804.

TCP1 and ECP1 in Figure 6 are the technical progress and efficiency improvement curves of governmental input path model for 13 provincial public hospitals in Zhejiang Province during period 200501-200812. It is obvious that the accession of governmental input path to initial production system brings about distinct changes in both efficiency improvement and technical progress curves. Specifically, ECP1 fluctuates slightly and keeps at the efficient level of 1.1 during all period. Instead, TCP1 fluctuates strongly during all period and it can be into three stages.

First, TCP1 is higher than ECP1 and reaches a summit during period 200505-200609, indicating the effectiveness of governmental financial investment at this period. Second, TCP1 is lower than ECP1 during period 200610-200806 and suffers a trough at 200709. The governmental financial input is inadequate and exerts technical decline in this period, and the technical decline disappointingly brings about overall productivity decline despite of slight efficiency improvement. Third, TCP1 exceeds ECP1 and exerting an increasing trend during period 200707-200812. The fact indicates the governmental financial input finally brings about technical progress and it contributes as the major part of productivity change for public hospitals during final investigated period.

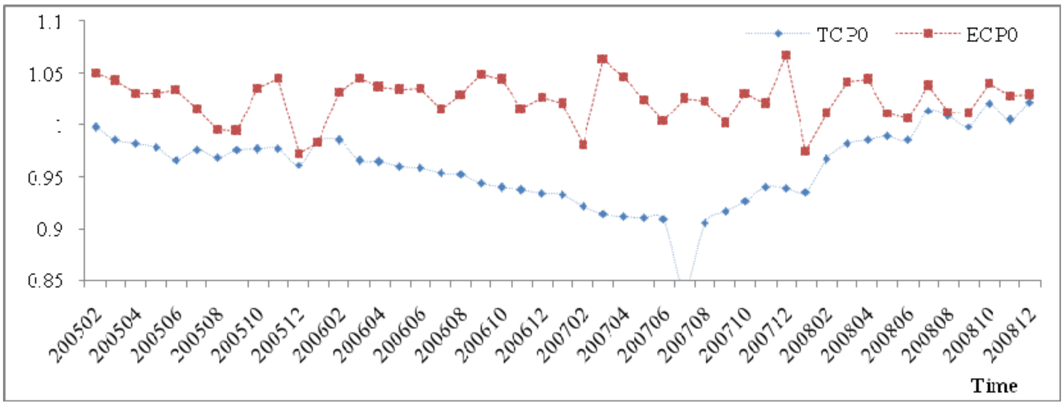

FIGURE 5. Technical progress and efficiency improvement indexes of benchmark model under path converged design for provincial public hospitals

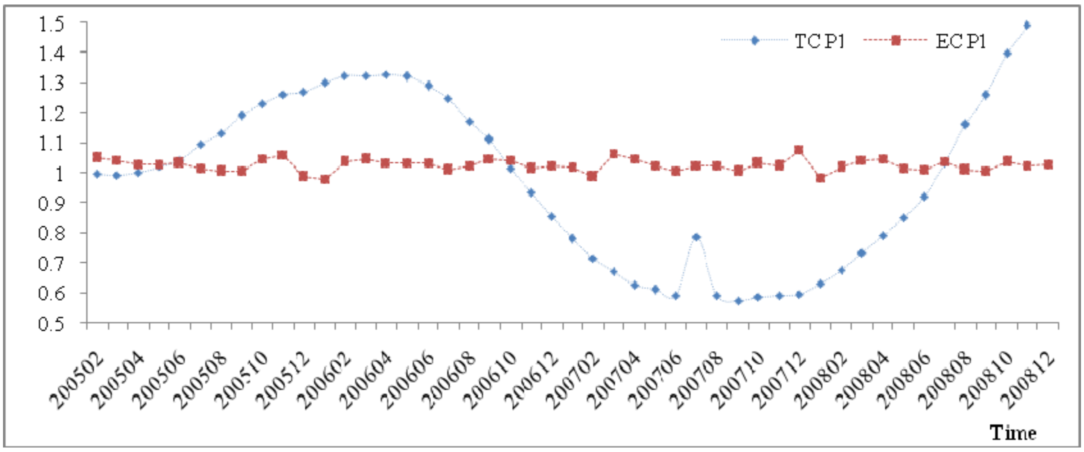

FIGURE 6. Technical progress and efficiency improvement indexes of governmental input path model under path converged design for provincial public hospitals

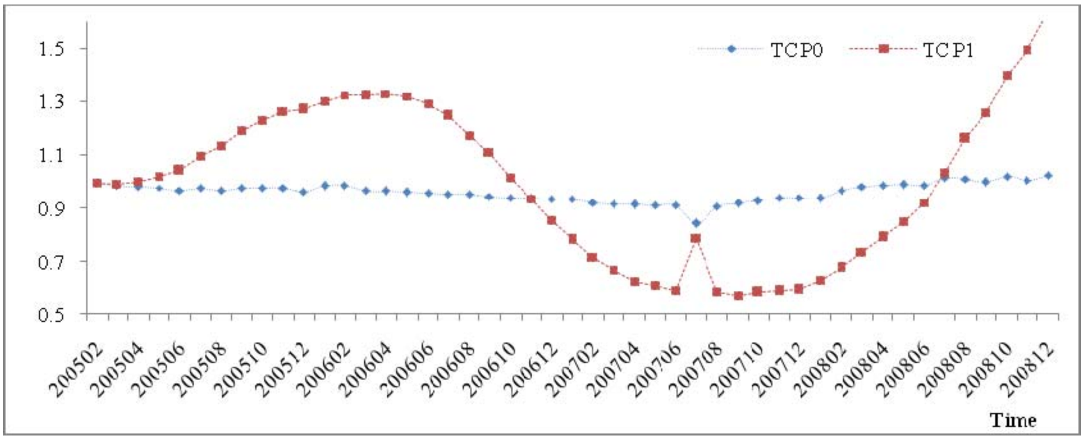

FIGURE 7. Technical progress comparison with benchmark and governmental path model under path converged design for provincial public hospitals

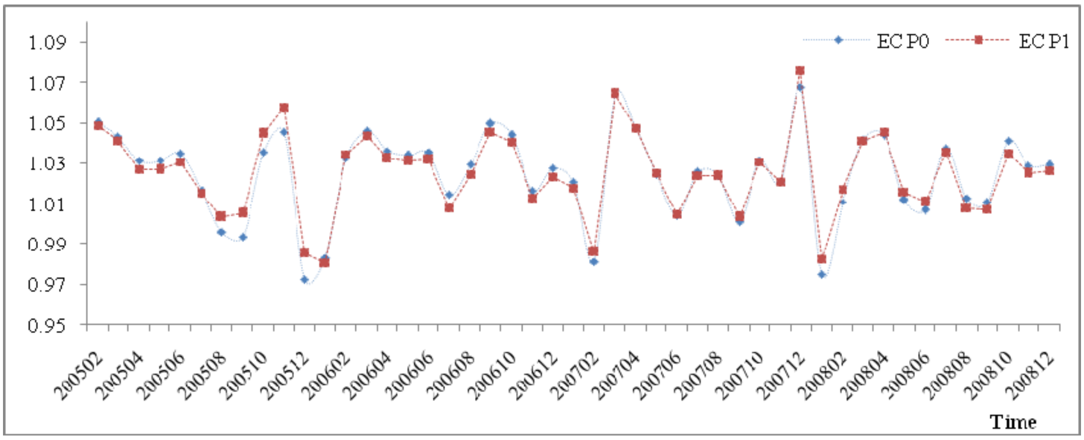

FIGURE 8. Efficiency improvement comparison with benchmark and governmental path model under path converged design for provincial public hospitals

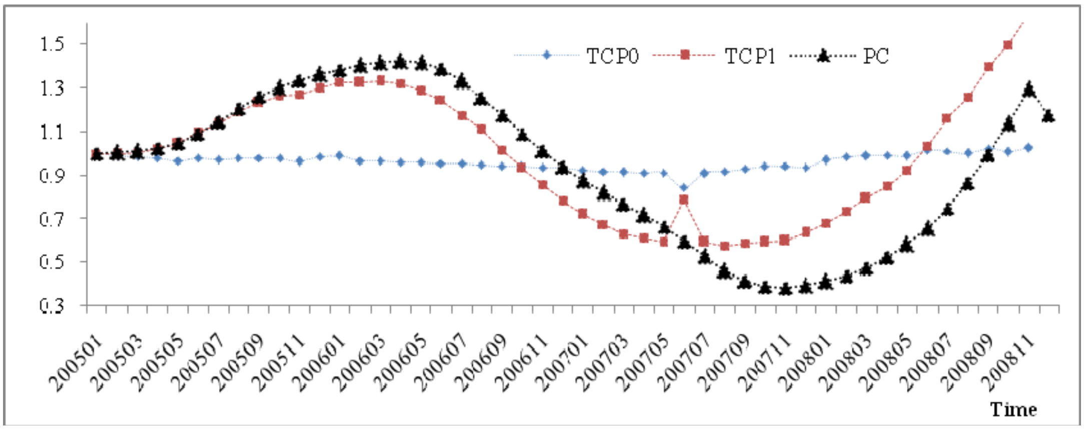

FIGURE 9. Technical progress explained by governmental financial input path for provincial public hospitals in Zhejiang province during 200501-200812

The comparison figures of technical progress indexes (Figure7) and efficiency improvement indexes (Figure 8) present information as follows. On the one hand, the technical progress index of path model fluctuates more obviously than the one of benchmark model when the governmental input path is introduced. More specifically, 1. TC P1 is larger than 1and it is higher than TC P0 during 200505-200610, implying governmental input directly promotes the technical progress for public hospitals. 2. TC P1 is less than 1 and it is lower than TC P0 during 200611-200806, implying the inadequate input of governmental financial input in bringing about technical progress for public hospitals. 3. TCP1 finally exceeds TC P0 during 200807-200812, indicating governmental financial input finally breaks through the initial bottlenecks and brings about technical progress for public hospitals. On the other hand, EC P0 is very close to EC P1 during almost all period, implying the governmental input has no significant impact on efficiency improvement for public hospitals.

5.3. Sustainable Analysis of Technical Progress. The conventional idea to explore the reason on why governmental input pushes technical progress is to investigate the proportion of governmental financial inputs to total revenue for provincial public hospitals in Zhejiang Province (Figure 1). Figure 1 shows that the proportion fluctuates constantly and the peak firstly increases (period 200505-200803) and then declines (period 200804-200812). Combining the stage decomposition in Figure 7, the average proportion during 200611-200806 is 4.58 percents, which is higher than the 3.86 and 2.92 percents for periods 200505-200610 and 200807-200812 respectively. Intuitively, the more of governmental financial input is, more significant the technical progress will be. However, Figure 7 denies the intuitive fact and reflects a totally different technical progress trend.

The simple input-output proportion information fails to integrate the matching information of capital K and Labor L in the production system and will induce error in judgment. In fact, equation (14) reflects the comprehensive information of governmental financial input path in production system because it integrates not only the change of governmental financial path, but also the impact of other input factors in output elasticities. The PC curve in Figure 9, estimated by equation (14), shows that the difference between technical progress curve of benchmark model and the one of path model can be explained by the governmental financial input path. Figure 9 shows that $TC_1 < TC_0$ and $\Delta PTC < 1$ during period 200611-200806, indicating the governmental input is both ineffective and unsustainable in promoting technical progress for public hospitals. While $TC_1 > TC_0$ and $\Delta PTC > 1$ during periods 200505-200610 and 200807-200812, indicating the governmental input in these periods is both effective and sustainable in promoting technical progress for public hospitals.

5.4. Comprehensive Analysis of governmental Input Path Model. Table 2 presents the decomposition of average TFPC index under path converged design approach. It validates the path converged design framework can clearly identify the contribution of governmental financial input to technical progress and efficiency improvement for public hospitals.

TABLE 2. Average TFPC index and its decomposition under path converged design for provincial public hospitals in Zhejiang province during different periods

Benchmark Measurement				Governmental Input Path Measurement				
Periods	EC P0	TC P0	TFPC P0	Periods	EC P1	TC P1	TFPC P1	$\Delta\bar{P}TC$
200505-200610	1.0232	0.9645	0.9869	200505-200610	1.0236	1.1829	1.2108	1.2731
200611-200806	1.0220	0.9340	0.9545	200611-200806	1.0233	0.6960	0.7123	0.5723
200807-200812	1.0278	1.0090	1.0371	200807-200812	1.0245	1.2965	1.3283	1.0168

Note: EC, TC, and TFPC are the efficiency improvement index, technical progress index, and the total factor productivity change index under path converged design framework respectively. The index at each period is the average index, which can be obtained by $(\prod_{t=1}^{n} TC\,P0_t)^{1/n}$, $(\prod_{t=1}^{n} EC\,P0_t)^{1/n}$. $\Delta\bar{P}TC$ is the part of technical progress that explained by governmental financial input path, which is obtained by $(\prod_{t=1}^{n} \Delta PTC_t)^{1/n}$.

(1) The governmental financial input is effective in promoting technical progress and insignificant in promoting efficiency improvement during periods 2005-2006 and 200807-200812. Fortunately, the technical progress is remarkable enough to ultimately pushes the significant promotion in productivity for provincial hospitals in Zhejiang Province. Take period 200807-200812 for instance, the governmental input path has climbed the technical progress from 0.9 percents with benchmark model to 29.6 percents with path model, and hence realized a productivity promotion of 32.8 percents.

(2) The governmental financial input is inadequate and exerts technical decline in period 200611-200806. The governmental input path in this period has disappointingly aggravated the technical decline from 6.6 percents with benchmark model to 30.4 percents with path model. The technical decline brings about overall productivity decline despite of slight efficiency improvement.

(3) The sustainable indexes of productivity for hospitals explained by governmental financial input path are 12 .7.3, 57 .2, and 101.7 percents respectively for periods 200505-200610, 200807-200812, and 200807-200812 respectively. The different

effectiveness information of governmental financial input during different periods indicates the unsustainable reality of productivity because of inadequate governmental inputs in period 200807-200812.

6. Conclusion. Governmental financial inputs is the basis to realize commonweal return for public hospitals in China, and the technical progress and efficiency improvement is of crucial importance to realize commonweal return for public hospitals. Based on the monthly data of provincial hospitals in Zhejiang Province during 2005-2008, the research aims to identify the technical progress and efficiency improvement due to governmental inputs, and furthermore explore the relative effectiveness of governmental inputs during different periods.

First of all, the research measures how governmental financial input impacts on productivity change under the framework of Malquist index. Specifically, the research builds a governmental input path Malquist model and a benchmark Malquist model without path for comparison and finds out the following results. On the one hand, no significant difference while convergence is observed between Malquist benchmark technical progress (TC M0) and Malquist path technical progress (TC M1) during all investigated period. On the other hand, great consistence of 1 is observed between Malquist benchmark efficiency improvement (EC M0) and Malquist path efficiency improvement (EC M1) during all investigated period. Therefore, the research framework of Malquist index fails to identify the impacts of governmental financial inputs on technical progress and efficiency improvement for public hospitals in China.

Secondly, let the dependent variable be technical progress index of path Malqusit model (TC M1), the independent variable be the proportion of the total values of governmental financial input to total revenue, the total values of governmental financial input, and the designed governmental financial input path respectively for OLS regression, the research finds out that the correlation coefficients and estimated equations of the three linear regression equations are insignificant. In this sense, general OLS regression approach can't identify the role of governmental financial inputs on technical progress for public hospitals statistically.

Finally, based on the framework of path converged design (Xu, 2010) and its further decomposition of productivity change with Cobb-Douglas production model (Zeng et al., 2010), the research explores how governmental financial input path contributes to the technical progress and efficiency improvement for public hospitals, and further realizes the identification of relative effectiveness of governmental financial input in different periods. The main findings are presented as follows.

(1) The governmental financial input is effective in periods 2005-2006 and 200807-200812. The path technical progress index (TC P1) and benchmark technical progress index (TC P0) are both greater than 1 during both periods. The fact illustrates the governmental financial inputs significantly promotes the technical progress, and ultimately pushes the significant promotion in productivity for provincial hospitals in Zhejiang Province. Take period 200807-200812 for instance, the governmental input path has climbed the technical progress from 0.9 percents with benchmark model to 29.6 percents with path model, and hence realized a productivity promotion of 32.8 percents.

(2) The governmental financial input is inadequate and exerts technical decline in period 200611-200806. The governmental input path in this period has disappointingly aggravated the technical decline from 6.6 percents with benchmark model to 30.4 percents with path model. The technical decline brings about overall productivity decline despite of slight efficiency improvement.

(3) The sustainable indexes of productivity for hospitals with governmental financial input path are 12.7.3, 57.2, and 101.7 percents respectively for periods 200505-200610, 200807-200812 and 200807-200812 respectively, which indicate the unsustainable reality of productivity because of inadequate governmental inputs in period 200807-200812.

The research clearly identifies the historical experiences on sustainable technical progress due to governmental financial inputs for public hospitals, and provides strong decision support in formulating governmental financial compensation policies to realize commonweal return for public hospitals. However, under the framework of path converged design, the problems of how to promote the governmental input from ineffective to effective in pushing technical progress, how to realize the efficiency improvement with governmental financial input remain to be further explored.

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ASSESSING THE ABILITY OF MANAGING SAFETY RISK IN CONSTRUCTION PROJECTS

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ABSTRACT. *This study investigates the evaluation criteria to manage safety risk for construction contractor through literature reviews. based on the identified criteria, a hierarchical structure of five dimensions and thirty criteria. A systematic approach to building consistent fuzzy preference relations was employed to assess the relative importance rates and rankings of these criteria. Among the identified dimensions, "policies of safety management" was considered the most important dimension to offset the safety performance in a construction project.*

Keywords: Assessing; Ability of Safety Management; Construction Project; Consistent Fuzzy Preference Relations

1. Introduction. In recent decade, complexity and scale of construction projects have enormously increased, which amplified risk exposures no matter on the project performance of finance, quality, schedule and safety. Construction safety had attracted much attention due to its regular poor performance on labor fatalities and injuries. Construction industry in the United State has the worst fatality record in 2008. The number of labor fatalities in construction industry is 969 which accounts for 22% of all occupational fatalities according to the Census of Fatal Occupational Injuries, Bureau of Labor Statistics (2009) although construction workers account for only 5~6% of the industrial workers. In Taiwan, according to the statistical information from Taipei Bureau of Labor the occupational fatalities in Taipei's construction projects from 2001 to 2006 are 121 which accounts for 77.6% of all occupational fatalities. In 2007 the occupational fatalities in Taiwan's construction industry are 22 which accounts for 78.6% of all occupational fatalities. Construction industry is, therefore, attributed to the highest safety-risk sectors.

Risk base project management has been a popular issue in many practical construction projects and associated academic studies. Most of past implementations and research attempts put much attention on the risk assessment or management of project success. Some attempts worked for strategies and approaches of construction safety, but most of them focused on the investigations of safety technology as well as safety management policy. Fewer attempts put efforts on facilitating and improving safety risk assessments to assist contractors in improving and enhancing their safety risk management, or help owners to evaluate contractors' ability of safety risk management for further bidding decision and project management. However, safety responsibilities have rested on the shoulders of construction contractors. Contractors are the pivotal party to perform safety measures in job sites. The purpose of this study is to establish an efficient and systematic model to evaluate contractors' ability to organize and manage safety risks for construction projects.

2. Literature Review. An effective safety program could lead management levels to build a safer operating process and environment for workers to perform their jobs to prevent from injuries and fatalities. Proactive safety program is the best strategy to enhance the safety performance of construction job sites (Rowlinson, 2003; Tam et al., 2004). An effective safety program would encourage participated management staffs and workers to cooperate during project executions and implant safety awareness and knowledge to the project organization (Findley et al., 2004). Construction Industry Institute (CII) conducted a series of studies with regard to owner's role on construction safety, zero accident technique and construction safety self-assessment process (Liska et al., 1993a, 1993b; Hinze, 2002; Hinze and Huang, 2003). The focus of CII is to implement a comprehensive safety program to improve contractors' safety performance on construction projects. In order to efficiently and effectively improve contractor's ability and performance on safety risk management, the relative importance of the items in the construction safety program should be well investigated for better safety improvement. However, the relative importance of safety performance criteria has not been well studied in past research attempts.

When contractor's safety performance on construction projects was evaluated and reviewed by CII, four indicators was frequently used, which include experience modification rates (EMR), recordable incident rate (RIR), lost workday incident rate (LWIR), and workers' compensation claims frequency indicator (WCCFI) (de la Garza et al. 1998).

The relationship between safety performances and safety management intensities of construction projects in Australia were investigated. Six safety management indices (SMI) were investigated to evaluate safety performance and safety management intensity (Mohamed, 1999). Although the findings in this study presented that no linear relationship between safety performance index (SPI) and SMI, and less significant differences was found for the mean safety performance of performance variables among various groups on safety management intensity of construction projects, sample size suggested by the author is not enough to convince those findings.

Seven SMI were proposed to evaluate and deliver safety assurances of construction projects.(Fang et al., 2004) The seven indices include twenty five measured items from project nature, historic factors, organizational structure, management measures, individual involvement, economic investment and labor-management relations. For specialty contractors of roofing contractors and mechanical contractors, eight factors were identified with possible significant impact on construction safety record, which are turnover rate, public or private project, safety incentives, worker training, role of contractor association, drug testing, and safety inspection (Hinze and Gambatese, 2003). More factors including comprehensive safety policies, safety inductions, accident investigations, in-house safety rules, control of subcontractors, selection of employees, personal protection programs, emergency preparedness planning, safety related promotions, safety auditing, safety record keeping, and job hazard analysis were suggested to evaluate safety performance of construction projects.

3. Hierarchical Structure of Safety Risk Management Evaluation. Through the review of past attempts, the construction safety factors applied to this study were screened and synthesized based on Taiwan's construction environment. Twenty nine construction safety evaluation factors were categorized to five dimensions which include experiences of safety management, organizations of safety management, model of safety management, investment of safety management, safety management policy. The followings are the definition of five dimensions and the associated safety factors of each defined dimension, and its hierarchical structure as Figure 1.

3.1. Experience of Safety Management. Experience of safety management learned from past projects could effectively improve general contractor's safety performance. Factors affected the experience learned include experience of construction project management, experience of safety personnel, education background of safety personnel, ability of handling serious accident, experience on reward and punishment for safety performance.

3.2. Organization of Safety Management. Organization of safety management is responsible for guiding and auditing safety work in a construction project, therefore, the functions of safety management organization play an important role to assure safety performance. Several factors which could affect the functions of safety management organization include number of allocated safety supervisor, extent of high-level management staffs' participation in safety management, extent of foremen's participation in safety management, safety-related professional certificate of safety supervisors, allocated responsible area to each safety supervisor, responsibility assign in the organization.

3.3. Operation Model of Safety Management. The efficiency of safety management operations could drive the safety performance of a construction project. Frequency of safety auditing, power to perform safety auditing, frequency of safety meeting, participants' highest management level, integrity and details of safety management plan, completeness and details of safety auditing record, incentives and punishments for safety performance are those factors influencing the efficiency of safety management.

3.4. Investments on Safety Management. When general contractors invest more on safety management, more safety equipments, manpower, and discipline on safety personnel could contribute to better safety performance in a construction project. Factors associated with investments on safety management include integrity of whole safety facility, extent of investments on safety facilities, equipments and tools, integrity of safety equipments and tools allocated to each worker, maintenance of safety facilities and equipments, occupational insurance.

3.5. Policies of Safety Management. Policies of safety management followed by a general contractor will influence the attitude and concept it adapts on safety management when they perform a construction project. Factors in this dimension include establishment of safety goals, developments of safety evaluation criteria, regulations on safety auditing power, regulations on safety management responsibility, process to evaluate safety management performance, attitude of high-level management staff on safety management, and education and discipline plan on safety management.

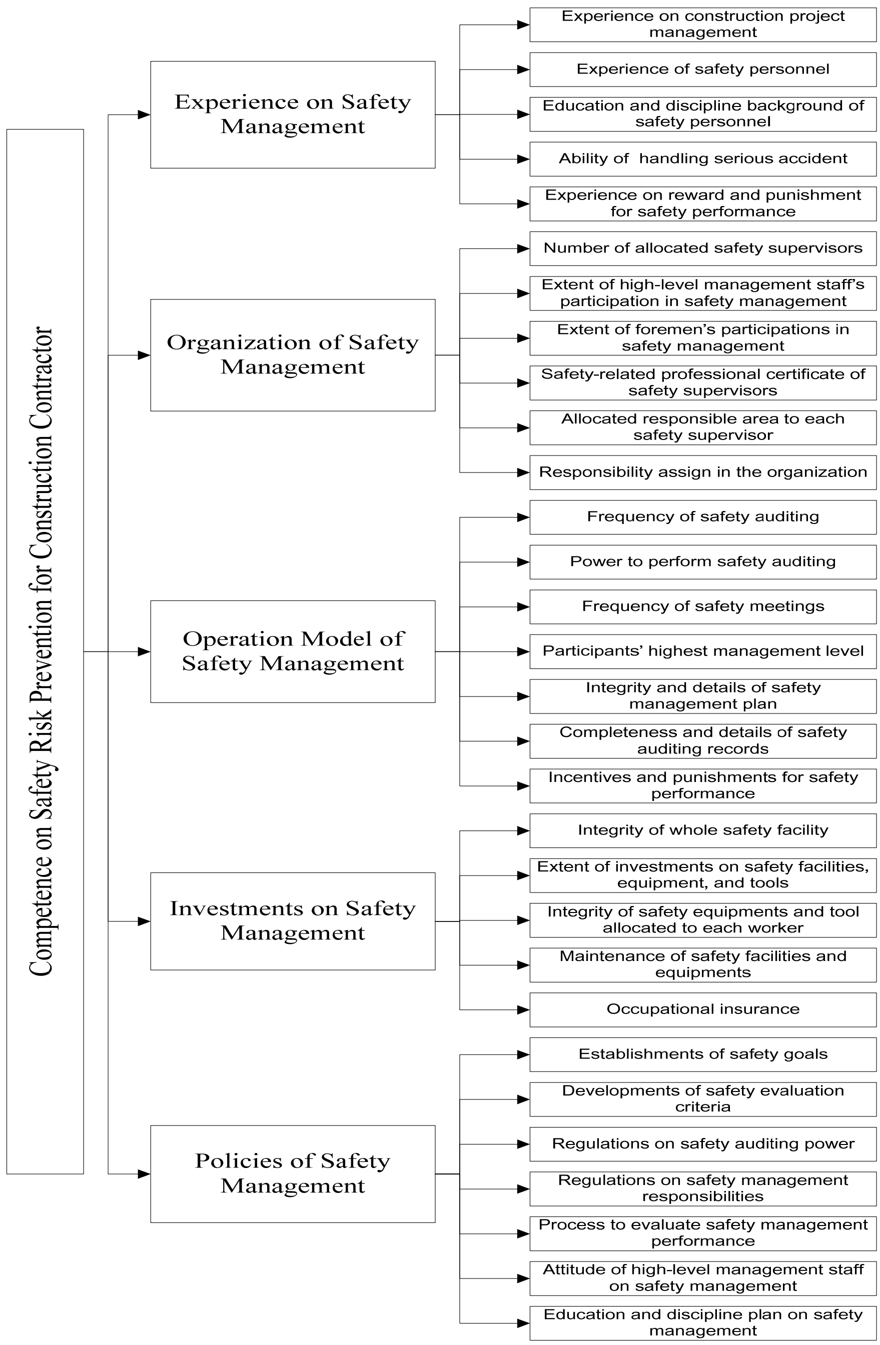

FIGURE 1. Hierarchical structure of safety risk management evaluation in a construction project

4. Consistent Fuzzy Preference Relations. This study would like to assess the priority of evaluation criteria of ability of managing safety risk for construction contractors. Thus, this study applies the consistent fuzzy preference relations (CFPR) approach, proposed by Herrera-Viedma et al. (2004), for constructing the decision matrices of pairwise comparisons based on additive transitivity property. The CFPR not only enables a decision-maker to give values for a set of criteria with the least judgments, but also avoids checking the consistency in decision-making process. The following provides a brief introduction on the definitions and steps of the proposed method.

4.1. Multiplicative Preference Relations. Matrix $\boldsymbol{A} \subset \boldsymbol{X} \times \boldsymbol{X}$ denotes the multiplicative preference relations of X criterion centers on A, where $\boldsymbol{A} = [a_{ij}]$, a_{ij} is the preference intensity ratio of criterion x_i to criterion x_j. Saaty (1997) suggested a_{ij} is scaled from 1 to 9. Herein, $a_{ij} = 1$ represents the existence of indifference between criterion x_i and x_j, $a_{ij} = 9$ manifests that x_i is absolutely important than x_j. In this case, the preference relation is typically assumed to be a multiplicative reciprocal:

$$a_{ij} \cdot a_{ji} = 1 \quad \forall i, j \in \{1, \cdots, n\} \tag{1}$$

4.2. Fuzzy Preference Relations. The fuzzy preference relation P on a set of criteria/alternatives X is a fuzzy set of the product $X \times X$ with membership function $\mu_p : X \times X \to [0,1]$. The preference relation is denoted by the matrix $\boldsymbol{P} = [p_{ij}]$, where $p_{ij} = \mu_p(x_i, x_j)$. Herein, p_{ij} is interpreted as the degree of importance ratio of criterion x_i over x_j. If $p_{ij} = 1/2$, it means that x_i and x_j are equally important (i.e. $x_i \sim x_j$); $p_{ij} = 1$ indicates that x_i is absolutely more important than x_j; $p_{ij} > 1/2$ shows that x_i is more important than x_j, i.e. $x_i \succ x_j$. In this case, the preference matrix, P, is usually assumed additive reciprocal, i.e.

$$p_{ij} + p_{ji} = 1, \forall i, j \in \{1, \cdots, n\} \tag{2}$$

4.3. Consistent Fuzzy Preference Relations. A set of alternatives $\boldsymbol{x} = \{x_1, \cdots, x_n\}$ and $\boldsymbol{x} \in X$ is associated with a reciprocal multiplicative preference relations $\boldsymbol{A} = [a_{ij}]$ for $a_{ij} \in [1/9, 9]$. Then a_{ij} can use Equation (3) to obtain the corresponding reciprocal fuzzy preference relation $\boldsymbol{P} = [p_{ij}]$ for $p_{ij} \in [0,1]$ associated with $\boldsymbol{A}$:

$$p_{ij} = g(a_{ij}) = \frac{1}{2}(1 + \log_9 a_{ij}) \tag{3}$$

Herein, $\log_9 a_{ij}$ is considered because a_{ij} is between $1/9$ and 9. When the reciprocal fuzzy preference relation $\boldsymbol{P} = [p_{ij}]$ is additive consistency, there exist the relationships as Equations (4) and (5):

$$p_{ij} + p_{jk} + p_{ki} = \frac{3}{2} \quad \forall i < j < k \tag{4}$$

$$p_{i(i+1)} + p_{(i+1)(i+2)} + \cdots + p_{(j-1)j} + p_{ji} = (j - i + 1)/2, \forall i < j \tag{5}$$

4.4. Determining the Priority of Criteria. When we obtain the $n-1$ preference intensity ratios $\{a_{12}, a_{23}, \cdots, a_{n-1,n}\}$ of criteria $\boldsymbol{x} = \{x_1, \cdots, x_n \mid n \geq 2\}$ from experts' judgments, Formula (3) can be used to construct a fuzzy preference relation for the set of n–1 values $\{p_{12}, p_{23}, \cdots, p_{n-1,n}\}$. Then the other preference relations values of the decision matrix $\boldsymbol{P}$, $\boldsymbol{B} = \{p_{ij} \mid \underset{i<j}{\wedge} p_{ij} \notin \{p_{12}, p_{23}, \cdots, p_{n-1,n}\}\}$, will be obtained by the formulae (2), (4) and (5). However, after this calculation, all the necessary elements in the decision matrix $\boldsymbol{P}$ not really lie within [0,1] but will lie within $[-a, 1+a]$, where $a = \left|\min\{\boldsymbol{B} \cup \{p_{12}, p_{23}, \cdots, p_{n-1n}\}\}\right|$. Therefore, it can be obtained the consistent reciprocal fuzzy preference relation matrix $\boldsymbol{P'}$ by the transformation function $\boldsymbol{P'} = f(p)$. This process can make the decision matrix maintaining reciprocity and additive consistency. The transformation function is written in the following:

$$f : [-a, 1+a] \to [0,1],\ f(x) = (x+a)/(1+2a) \tag{6}$$

The obtained assessment decision matrix, $\boldsymbol{P'} = (p'_{ij})$, shows the consistent reciprocal relation. It can apply the Equation (7) to determine the corresponding degree of importance for each criterion:

$$A_i = (\textstyle\sum_{j=1}^{n} p'_{ij}) / n, \quad w_i = A_i \big/ \textstyle\sum_{i=1}^{n} A_i \tag{7}$$

Lastly, we can base on this assessment results to understand the priority of ability of managing safety risk for construction contractors. In addition, it should also help decision makers to draw up appropriate safety management strategies on dealing with the more significant safety risk management factors.

5. Results and Conclusions. Five experts with more than twenty years experience on construction project management were invited to provide response to the questionnaire survey. They were asked to provide the inputs of relative importance of pair evaluation factors identified in this study on safety performance of construction projects. The reciprocal multiplicative preference relation matrix was then established according to experts' pairwise comparison inputs and was further computed through Equations (3)~(6) to obtain a consistent reciprocal fuzzy preference relation matrix. Equation (7) was employed to explore the relative importance rate for each evaluation factor. Table 1 shows the initial assessed pairwise comparison matrices of the five experts for five evaluation dimensions. Table 2 shows the initial assessed pairwise comparison matrices of the five experts for thirty factors. The relative importance rates and ranking of evaluation criteria for safety risk management dimensions and safety risk factors are displayed in Table 3.

Among the identified five dimensions, "Policies of safety management" was considered as the most important dimension to offset the safety performance in a construction project. "Organization of safety management" and "Experience of safety management" are the second and third important dimensions to improve safety performance. "Investments on safety management" and "Operation model of safety management" are the last two dimensions in sequence on relative importance affecting safety performance.

Among the five factors in the "Policies of safety management", attitude of high-level management staff on safety management and regulations on safety management responsibility were considered as the highest two important factors affecting safety performance. Both factors have similar relative importance rates. Regulations on safety auditing power and development of safety evaluation criteria were considered as high important factors related safety performance since both factor have higher relative importance rates in the "Policies of safety management" dimension.

For the "Organization of safety management" dimension, extent of foremen's participations in safety management has the highest relative importance rate among six risk factors. Because foremen is the leader of workers with highest accident rates among construct project personnel and in charge of not only working process but also safety protection supervising, foremen willing to participate and elaborate in safety management could greatly enhance safety performance in a construction project. Extent of high-level management staff's participation in safety management, number of allocated safety supervisors, and responsibility assign in the organization are another three risk factors with higher relative importance rates among six risk factors in this group.

Ability of handling serious accident is the most important risk factor affecting safety performance in a construction project for the "Experience of safety management" dimension. Experience of construction project management, and experience of safety personnel are also two important factors affecting safety performance of a construction project.

Among the "Investments on safety management" dimension, maintenance of safety facilities and equipment was considered as the most important factor. Integrity of safety equipments and tools allocated to each worker is another with higher relative importance rate to safety performance in this group. For the "Operation model of safety management" dimension, frequency of safety auditing, frequency of safety meeting, and incentives and punishments for safety performance are the most important risk factors among seven risk factors.

In this study, thirty risk factors were investigated in this study. If AHP concept was employed to determine the relative importance rates of risk factors, pairwise comparisons of risk factors should be conducted for 335 times, which was computed using the equation of n(n-1)/2 for n criteria. It is not practical since the evaluation process should be time consuming, and results could be inconsistent because evaluators could be inpatient and may yield chaos to the items in the survey questionnaire. This study adopted CFPR process model, proposed by Herrera-Viedma et al.(2004), to determine the relative importance rates of thirty risk factors associated with safety management on safety performance of a construction project. The implementation of CFPR could benefit on the reduction of required pairwise comparisons, facilitate the development and response of survey questionnaire and remain the consistency of pairwise comparisons.

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Appendix.

TABLE 1. Initial assessment results of the five experts for five evaluation dimensions

	E_1	E_2	E_3	E_4	E_5	
D_1	11/	51		5	1/7	D_2
D_2	76	1		4	1/6	D_3
D_3	51/	94		1/3	1/8	D_4
D_4	1/51/	5	1/21	/4	6	D_5

TABLE 2. Initial assessment results of the five experts for thirty factors

D_1:	E_1	E_2	E_3	E_4	E_5	
C_{11}	5	5	1	1/3	1/5	C_{12}
C_{12}	7	3	3	3	5	C_{13}
C_{13}	1/7 1/	8 1/	6	1/5	1/5	C_{14}
C_{14}	7	9	1	5	1/7	C_{15}
D_2:						
C_{21}	1	1/9	1	1/3	6	C_{22}
C_{22}	1/5 9		4	1/5	1/6	C_{23}
C_{23}	5	5	4	3	8	C_{24}
C_{24}	7	3	1	1/4	1/5	C_{25}
C_{25}	1/3 1/	4	1	1/5	1/7	C_{26}
D_3:						
C_{31}	5	1/8	1	4	4	C_{32}
C_{32}	1/5 7		1	4	1/5	C_{33}
C_{33}	7	1/9	1	4	1/3	C_{34}
C_{34}	3	9	1	1/6	1/6	C_{35}
C_{35}	1	41		1/6	7	C_{36}
C_{36}	3	1/3	1	1/6	1/9	C_{37}
D_4:						
C_{41}	5	1/9	1	5	1/6	C_{42}
C_{42}	1/3 9		1	1/3	1/7	C_{43}
C_{43}	1/3 1/	5	1	1/4	7	C_{44}
C_{44}	7	6	3	1	5	C_{45}
D_5:						
C_{51}	1/5 1/	4	1	1/5	1/5	C_{52}
C_{52}	1/5 1/	6	1	1/3	6	C_{53}
C_{53}	5	8	1	1/4	1/7	C_{54}
C_{54}	7	8	1	1/3	5	C_{55}
C_{55}	1	1/9 1		1/4	1/6	C_{56}
C_{56}	5	9	/3	1/5	8	C_{57}

TABLE 3. The relative importance rates and ranking of evaluation criteria for safety risk management

Evaluation criteria	Average	Ranking
Experience on Safety Management	0.207 3	
Experience on construction project management	0.219	2
Experience of safety personnel	0.216	3
Education and discipline background of safety personnel	0.121	5
Ability of handling serious accident	0.252	1
Experience on reward and punishment for safety performance	0.192	4
Organization of Safety Management	0.216 2	
Number of allocated safety supervisors	0.181	3
Extent of high-level management staff's participation in safety management	0.187	2
Extent of foremen's participations in safety management	0.199	1
Safety-related professional certificate of safety supervisors	0.129	5
Allocated responsible area to each safety supervisor	0.128	6
Responsibility assign in the organization	0.178	4
Operation Model of Safety Management	0.169 5	
Frequency of safety auditing	0.162	1
Power to perform safety auditing	0.145	4
Frequency of safety meetings	0.151	3
Participants' highest management level	0.135	6
Integrity and details of safety management plan	0.140	5
Completeness and details of safety auditing records	0.116	7
Incentives and punishments for safety performance	0.152	2
Investments on Safety Management	0.177 4	
Integrity of whole safety facility	0.187	4
Extent of investments on safety facilities, equipment, and tools	0.188	3
Integrity of safety equipments and tool allocated to each worker	0.210	2
Maintenance of safety facilities and equipments	0.259	1
Occupational insurance	0.156	5
Policies of Safety Management 0.231		1
Establishments of safety goals	0.109	7
Developments of safety evaluation criteria	0.154	4
Regulations on safety auditing power	0.156	3
Regulations on safety management responsibilities	0.163	2
Process to evaluate safety management performance	0.121	6
Attitude of high-level management staff on safety management	0.164	1
Education and discipline plan on safety management	0.133	5

FUZZY EVALUATION ON TIME MANAGEMENT FOR THE SCHOOL LEADERS

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ABSTRACT. *As is the leader, so is the school. A leader has a decisive influence to school management. Educational administration and leadership in the work environment and job characteristics on the working time of the application must also be efficient management. How to effectively allocate time and a leader's effectiveness to achieve educational goals of competent performance is especially important in leadership effectiveness. In this study, we use fuzzy statistical analysis from leaders to various administrative and processing time distributions. Based on the fuzzy survey, we find that the leaders in the time allocated, effective leadership performance levels, providence for educational administration and leadership are highly correlated with time allocation.*

Keywords: Fuzzy Evaluation; Time Management; School Leaders

1. Introduction. Under the global educational revaluation, how to promote the quality of education has become an important issue. Since a leader leads a school's education policy development and prospects, how to manage the time is important, and all leaders look forward to working with the responsibility to manage it.

School leaders' work is complex. Peterson (1978) demonstrates that the leaders at elementary schools spend less than 7% of their time on course research, and less then 5% in class. Crowson et al. (1984) find that most leaders spend less than 9% of their time on class interview. Murphy (1990) reviews other literatures and finds that school administrative leaders spend most of their time in curriculum and instruction, while spending less on students' discipline, parent relations, school facilities and school financial management. Horng et al. (2009) claims that the leaders at elementary schools spend 25.3% on administration, 20.9% on organization management and 17.3% on internal relations.

Samuels (2008) claims that most leaders probably hope that at least half their working day is spent on meaningful interactions with teachers and students, but that's not likely. Leaders spend only a third of their day, or less, on tasks that involve interaction with students and teachers. And often, the contact with them was too short and unfocused to lead to actual instructional improvement. In this research, we are going to investigate the effectiveness of leaders' management and efficiency of time allocation through the application of fuzzy set theory.

On the other hand, social science studies always uses the basic narrative of statistics, such as mean, median and mode in the analysis of data, by which we can simply describe the basic structure of the data. However, in many fields, such as human language, thought and decision making, it is vague and non-quantitative, of which many are non-specific preferences. Zedah (1999) first proposed the fuzzy set (logic) concept, arguing the dynamic environment of the human brain to use fuzzy metrics and classification leaders of the complex phenomenon of fuzzy is a robust description of the solutions.

When we deal with the fuzzy data, we will approach the computing problem if we use the traditional statistical methods to deal with the fuzzy data. Since human thinking is subjective and complex, this allows research on statistical analysis to be more precise so that researchers can further analyze the approach data and the use of the soft statistical methods become more important.

Since these statistical phenomenons can easily and quickly describe the basic structure of the information for data analysis, they have been widely employed in many academic areas. The mean is the most popular among them. However, when we want to understand the research target's opinions or consensus on some public issues, the application of mode will be more proper than mean. But since the mode for traditional statistics only involves a single number and is unable to express the human thought and the complexity of subjective matter, the fuzzy mode should be developed to have more honesty and detailed description for these issues. Fuzzy theory describes the membership between [0,1] to illustrate the relationship between elements and sets.

Most literatures have not considered the measurement on the statistics of realistic and expect time for school leaders business hours. Moreover using fuzzy statistics to analyze the interval data. The main purpose of this research will include the following four points: (1) A discussion on the school leaders, operating characteristics and time. (2) Analysis of the school leaders' hours in leading business content and services, the object assigned. (3) Providence of school leadership level and time use correlation analysis. (4) Discount the distance between idea and realist of the school leaders' leadership level. We will use fuzzy evaluating and fuzzy statistical methods on work assessment and time management for the school leaders.

2. Literature Review. From a legal point of view, article 9 of the Law of National Education states that: All elementary schools should have one leader, whose duty is to handle school issues, the job should be full-time, and goes by term of office, of which one can renew once in the same school. National education law article 10 states that the provisions of the leader under the auspices of the Council meeting, convened by the need to resolve major issues (i.e. the Council of the school development plan, school into a variety of important terms, according to the Decree of the Board of Governors Meeting resolved issues, school leaders to discuss matters). Spillane et al. (2007) studied that leader duties described by four categories were: Administrative (e.g., managing budgets, managing personnel); Instruction and Curriculum (e.g., observing classroom instruction, planning curricula); Professional Growth (e.g., receiving coaching, studying effective practices); and

Fostering Relationships (e.g., interacting socially).

This article will work intension to leader of three areas, namely for teaching leadership, administrative leadership and public relations leadership, three areas, the school leaders work content analysis are as follows:

2.1. Teaching Leadership. Course guide: school-based curriculum planning and development, implementation, and supervision of teaching: promoting teaching and research, the oversight of the teaching process, concept of teaching management communication, problem solving, improving teaching effectiveness; provide various studies: help teachers designed to grow and contribute to the interaction with professional; student services: active exploration students demand, concerns situations where student progress and for students; continuous learning, reflection, learning the latest known and technology.

2.2. Administrative Leadership. Planning and organization: elaboration of school development projects, planning and steering of school organization, the organization and operation, the morale of teachers and students of shock; policy, management and ego: decisions, decisions, assist the bailiff; monitoring and evaluation: the performance of the feedback given to members; office services: official documents and correspondence department, funding use auditing, meetings, relevant and various gatherings; funding and equipment : supervision of engineering into , survey school construction equipment, verification requirements; do resource management: a project containing school internal and community who serves, serves as a technical and organizational resources; accidental event handling: various unexpected events, including students, teachers, sick, when an emergency meeting, crisis management, etc.

2.3. Public Relations Leadership. And the superior authority of his associates is involved in: relevant and meetings, instruction execution method, communication, and reporting the results of the school of business administrative; relevant with the community or the media activities: parents, community celebrations, community friends, media, and interactive limited.

CTS objects classified as: student, staff, parents, extracurricular education personnel, people outside the offices of five categories according to the nature of the work is classified as academic, studies, general comptroller, personnel four categories.

3. Methods.

3.1. Fuzzy Questionnaire. After the research of FGRS (Fuzzy Graphic Rating Scale) presented by Hesketh et al. (1988), Costas et al. (1994) furthered to choose 100 university students as a sample of the research, they found that FGRS really fits to the feature of human psychology.

Herrera et al. (2000) presented the steps of linguistic decision analysis under linguistic information. Their statements believe that there are certain degrees of possibilities to express linguistics based on fuzzy number, but it should be reconsidered that if the response will produce the same fuzzy number.

Liu and Song (2001) develop one type of measurement whose linguistic is similar with semantic proximity. Based on the similarity of linguistic concept, they present a formula of fuzzy association degree. Liu and Song (2001) use the information of botany as an example to illustrate and analyze the categorical similarity of rare plant in the ecology. Carlsson and Fuller (2000a), Carlsson and Fuller (2000b), Chiang et al. (2000), Herrera et al. (2000), Dubois and Prade (1991) have discussed many concepts about the computation of fuzzy linguistic and these concepts are worthy to broadcast.

Based on associated research archives from previous statements, we can have the following inference:

(1) The methods of traditional statistical analysis and measurement used in public consensus are incomplete and not enough. Based on the fuzzy feature of human thought, quantifying the measurement of public consensus processed by fuzzy number should be seriously considered and discussed.

(2) The measurement of attitudes and feelings based on the fuzzy theory is a very critical method in recent years. There are many associated scholar arenas in this type of research. However, educational and psychological researches are still not as many as other research fields. In conclusion, the theory research of fuzzy mode and experimental discussion presented in this paper is a possible solution with its importance.

3.2. How to Use Fuzzy Statistics. In the research of social science, the sampling survey is always used to evaluate and understand public opinion on certain issues. The traditional survey forces people to choose fixed answer from the survey, but it ignores the uncertainty of human thinking. For instance, when people need to choose the answer from the survey which lists five choices including "Very satisfactory," "Satisfactory," "Normal," "Unsatisfactory," "Very unsatisfactory," and the answer of the question is continual type, we may be only allowed to choose one answer. It limits the flexibility of the answer and forces people to choose fixed answers. When the survey proposes to have the answer for sleeping hours of a person, it will be difficult to describe the feeling or understanding reasonably unless the fuzzy mode is adopted.

Traditional statistics deals single answer or certain range of the answer through sample survey, and unable to sufficiently reflect the thought of an individual. If people can use the membership function to express the degree of their feelings based on their own choices, the answer presented will be closer to real human thinking. Therefore, to collect the information based on the fuzzy mode should be more reasonable. In the consideration for the question related with fuzzy property, the information itself had the uncertainty and fuzzy property. The following is the definitions of discrete fuzzy mode and continuous fuzzy number. The discrete fuzzy mode is simpler than continuous fuzzy mode. The computation of discrete number is easier than the continuous one.

Since many sampling survey is closely related with fuzzy thinking while the factor of set can be clearly grouped into many categories, it will be useful if we apply discrete fuzzy number in the public consensus.

Definition 3.1. Fuzzy Mode (data with multiple values).

Let U be the universal set (a discussion domain), $L=\{L_1, L_2, \cdots, L_k\}$ a set of k-linguistic variables on U, and $\{FS_i, i = 1,2\cdots,n\}$ a sequence of random fuzzy sample on U. For each sample FS_i, assign a linguistic variable L_j a normalized membership $m_{ij}(\sum_{j=1}^{k} m_{ij} = 1)$, let $S_j = \sum_{i=1}^{n} m_{ij}$, $j = 1,2,\cdots,k$. Then, the maximum value of S_j (with respect to L_j) is called the fuzzy mode (FM) of this sample. That is $FM = \{L_j \big| S_j = \max_{1\le i\le k} S_i\}$.

Note. A significant level α for fuzzy mode can be defined as follows: Let U be the universal set (a discussion domain), $L = \{L_1, L_2, \cdots, L_k\}$ a set of k-linguistic variables on U, and $\{FS_i, i = 1,2\cdots,n\}$ a sequence of random fuzzy sample on U. For each sample FS_i, assign a linguistic variable L_j a normalized membership $m_{ij}(\sum_{j=1}^{k} m_{ij} = 1)$, let $S_j = \sum_{i=1}^{n} I_{ij}$, $j = 1,2,\cdots,k$ $I_{ij} = 1\ if\ m_{ij} \ge \alpha,\ I_{ij} = 0\ if\ m_{ij} < \alpha$, α is the significant level. Then, the maximum value of S_j (with respect to L_j) is called the fuzzy mode (FM) of this sample. That is $FM = \{L_j \big| S_j = \max_{1\le i\le k} S_i\}$. If there are more than two sets of L_j that reach the conditions, we say that the fuzzy sample has multiple common agreements.

Definition 3.2. Fuzzy Mode (data with interval values).

Let U be the universal set (a discussion domain), $L = \{L_1, L_2, \cdots, L_k\}$ a set of k-linguistic variables on U, and $\{FS_i = [a_i, b_i], a_i, b_i \in R, i = 1,2,\cdots,n\}$ be a sequence of random fuzzy sample on U. For each sample FS_i, if there is an interval [c, d] which is covered by certain samples, we call these samples as a cluster. Let MS be the set of clusters which contains the maximum number of sample, then the fuzzy mode FM is defined as

$$FM = [a,b] = \{\cap[a_i, b_i] \| [a_i, b_i] \subset MS\}$$

If $[a,b]$ does not exist (i.e. $[a,b]$ is an empty set), we say this fuzzy sample does not have fuzzy mode.

Suppose eight voters are asked to choose a chairman from four candidates. Table 1 is the result from the votes with two different types of voting: traditional response versus fuzzy response.

From the traditional voting, we can find that there are three persons voting for *B*. Hence the mode of the vote is *B*. However, from the fuzzy voting, *B* only gets a total membership of 2.1, while *C* gets 3.2. Based on traditional voting, *B* is elected the chairperson, while based on the fuzzy voting or membership voting, *C* is the chairperson. The voters' preference is reflected more accurately in fuzzy voting; *C* deserves to be the chairperson more than *B* does.

Definition 3.3. Fuzzy expected values (data with multiple values).

Let U be the universal set (a discussion domain), $L = \{L_1, L_2, \cdots, L_k\}$ be a set of k-linguistic variables on U, and $\{FS_i = \frac{m_{i1}}{L_1} + \frac{m_{i2}}{L_2} + ... + \frac{m_{ik}}{L_k}, i = 1,2,...,n\}$ be a sequence of random fuzzy sample on U, $m_{ij}(\sum_{j=1}^{k} m_{ij} = 1)$ is the memberships with respect to L_j. Then, the Fuzzy expected value was defined as

$$E(X)=\frac{\frac{\sum_{i=1}^{n} m_{i1}}{n}}{L_1}+\frac{\frac{\sum_{i=1}^{n} m_{i2}}{n}}{L_2}+...+\frac{\frac{\sum_{i=1}^{n} m_{ik}}{n}}{L_k}.$$

TABLE 1. Response comparison for the eight voters

Candidate Voter	traditional response				fuzzy response			
	A	B	C	D	A	B	C	D
1		V				0.7	0.3	
2	V				0.5		0.4	0.1
3				V			0.3	0.7
4			V		0.4		0.6	
5		V				0.6	0.4	
6				V	0.4		0.2	0.6
7		V				0.8	0.2	
8			V				0.8	0.2
Total	1	3	2	2	1.3	2.1	3.2	1.6

Definition 3.4. Fuzzy expected values (data with interval values).

Let U be the universe set, and $\{FS_i=[a_i,b_i],a_i,b_i\in R,i=1,2,\cdots,n\}$ be a sequence of random fuzzy sample on U. Then the fuzzy expected value is defined as

$$E(X)=[\frac{\sum_{i=1}^{n} a_i}{n},\frac{\sum_{i=1}^{n} b_i}{n}]$$

Example 3.2. Let the time series $\{X_t\}$ = {0.8, 1.6, 2.8, 4.2, 3.6, 3.1, 4.3}，be the variation of a stock's value with 7 days . We can see the total range is 4.3 - 0.8 = 3.5. We give a equal interval partition for [0.8, 4.3], say U = {(0,1)，(1,2)，(2,3)，(3,4)，(4,5)}. The linguistic variable with respect the intervals are：very low $=L_1\propto(0,1]$，low $=L_2\propto(1,2]$，medium $=L_3\propto(2,3]$，high $=L_4\propto(2,3]$, very high $=L_5\propto(2,3]$; where $\propto$ means "respect to". The medium for each partition are $\{m_1=0.5$，$m_2=1.5$，$m_3=2.5$，$m_4=3.5$，$m_5=4.5\}$. Since X_1 falls between 0.5 and 1.5. $\frac{1.5-0.8}{1.5-0.5}=0.7\in L_1$, $\frac{0.8-0.5}{1.5-0.5}=0.3\in L_2$ the fuzzy value of X_1 is $F_1=(0.7,0.3,0,0,0)$. Similarly, we get the other fuzzy samples as follows:

The fuzzy expected value for the time series is

$$E(X)=\frac{0.7/7}{1}+\frac{(0.3+0.9)/7}{2}+\frac{(0.1+0.7+0.4)/7}{3}+\frac{(0.3+0.3+0.9+0.6+0.2)/7}{4}+\frac{(0.7+0.8+0.1)/7}{5}$$

$$=\frac{0.1}{1}+\frac{0.17}{2}+\frac{0.17}{3}+\frac{0.33}{4}+\frac{0.23}{5}$$

TABLE 2. The fuzzy values for time series $\{X_t\}$

	Very low=1	Low=2	Medium=3	High=4	Very high=5
F_1	0.7	0.3	0	0	0
F_2	0	0.9	0.1	0	0
F_3	0	0	0.7	0.3	0
F_4	0	0	0	0.3	0.7
F_5	0	0	0	0.9	0.1
F_6	0	0	0.4	0.6	0
F_7	0	0	0	0.2	0.8

3.3. Fuzzy Distance between Idea and Realistic. An interval-valued fuzzy set can be viewed as a continuous fuzzy set, which further represents uncertain matters. Take "test results" as an example. In foreign countries, A, B, C and D are used to evaluate a student's result, whereby A represents 100 – 80 marks, B represents 79 -– 70 marks, C represents 69 – 60 marks, D represents 59 – 50 marks, in place of numerical scores. In the past we think that obtaining a high score means learning well. However, does a student who gets 85 marks have better learning ability than another who scores 80 marks? Not necessarily so. That's why the interval-valued fuzzy set resolves the phenomena of uncertainty.

When a sample of interval-valued fuzziness is available, we have to consider the calculation for intervals. Refer to Nguyen, H. and Wu, B. (2006) for interval calculations. However, there is still no complete definition for the measure of interval distance. This chapter will define a well-defined interval distance, and use this definition to calculate the cluster center of interval and the membership degree of interval.

How to define a well-defined interval distance? First we represent the interval with $(c_i; r_i)$ with c being the center, r being radius. This way, the interval distance can be considered as the difference of the center plus the difference of the radius. The difference of the center can be seen as the difference in location, and the difference of the radius can be seen as the difference in scale. However, in order to lower the impact of the scale difference on the location difference, we take the *ln* value of the scale difference, and then plus 1 to avoid the *ln* value becoming negative.

Definition 3.5. Distance between samples of interval-valued data.

Let U be the universe of discourse. Let $\{x_i = [a_i, b_i], i = 1,2\}$ be two samples from U, with center $c_i = \frac{a_i + b_i}{2}$, and radius $r_i = \frac{a_i - b_i}{2}$, the distance between the two samples x_1 and x_2 is defined as

$$d(x_1, x_2) = |c_1 - c_2| + \ln(1 + |r_1 - r_2|)$$

Example 3.3.

Let two sets of interval data be $x_1 = [2,5]$, $x_2 = [3,7]$. Then $x_1 = (3.5; 1.5)$, $x_2 = (5; 2)$

$$d(x_1, x_2) = |3.5 - 5| + \ln(1 + |1.5 - 2|) = 1.9$$

The greater the distance stated leader leadership level perceptions and actual elapsed time does not meet, i.e. no efficiency; the smaller the distance stated leader leadership level perceptions and actual running time related consistency can show their work efficiency. In order to have a clear picture about the distance between idea and realistic we need the following definition, for which the value will be standardized constraint on 0 and 1.

Definition 3.6. Index of Fuzzy distance between idea and realistic.

Let U be the universe of discourse. Let OI=(c_o;r_o) be the observed data and EI=(c_e;r_e) be the expected data from U. The index of fuzzy distance between observed and idea data is defined as

$$IOE = e^{-\left(\left|\frac{c_o - c_e}{c_o}\right| + \ln\left(1 + \left|\frac{r_o - r_e}{r_o}\right|\right)\right)}$$

The higher value the IOE is the more efficient of time management did. If IOE= 1, we call leadership is absolutely efficiency in the time management. If IOE=0, we called the leader ship is no efficient at all.

4. Empirical Analysis. In the questionnaire and sampling survey, we collect 40 school leaders reply the information. Ages from 30 to 60, sex is male 29, female 11. Most schools are around at the countryside. By questionnaire results, leaders of work characteristics and time, the fuzzy mean up to leading accounting 39.7% , followed by research and concept covers 24.8% , accounted for collaborative again 18.8% , and finally to implement accounting 16.8% .

4.1. Time Allocation for School Leaders. In this sampling survey, we find school leader spends 44.5 – 51 hours a week in the educational management. Which include: 36.7-41.3 hour for the office hours, 6-9.9 hours for extended work after school, 2.9-4.8 hours for leisure time, 2.6-4.7 hours fooling around. Most effective time 17-21 hours, most of the time off for 1.3-4.4 Hours. Visible school leaders to everything else, except public holidays or special operations, or have never leave.

Leaders never ceased, and their satisfaction with the time management: General satisfaction as 38.9% ; Secondly, for the majority accounting for 38.7% ; Once again, not very satisfied, 15.6% ; Last dissatisfied, 6.3% . Indicates that the leader's time management effectiveness in good, leaders must first be able to control their own, they are best friends, is the greatest enemy.

(1) School leaders' hours in leading business content distribution scenarios. School leaders hours in leading business content distribution scenarios, according to the traditional way of ranking order, is namely the administrative leadership, teaching leadership, and public relations leadership. First is administrative leadership, membership for 42.3%; Secondly, the time for instructional leadership, membership for 38.1%; last public relations leadership, membership for 20.1%. Visible school leaders continue to believe that the administrative leadership of the comprehensive plans that can assist in effective instructional leadership and public relations leadership.

TABLE 3. A comparison with different answering about the importance of leaderships

	Average rank	Membership	Observative (hours／week)
administrative leadership	1.4	42.3%	21.0-31.6
instructional leadership	1.8	38.1%	15.7-23.2
public relations leadership	2.8	20.1%	4.9-8.2

(2) School leaders' hours in leading business services allocation. School leaders hours in leading business services allocation to academic time, the membership for 32.4% ; Secondly, the student affairs, membership for 28.1% ; Once again, the general comptroller, membership for 25.7% ; And finally for the personnel, membership for 13.8% . Visible school leaders' leading business most time is academic that can assist leadership effective.

(3) School leaders' hours in leading business object allocation. School leaders hours in leading business object allocation , staff time, fuzzy mean for 37.9% ; Secondly to students, fuzzy mean for 27.5% ; Next time for parents, fuzzy mean for 17% ; extramural education officers again, fuzzy mean for 10.8% ; And finally for the people outside, fuzzy mode for 9.3% . Visible school leaders' leading business object most time is staff that can assist leadership effective.

TABLE 4. Membership allocation for school leaders' hours in leading business services and leading business object

Leading Business Services	Leading Business Object
Academic 32.4% Student affairs 28.1% General comptroller 25.7% Personnel 13.8%	Staff 37.9% Students 27.5% Parents 17% Extramural 10.8% People outside 9.3%

4.2. Efficiency of Time Allocation. Use the definition 3.4 and 3.5 at section 3.4 we can compute the gap for observation and expected time. Table 5 illustrates the distances and indies for the three types of leaderships.

From Table 5 we can see the distance between observed and expected time. The indices IOE of instructional leadership are a maximum of 0.57, administrative leadership 0.46 is second, public relations leadership is last with 0.39. From this investigation, we can draw conclusion that the leaders' instructional leadership skills are closest to ideal fits in more, it means the level is highly efficient. But it has greater individual differences thus displaying polarization. The time spent on public relations leadership is less and the biggest difference presents the poor performance.

TABLE 5. Illustrates the distances and indies for the three types of leaderships

	Observed	Expected	$d(x_1, x_2) = \lvert c_1 - c_2 \rvert + \ln(1 + \lvert r_1 - r_2 \rvert)$	Indies IOE $= e^{-(\lvert\frac{c_o - c_e}{c_o}\rvert + \ln(1+\lvert\frac{r_o - r_e}{r_o}\rvert))}$
Administrative	[21,31.6]	[18.9,21.7]	7.6	0.46
Instructional	[15.7,23.2]	[17, 19.5]	2.5	0.57
Public relations	[4.9,8.2]	[8.9,10]	3.6	0.39

5. Conclusions. Einstein once said: If you want to have mathematical law and reality, they do not determine it; if you want them to determine, not reality. This article is to use fuzzy statistics in leader leadership effectiveness of fuzzy time allocation and management assessments. The proposed IOE is a useful measure to evaluate the efficiency of School leader's time allocation.

Application of fuzzy statistics analysis with a fuzziness of numerical data, rather than using traditional statistic we can get a deeper investigation for the school leaders time administration. Some interesting result including:

(1) As a school leader, in order not to spend not too much time in inappropriate implementation. To provide school leaders time management training course to assist them work efficient is an urgent project. They have the ability to perform their plan and reach the goal by the efficient time allocation.

(2) School leaders have too much working load than expected, either in the administration or in the instruction. It suggested that appropriate relax is important. On the other hand, in order to promote the teachers background to do a closer cooperative work with school leader, teacher professional advanced studies is necessary to make the leadership effective.

(3) School leaders spend less time in public relation than expected. It seems that most school leaders concentrated on the administration work than acting on the public relation.

Finally, this research propose following recommendation: 1.school leaders should make their own time management, leadership effectiveness to play an extreme; 2. providing school leaders time management training course to assist them work efficient; 3. strengthen fundamental education on time management skills of school leaders.

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OPTIMAL PRICES IN THE PRESENCE OF DISCOUNTS: A NEW ECONOMIC APPLICATION OF CHOQUET INTEGRALS

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ABSTRACT. *In many real-life situations, there are "package deals", when customers who buy two or more different items get a special discount. For example, when planning a trip, a deal including airfare and hotel costs less than the airfare and hotel on their own; there are often also special deals when we combine airfare with car rental, and deals that cover all three items plus tickets to local tourist attractions, etc.*
Usually, there are several such deals with different combinations and different discounts. What if we plan to buy several different copies of each item: e.g., we plan a group tour in which some tourists want to rent car, some want to visit certain tourist attractions, etc. What is the best way to use all available discounts? We show that, under reasonable assumptions, the optimal price is provided by the Choquet integral.
Keywords: Package deal, optimization, choquet integral.

1. Practical Problem and Its Reformulation in Precise Terms.

Practical situation: discounts. In many real-life situations, there is a "package deal": customers who buy two or more different items get a special discount. For example:

- when planning a trip, a deal including airfare and hotel costs less than the airfare and hotel on their own;
- there are often also special deals when we combine airfare with car rental, and deals that cover all three items plus tickets to local attractions, etc.;
- when a customer buys a house, there are often package deals which enable the customer to also buy the original furniture and/or car at a special discount;
- in fast food restaurants, such group discounts are a norm.

Usually, there are several such deals with different combinations and different discounts.
How to describe discounts in precise terms. Let us denote, by n, the total number of different items, and let us denote these items by $x_1, \ldots, x_n$, so that the set of all the items is $X = \{x_1, \ldots, x_n\}$. Let $v(x_i)$ denote the price of each individual item.

A discount means that for some sets of items $S \subseteq X$, the overall price $v(S)$ of buying all the items from this set is smaller than the total price $\sum\limits_{x_i \in S} v(x_i)$ that we would have to pay if we bough them separately. For example, if x_1 is the airfare and x_2 is the hotel, then a package deal means that $v(\{x_1, x_2\}) < v(x_1) + v(x_2)$.

Not all combinations lead to package deals. For some combinations S, the cheapest price $v(S)$ is exactly the sum $\sum\limits_{x_i \in S} v(x_i)$ of individual prices.

We assume that we know all the discounts. We assume that for every subset S, we know the cheapest price $v(S)$ that we have to pay if we want to buy all the items from this set S.

Natural assumption: the larger the group, the better the discount. A natural assumption is that the larger the group, the better the discount. So, if we want to buy items from two sets S and S', then, instead of buying them separately and paying the sum $v(S) + v(S')$, it is cheaper (or at least not more expensive) to buy the whole group $S \cup S'$ – and then buy additionally all the duplicate items, from the intersection $S \cap S'$. In other words, we require that for all sets S and S', we have $v(S) + v(S') \geq v(S \cup S') + v(S \cap S')$.

What if we want to buy several items of each type: formulation of the practical problem. What if we want to buy several items of each type, i.e., we want to buy d_1 items of type x_1, d_2 items of type x_2, etc. For example, we want to plan a group tour in which some tourists want to rent car, some want to visit certain attractions, etc.

The problem is: What is the best way to use all available discounts?

Mathematical comment. We assume that we know the prices $v(S)$ corresponding to all possible sets S, i.e., situations in which for each item i, we either buy it ($d_i = 1$) or not ($d_i = 0$). Now, we want to extend the price function to situations in which each d_i can take any natural value 0, 1, 2, …In mathematics, such combinations in which we may have several copies of each item are called *bags* (also known as *multisets*)– because of their relation to grocery bags, for which, by the way, discounts are also frequent; see, e.g., [2, 4]. Thus, from the mathematical viewpoint, the problem is how to extend a given function $v(S)$ from sets to bags.

Towards the formulation of our main problem in precise terms. Each way to use the discounts consists of selecting discounts – i.e., sets $S_1, \ldots, S_m$ – and selecting how many times $t_1, \ldots, t_m$ we use each of the discounts so that totally, we get exactly d_1 objects of type x_1, d_2 objects of type x_2, etc.

The desired amounts can be described by a tuple $d = (d_1, \ldots, d_n)$. Each set $S_i \subseteq X$ can be identified with its characteristic function, for which $\chi_{S_j}(x_i) = 1$ if the item x_i is in the set S_j and $\chi_{S_j}(x_i) = 0$ otherwise. For each selection of sets S_i and times t_i, the overall price is equal to $t_1 \cdot v(S_1) + \ldots + t_m \cdot v(S_m)$. Thus, we arrive at the following precise optimization problem.

2. **Precise Optimization Formulation of the Practical Problem.**

Definition 1. *Let $X = \{x_1, \ldots, x_n\}$ be a finite set. By a* discount function*, we mean a function $v(S)$ that maps every subset of X into a non-negative real number in such a way that for every two sets S and S', we have*

$$v(S) + v(S') \geq v(S \cup S') + v(S \cap S'). \tag{1}$$

Definition 2. *Let $X = \{x_1, \ldots, x_n\}$ be a finite set.*

- *By a* task*, we mean a tuple $d = (d_1, \ldots, d_n)$ in which d_i are natural numbers (i.e., non-negative integers).*
- *By a* purchasing plan*, we mean a pair $P = \langle (S_1, \ldots, S_m), (t_1, \ldots, t_m) \rangle$, in which S_j are subsets of the set X and t_j are non-negative integers.*
- *We say that a plan $P = \langle (S_1, \ldots, S_m), (t_1, \ldots, t_m) \rangle$* satisfies *the task d if for every element x_i, we have $d_i = \sum\limits_{j=1}^{m} t_j \cdot \chi_{S_j}(x_i)$.*

- *By a* price $v(P)$ *of the purchasing plan* $P = \langle (S_1, \ldots, S_m), (t_1, \ldots, t_m) \rangle$, *we mean the value*

$$v(P) \stackrel{\text{def}}{=} t_1 \cdot v(S_1) + \ldots + t_m \cdot v(S_m). \tag{2}$$

Problem:

GIVEN: *a discount function* v *and a task* d,
AMONG: *all the purchasing plans which are consistent with the task,*
FIND: *the purchasing plan with the smallest price* $v(P)$.

The price of this cheapest purchasing plan will be called the *price of the task* and denoted by $v(d)$.

3. **Main result.**

Theorem. *For every discount function* v *and for every task* d, *the price of this task can be determined as follows. If we order the values* d_i *in the increasing order, into the sequence*

$$d_{(1)} \le d_{(2)} \le \ldots \le d_{(n)} \tag{3}$$

and order the items accordingly, then

$$v(d) = d_{(1)} \cdot v(\{x_{(1)}, x_{(2)} \ldots, x_{(n)}\}) + (d_{(2)} - d_{(1)}) \cdot v(\{x_{(2)}, \ldots, x_{(n)}\}) + \ldots +$$
$$(d_{(i)} - d_{(i-1)}) \cdot v(\{x_{(i)}, x_{(i+1)}, \ldots, x_{(n)}\}) + \ldots + (d_{(n)} - d_{(n-1)}) \cdot v(\{x_{(n)}\}). \tag{4}$$

Comment. The expression (4) is exactly (discrete) Choquet integral; see, e.g., [1, 5]. Thus, under reasonable assumptions, the optimal price is indeed provided by the Choquet integral.
Historical comment. For the case of $n = 2$, this interpretation of the Choquet integral was first outlined in [3]. For other economic applications of Choquet integral – to decision making – see, e.g., [6] and references therein.
Proof. The above value is attained when we take the following purchasing plan P_0: $d_{(1)}$ copies of the set $\{x_{(1)}, x_{(2)} \ldots, x_{(n)}\}$, $d_{(2)} - d_{(1)}$ copies of the set $\{x_{(2)}, \ldots, x_{(n)}\}$, $\ldots$, $d_{(i)} - d_{(i-1)}$ copies of the set $\{x_{(i)}, x_{(i+1)}, \ldots, x_{(n)}\}$, $\ldots$, and $d_{(n)} - d_{(n-1)}$ copies of the set $\{x_{(n)}\}$. So, to prove the theorem, it is sufficient to prove that for every other purchasing plan $P = \langle (S_1, \ldots, S_m), (t_1, \ldots, t_m) \rangle$ which is consistent with the task d, we have $v(P) \ge v(P_0)$. Indeed, let P be such a plan.

Without losing generality, we can ignore the items which are not included in the task d, i.e., for which $d_i = 0$. As a result, we can assume that the list of items X includes only the items x_i for which $d_i > 0$. Without losing generality, we can also assume that all the sets S_i are different – otherwise, if some of them are equal, we can simply add up the corresponding times t_i that this bargain is used.

Let us denote, by $t_{(1)}$, the smallest possible value t_i: $t_{(1)} \stackrel{\text{def}}{=} \min(t_1, \ldots, t_m)$. Due to the property (1), if we replace S_1 and S_2 with $S_1 \cup S_2$ and $S_1 \cap S_2$, the sum of the prices either decreases or stays the same:

$$v(S_1) + v(S_2) \ge v(S_1 \cup S_2) + v(S_1 \cap S_2). \tag{5}$$

By adding $v(S_3)$ to both sides, we get

$$v(S_1) + v(S_2) + v(S_3) \ge v(S_1 \cup S_2) + v(S_1 \cap S_2) + v(S_3). \tag{6}$$

Similarly, if we replace $S_1 \cup S_2$ and S_3 with $S_1 \cup S_2 \cup S_3$ and $(S_1 \cup S_2) \cap S_3$, the sum of prices does not decrease:

$$v(S_1 \cup S_2) + v(S_3) \ge v(S_1 \cup S_2 \cup S_3) + v((S_1 \cup S_2) \cap S_3). \tag{7}$$

By adding $v(S_1 \cap S_2)$ to both sides, we get

$$v(S_1 \cup S_2) + v(S_1 \cap S_2) + v(S_3) \ge v(S_1 \cup S_2 \cup S_3) + v((S_1 \cup S_2) \cap S_3) + v(S_1 \cap S_2), \tag{8}$$

and hence, due to (6), we get

$$v(S_1) + v(S_2) + v(S_3) \geq v(S_1 \cup S_2 \cup S_3) + v((S_1 \cup S_2) \cap S_3) + v(S_1 \cap S_2). \quad (9)$$

By adding $v(S_4)$ to both sides, we get

$$v(S_1)+v(S_2)+v(S_3)+v(S_4) \geq v(S_1 \cup S_2 \cup S_3)+v((S_1 \cup S_2) \cap S_3)+v(S_1 \cap S_2)+v(S_4). \quad (10)$$

If we replace $S_1 \cup S_2 \cup S_3$ and S_4 with $S_1 \cup S_2 \cup S_3 \cup S_4$ and $(S_1 \cup S_2 \cup S_3) \cap S_4$, the sum of prices does not increase:

$$v(S_1 \cup S_2 \cup S_3) + v(S_4) \geq v(S_1 \cup S_2 \cup S_3 \cup S_4) + v((S_1 \cup S_2 \cup S_3) \cap S_4), \quad (11)$$

and thus,

$$v(S_1) + v(S_2) + v(S_3) + v(S_4) \geq$$
$$v(S_1 \cup S_2 \cup S_3 \cup S_4) + v((S_1 \cup S_2 \cup S_3) \cap S_4) + v((S_1 \cup S_2) \cap S_3) + v(S_1 \cap S_2). \quad (12)$$

After repeating this argument for all n items, we conclude that

$$v(S_1) + \ldots + v(S_n) \geq$$
$$v(S_1 \cup \ldots \cup S_n)+v((S_1 \cup \ldots \cup S_{n-1}) \cap S_n)+\ldots+v((S_1 \cup \ldots \cup S_{i-1}) \cap S_i)+\ldots v(S_1 \cap S_2). \quad (13)$$

Thus, in the purchasing plan P, we can replace $S_1, \ldots, S_n$ with a new sequence of sets in which one of them is the union $S'_1 = S_1 \cup \ldots \cup S_m$ of the original sets – and do not increase the total price. We can do this with all $t_{(1)}$ copies of all the sets $S_1, \ldots, S_m$.

All the remaining sets in the resulting purchasing plan are then proper subsets of the union S'_1.

To the remaining sets, we can apply the same procedure, and get a new collection of sets in which one of the sets S'_2 is a union of the remaining sets (and hence $S'_2 \subset S'_1$) and others are proper subsets of S'_2. Repeating this procedure for all the remaining sets, we get a collection with a new set $S'_3 \subset S'_2$, etc. After we repeat this procedure m times, we get a new purchasing plan, with sets $S'_1, S'_2, \ldots, S'_m$ repeated certain number of times $t'_1, \ldots, t'_m$. By construction, we have

$$S'_1 \supset S'_2 \supset \ldots \supset S'_m. \quad (14)$$

Since on each step of this construction, the price of the purchasing plan does not increase, we conclude that

$$v(P) = t_1 \cdot v(S_1) + \ldots + t_m \cdot v(S_m) \geq t'_1 \cdot v(S'_1) + \ldots + t'_m \cdot v(S'_m). \quad (15)$$

Let us show that the new purchasing plan $P' = \langle (S'_1, \ldots, S'_m), (t'_1, \ldots, t'_m) \rangle$ is exactly the plan P_0. Then, (15) would mean that $v(P) \geq v(P_0)$.

Indeed, at each step, we did not change the total number of objects of each type, so the new purchasing plan still satisfies the original task d. Thus, for every element x_i, d_i is equal to $\sum\limits_{j=1}^{m} t'_j \cdot \chi_{S'_j}(x_i)$. For values x_i that belong to S'_m, due to (14), we have $d_i = t'_1 + \ldots + t'_m$. For values x_i that belong to S'_{m-1} but do not belong to S'_m, i.e., that belong to the set difference $S'_{m-1} \setminus S'_m$, we get $d_i = t'_1 + \ldots + t'_{m-1}$. In general, for values x_i that belong to $S'_j \setminus S'_{j+1}$, we have

$$d_i = t'_1 + \ldots + t'_j. \quad (16)$$

Thus, all elements from each set $S'_j \setminus S'_{j+1}$ have the exact same value d_i, which we will denote by $d(j)$. By (16), the larger j, the larger the corresponding values $d(j)$, i.e., $d(1) \leq d(2) \leq \ldots \leq d(m)$. In other words, the values $d(j)$ are the values d_i sorted in increasing order – i.e., in effect, the values $d_{(j)}$.

The set S'_1 consists of all the items. The set S'_2 consists of all the items except for the items from the set difference $S'_1 \setminus S'_2$. Thus, to get S'_2, we exclude the elements with the smallest possible value $d(1)$, and only include the elements x_i for which $d_i \geq d(2)$. Similarly, the set S'_j consists of all the elements x_i for which $d_i \geq d(j)$. Thus, if we sort the elements x_i in the increasing order of their values d_i, we conclude that $S'_j = \{x_{(j)}, x_{(j+1)}, \ldots, x_{(n)}\}$, i.e., we get the same sets as in the purchasing plan P_0.

By comparing the values $d_{(i)} = t'_1 + \ldots + t'_{i-1} + t'_i$ and $d_{(i-1)} = t'_1 + \ldots + t'_{i-1}$ computed according to the formula (16), we conclude that $t'_i = d_{(i)} - d_{(i-1)}$, i.e., that not only the sets in the purchasing plan P' are the same as in P_0, but the numbers of times are the same. Thus, indeed, $P' = P_0$, and the theorem is proven.

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THE CONNOTATION, MODELS AND STRATEGIES OF LEISURE INDUSTRY CHAIN INTEGRATION

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ABSTRACT. *The development of industrial clusters plays a more and more important role in the world economy. And industry chain integration is the basic theory for its development. As one of the rising industries in the 21st century, leisure industry must join industry chain integration for its better development. Based on findings from related researches done at home and abroad, this paper applies the idea of industry chain integration to the field of leisure industry, integrates theories of industry organization with leisure economy, and aims to solve some problems that may arise in the process of leisure industry chain integration. After revealing the connotation, mode and micro-base of industry chain integration, the paper puts forward a strongly operational and measurable strategic project.*

Keywords: Leisure Industry; Industry Chain; Integration

1. Introduction. Industry chain integration is the process of promoting the integration between upstream and downstream industries. Its purpose is to draw all enterprises in different parts of value chain link closer to each other, to achieve coordination advantages and scale advantages, thus reducing costs, achieving optimal allocation of resource, and enhancing the competitiveness of industry as a whole. For its effectiveness industry chain integration has been applied to all aspects of the national economy, covering almost all industries. As one of China's emerging industries, leisure industry is essentially a convergence-based industrial system which is leaded by tourism industry chain, culture industry chain and sports and recreation industry chain. In fact, we can characterize the overall performance of leisure industry as follows: small scale, weak competitiveness, low level of coordination, few leading enterprises. And the reason is a lack of effective industry chain integration. Therefore, it is quite necessary to execute effective integration of industry chain to make leisure industry become a prosperous industry in the 21st century.

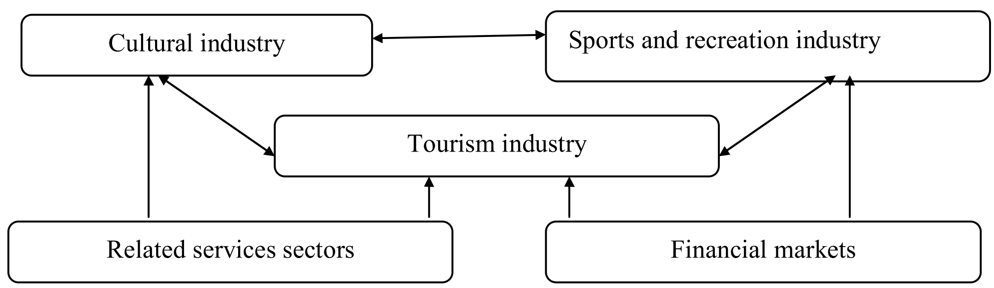
Existing researches on industry chain have mainly focused on its motivations, characteristics, models and methods, benefits, policies, and so on. Williamson (1981) proposed that the main purpose of vertical integration is to save transaction costs. Rui et al. (2006) pointed out industry chain integration based on functional division of labor, manifested by knowledge connection, puts knowledge integration which is the essence of integration at the core position of the whole integration process. Rai et al. (2006) indicated industry chain integration improves firm performance. Allen (2000)'s research pointed out that integration appears to bring about larger revenue efficiency gains than cost efficiency gains, and most of the gains appear to be linked to benefits from risk diversification. Industry chain integration mainly has three kinds of modes: horizontal integration, vertical integration and hybrid integration. And equity mergers and acquisitions, strategic alliances, industrial cluster are popular methods of industry chain integration (Rui, 2006; Zhao, 2008). Economides (1998) sumed up that vertical integration can bring the following benefits: better coordination among components; cost savings in joint production; possibility of a better integrated design; quicker information flow; vertical expansion to new components. Cheng et al. (2008) suggested that the government should develop effective industrial policy to encourage industry chain integration, establish a rational and efficient management system to guide the direction of industry chain integration, and create an open and flexible environment to reduce the costs of industry chain integration.

All these studies provide this paper with good references, but the study of the leisure industry chain integration is yet to be carried out. So it has become a political issue that the government and scholars work together to face it. By reading the latest research results both at home and abroad about industry chain integration, and combining them with the status and characteristics of the leisure industry, this paper defines the connotation of leisure industry chain integration, analyzes the integration patterns and basic conditions, and proposes integration strategies at the end of it.

2. The Connotation and Models of Leisure Industry Chain Integration.

2.1. The Connotation of Leisure Industry Chain Integration. Leisure industry chain is a value creation process that is composed of tourism industry, cultural industry and sports industry. Every element of the chain is closely connected with each other. They can create more synergies than a single industry. The value chain of leisure industry can be divided into three types: the vertical supply chain, the horizontal coordination chain and the mixed chain. Within them, the tourism industry, cultural industry, and sports and recreation industry constitute the main body of leisure industry. And related service departments and financial markets constitute a supporting system to provide consumers with leisure products. The development of leisure industry relies on the improvement of all aspects of service capacity and the assurance of quality. The relationship of each link of leisure industry is horizontal. Every link is in close relation with each other. From the information above, we can make leisure industry chain structure chart as follows:

TABLE 1. Leisure industry chain structure chart



Leisure industry chain integration can be explained like this: as a kind of productivity, leisure industry china integration puts all aspects of the various elements, various kinds of enterprises which constituted leisure industry together through specific market and government coordination mechanisms. Following the rule of "benefit and efficiency first", leisure industry promotes the optimum allocation of resources such as the people, finance, material, information, technology etc. within a certain range, making it possible to achieve reallocation of some resources including supporting services in a wider range of geographic and industrial areas. Through all of these, we achieve the purposes of reducing costs, improving structures, increasing efficiency, forming a unified market, organizing the ties of technical and economic of leisure industry chain, and promoting the rationalization and adaptability of the industry chain.

In essence, leisure industry chain integration is a kind of market integration which makes enterprises as the main body and industries as the framework. At the same time, leisure industry chain integration cannot be totally independent of the guidance of government, the coordination of industry organizations, the service of intermediary organizations, and the support of financial markets. The paper suggests related departments do as follows: the government can balance the interests of the involved parties to reach a consensus on mutual integration, and guide the integration of industry chain. It can build industry organizations of multi-stakeholder to strengthen the coordination capacity of the industry chain integration. It can improve systems of modern intermediary agencies such as companies which serve for investment and financing, property transactions, information and legal supply to enhance the service capabilities of industry chain integration. It also can establish the multi-layer financial market system to promote the organic integration of financial markets while industry chain integration plays the role of the original integration "drive".

2.2. The Integration Model. Strategic alliance is one of the most efficient models for the integration of leisure industry chain. It is built on the premise of independent business operation, and it attaches importance to link alliance partners in the joint area of each other's advantages so as to promote the business efficiency of all the alliance enterprises. Commonly, strategic alliance can be divided into three types. They are virtual alliance, common industry union strategic alliance and integrated strategic alliance.

Mergers and acquisitions (M&A) is a primary model for leisure industry chain integration. It is also an effective way to reduce costs or reconfigure the resource of enterprise, thus to improve the competition of the company. M&A can be classified into horizontal type, vertical type, and mixed type. Horizontal M&A involves two or more enterprises which engaged in the same type of business (for example, among hotels, among travel agencies, among entertainment enterprises, etc.). Vertical M&A happens among businesses in the same industry but different segments of the industry chain. For instance, travel agencies merger hotels, sports retailers takeover their manufacturers and so on. Mixed M&A involves businesses which engage in unrelated business of enterprises, for example, a tourist attraction buys the shares of an animation company and holds its shares.

Industry cluster is a highly effective new model of leisure industry chain integration. It integrates the leisure industry chain based on space view. It should rely on the joint efforts of the government, industry associations and enterprises to promote the integration of leisure industry chain with the help of industrial clusters. The government can build leisure creative parks, leisure science and technology park, LBD (leisure Business District), etc., to form industry cluster. The government should use many kinds of ways to attract investment and make preferential policies to attract many businesses to these areas. Then it can plan rational industrial structure and ultimately achieves the concentration of leisure industry to reach the integration effect of industry chain.

3. The Strategies of Leisure Industry Chain Integration.

3.1. Integrating Cognitive Environment to Form an Integrated Industry Chain of Social Consensus. First of all, we should take measures to improve the understanding of leisure industry education and cultivate the social consensus on developing leisure industry in the whole society. Secondly, we should enhance cognitive education of the nature of leisure industry to form the concept and behavior of integration. As we know, industry chain integration is essentially a kind of innovative behavior, so we can make people from all walks of life and all the involved participants fully understand the importance of innovation by the activities of cognitive education. We should make all-out efforts to encourage people to participate in innovation, making it the inherent drive for the integration of leisure industry chain, as well as making it a supporting force for dealing with internal and external environmental changes. Thirdly, we should strengthen cognitive education of chain integrity and integration to achieve stakeholders of industry chain integration in a win-win situation. In addition, we also should strengthen the risk education of chain integration to improve the awareness of risk prevention and the ability of risk prediction in the process of integration.

3.2. Integrating External Environment of Industry to Optimize External Drive Mechanism for the Industry Chain Integration. Integrating the institutional environment to build and promote the operational system of industry chain integration. Feasible suggestions are as follows:

Reorganize regulation structure. Involve related government departments to establish a coordinated management body by which these departments can promote the development of leisure industry, and enhance the process of industry chain integration.

Establish trade organizations. It is highly recommendable that a Leisure Industry Coordinating Committee be established. The Committee can do a lot of things to improve external environment, such as communicating to the public the spirit of government’s plan and requirements about the development of industry and the integration of industry chain, building public service platform for leisure industry with the help of the government, providing full-service for the development of leisure industry and the integration of leisure industry chain, making industry statute, uniforming industry standards, and establishing a sound health image of the industry and so on.

Form expert working group. It is necessary to form a Work Improvement Team, which is constituted of the relevant functional departments of senior officials, specialists in business practice circle and the experts in theoretical circle. The Work Improvement Team is a permanent establishment, affiliating to Leisure Industry Coordinating Committee. It dedicates the following things: studying the development of leisure industry, the integration of leisure industry chain, the integration of the various regulatory bodies and the corresponding policies of leisure industry; studying the various branches of leisure industry's developing planning and corresponding policies; and finding collaboration and integration path for existing planning and policies of branch industries.

Integrating institutional environment system to build the security system which promotes the integration of industry chain. In order to achieve the purpose above, the relevant departments should take such measures: making development plan of leisure industry and integration plan of industry chain; broadening the entry-barriers of the industry, and promoting industrial integration; innovating and optimizing the corresponding policies about the development of leisure industry and the integration of leisure industry chain; establishing security system of the integration of leisure industry chain.

Integrating investment and financing environment to build a financial market system which promote the industry chain integration. The following way is suggested to reach the goal: converting the usage of loans, making use of capital markets, guiding private investment, accelerating the introduction of foreign investment, and strengthening the financing networks of small-and-medium enterprises.

Integrating intermediary environment to build the social service system which promotes the integration of industry chain. A well-developed market-oriented operation of social service system is an important foundation to promote the integration of leisure industry chain. And integrating the environment of intermediary is the only way to promote the integration of leisure industry chain. The following are concrete methods: building public service platform of leisure industry and nurturing modern professional intermediaries such as companies about consulting, investment and financing, market research, property rights transactions, information, technology and legal, etc.

3.3. Integrating Internal Environment of Industry to Strengthen the Internal Driven Mechanism of Industry Chain Integration. Integrating spatial layout to form development pattern of concentration which supports the industry chain integration. We can achieve the goal by making two kinds of spatial layout. One is integrating leisure venues and facilities to prevent the duplication of leisure venues and to make further integration of the existing venues and facilities in area and optimize their layout. The other is integrating the spatial layout of leisure industry to form a concentration-style leisure industry spatial development pattern that is based on enterprise-style ecological communities.

Integrating industrial structure to form a reasonable industrial structure which supports industry chain integration**.** We should actively promote the process of integration among leisure industry and other industries (such as high tech, finance, education) as well as the various branches of industry, so as to integrate the industrial structure, then form a reasonable industrial structure that supports the integration of industry chain. Industry integration directly contributes to the industrial innovation. New industries and new products which are produced on the basis of industrial integration accelerate the process of integration and optimization among the whole leisure industry and various branches of industrial structure.

Integrating product structure to form a solid micro-foundation that supports industry chain integration. There are three kinds of products we should make great efforts to develop. They are "high, refined, unique, new" products which means high-level refined, distinctive, and high added-value, integration-type products which encourage cross-industry products to integrate, integrated products which means the product or project that is comprehensive, and can promote or even integrate the development of leisure products or projects in the entire chain of leisure industry.

Integrating industrial organization to form the core competitiveness that supports industry chain integration and to achieve a mechanism for leisure industry chain integration that is dominated by enterprises.

Integrating marketing resources and innovating marketing methods to achieve an overall marketing strategy. Based on different industry chain levels and parts, leisure marketing should establish an Integrated Marketing System characterized by clear labor division and close collaboration.

Integrating human resources and innovating personnel training model to build a diversified talent echelon that is adapted to leisure industry chain integration.

4. Conclusions. Along with the policies of developing modern service industry and expanding domestic demand, leisure industry naturally becomes one of the most preferred industries to implement new economic policies. And the industry chain integration is the foundation for leisure industry to fulfill its historic mission. Based on findings from related researches done at home and abroad, this paper applies the idea of industry chain integration to the field of leisure industry, integrates theories of industry organization with leisure economy, and aims to solve some problems that may arise in the process of leisure industry chain integration. After revealing the connotation, mode and micro-base of industry chain integration, the paper puts forward a strongly operational and measurable strategic project. Hopefully this paper can help upgrade and even optimize the leisure industry of China.

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DYNAMIC CASUAL RELATIONSHIPS AMONG MACROECONOMIC VARIABLES IN DEVELOPING ECONOMIES: A PANEL COINTEGRATION/VECTOR CORRECTION APPROACH

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ABSTRACT. *Many theoretical and empirical studies have addressed the important question of the exact causal relationship among macroeconomic variables such as the money supply, gross domestic product, the interest rate, the price level, the exchange rate , population and saving rate. The propose of this article is to conduct empirical test to identify, measure, and test the significance of the dynamic casual relationships among the macroeconomic variables money supply, gross domestic product, the interest rate, the price level, the exchange rate ,population and saving rate in 95 developing economies. In the framework of this empirical analysis, we applied the panel cointegration technique and investigated the existence of causal relationships of the variables in use. The main finding from the panel results is that there is a long-term equilibrium relationship among these variables except population and saving rate implying that demand side is the main source to determined output. This finding has strong policy implications for any monetary expansion since it found that money supply has greater impacts on gross domestic product than the other nominal variables, such as prices or exchange rates or interest rates in developing country.*

Keywords: Panel Cointegration; Causal Relationship; Panel Vector Error Correction; Macroeconomic Variables

1. Int roduction. Many theoretical and empirical studies have addressed the important question of the exact causal relationship among macroeconomic variables such as the money supply, gross domestic product, the interest rate, the price level ,the exchange rate , population and saving rate. Different schools of thought, such as the Classicals, the Keynesians, the Monetarist, the new Classicals, the new Keynesians and the New Growth Theorists, have provided different explanations about the relationship among these variables. For example, Keynes believed that effective demand plays a pivotal role in determining output. While acknowledging that a positive monetary shock will increase economic activity and the price level, Keynes emphasized fiscal rather than monetary policy as more important to the economy.

The monetarist school provides a different explanation: the money supply is the primordial factor in determining national income. Friedman and Schwartz (1963) studied the relationship between money supply and output, and the implications for effective of monetary policy in USA over a country. They advocated a Central Bank policy aimed at keeping the supply and demand for money at equilibrium, to adjust for differential growth rates of productivity and demand. Their conclusion was that monetary policy was effective and could explain the fluctuations in output.

Keynesians, Monetarists and the New Classicals agree that fluctuations around the trend are caused by nominal demand shocks such as monetary shocks, not real supply shocks such as technological breakthroughs. However, Nelson and Plosser (1982)'s attempt to answer whether fluctuations have a permanent component found that real factors such as the labour supply and technological innovation both determine output in the long run and act as substantial sources of shock to the economy. It is important to note that the labour supply is a double-edged sword in terms of policy to increase GDP per capita, since population and labour force growth rates are highly correlated.

Since the mid-1980s, the New Growth or Endogenous Growth Theory has emerged to criticize the neo-classical growth model. In the neo-classical models, the long-run growth rate is exogenously determined by either assuming a savings rate (the Harrod–Domar model) or a rate of technical progress net of depreciation and population growth (Solow model). As a result, the Solow model introduces the concepts of "effective" labour, capital "deepening" and capital "widening." However, the savings rate, population growth rate, and rate of technological progress remain exogenous and unexplained. Endogenous growth theory emphasized that economic growth results from increasing return associates with new knowledge. As a partial correction to these problems, the Hayami-Ruttan model endogenizes technical and institutional change as a response to changes in relative factor prices.

A vast empirical literature, such as Ambler (1989), Kamasa and Joyce (1993), Masih and Masih (1996b), Husain and Abbas (2000), Karras (1994, 1999), Chaido and Antonios (2005), Chaudhry et al. (2005) and Hsing et al. (2009), has tested the predictions of these theories. Some papers have found that the money supply does not affect output. For example, Ambler (1989) studied the impact of movement in monetary variables on movement of real output in Canada and found that increases in the money stock relative to nominal income raise spending and output in the short run. Moreover, the observed stationarity of Canadian velocity implies that money affects only price in the long run. Kamasa and Joyce (1993) investigated the impact of changes in monetary variables on the domestic and foreign sectors, the determinants of central bank policy, and the response to foreign monetary changes in Mexico and India. Their paper found that domestic monetary policy did not affect output in either country. Output responded in each country only to changes in foreign, not domestic, money. Masih and Masih (1996b) discerned the dynamic causal chain (in the Granger temporal sense rather than in the structural sense) among real output, money, interest rate, inflation and the exchange rate in the context of a small Asian developing economy, such as Indonesia. Their findings have clear policy implications for any accommodative and/or excessive monetary expansion since it is likely to be dissipated in terms of relatively higher nominal variables, such as prices, exchange rates or interest rates rather than real output. Husain and Abbas (2000) re-examined the causal relationship between money and income and between money and prices in Pakistan. Their paper showed that a unidirectional causality runs from income to money implying that probably real factors rather than money supply has played a major role in increasing Pakistan's national income. On the other hand, Karras (1994, 1999) find that money supply affects output, which increases its influence on inflation. Hsing et al. (2009) apply monetary function to explain fluctuation in output in Bangladesh and this paper found that real depreciation, a higher real stock price, a lower real federal funds rate, and more world output would increase real output.

However, there are some research that explain the historical patterns of fluctuations in economic activity and whether or not macroeconomic policy has any significant contribution to the patterns such as Canlas (2003), Cheng (2003), Hsing (2006), Balcilar and Tuna (2009) which shows that saving rate and population growth have positive and negative effects on growth and suggest that supply-side shocks are the main source of output fluctuations in the long run.

Moreover this article proposes to study the relationship among macroeconomic variables which as same framework as Masih and Masih (1996b), Chaido and Antonios (2005), Chaudhry et al. (2005) and Hsieh (2006) which have examined the interrelationship among money supply and macroeconomic variables for various countries and time periods. Furthermore, the different results lead to difficulty in making clear policy recommend-dations. The new advances in econometric modeling help to answer the question of the interrelations among the macroeconomic variables.

The propose of this article is to conduct empirical test to identify, measure, and test the significance of the dynamic casual relationships among the macroeconomic variables money supply, gross domestic product, the interest rate, the price level, the exchange rate , population and saving rate in 95 developing economies.

The remainder of this paper is organized as follows. Section 2 describes the data source as well as the limitations of the analysis. Section 3 outlines the methodology to test results for cointegration, unit root and estimated of error correction model. Section 4 presents and discusses the empirical results. Finally; section 5 draws together some concluding remarks.

2. Data and Empirical Methodology.

2.1. Data. The empirical analysis is based on 95 developing countries which is comprising equal numbers of Central and Eastern Europe, Middle East, Western Hemisphere, Commonwealth of Independent States, Asia and Sub-Saharan Africa.

We use annual data for the period 1996-2008 to investigate the casual relationships among macroeconomic variables such as the money supply, gross domestic product, the interest rate, the price level, the exchange rate, population and saving rate. Gross Domestic Product (GDP) at current price, money supply (M1), Interest rate (IR), National currency per us dollar or nominal exchange rate (ER) ,inflation rate (CPI) with base 2000 ,population (POP) and Saving rate at percent of GNI (SA) are used as income, money supply, interest rate, exchange rate ,level of price ,population and saving rate, respectively. The length of the period is dictated by the availability of data.

All series are obtained from the IMF (2009) and Central Bank of each country. The data were converted into natural logarithms prior to the empirical analysis.

3. Econometric Methodology. Following established procedures, we conduct the test of the causal relationship among money supply, gross domestic product, the interest rate, the price level, the exchange rate ,population and saving rate. in three stages. First, we test for the order of integration in the money supply, gross domestic product, the interest rate, the price level, the exchange rate, population and saving rate series. Next, we employ panel cointegration tests to examine the long-run relationships among the variables. Finally, we use dynamic panel causality tests to evaluate the short run cointegration and the direction of causality among the variables.

3.1. Panel Unit Root. The cointegration properties of the variables involved determine the appropriate specification of the real output function. If the series are cointegrated, then the relationship between macroeconomic variables such as money supply, gross domestic product, the interest rate, price level ,the exchange rate ,population and saving rate should be interpreted as a long run equilibrium, as deviations are mean-reverting. However, it is well known that, in small samples, standard unit root and cointegration tests can have low power against stationary alternatives. Panel data circumvent the low power problem of standard unit root tests by increasing the number of observations (Baltagi, 2007).

Six panel unit root tests were used in this paper: the Levin and Lin (1992, 1993) test, Breitung (2000), Im et al. (2003), two Fisher-Type tests using ADF and PP-test: Maddala and Wu (1999), Choi (2001) and Hadri (2000).

In general, the type of panel unit root tests is based on the following univariate regression;

$$\Delta y_{it} = \rho_i y_{it-1} + z'_{it}\gamma + u_{it} \tag{1}$$

where i=1,2,…,N is the country, t =1,2,…,T z_{it} is the deterministic components and u_{it} is i.i.d $(0,\sigma_i^2)$ z_{it} could be zero, one, the fixed effects or fixed effect as well as a time trend (t).

For the five considered tests, the null hypothesis is that all series have a unit root, that is $\rho_i = 0 \ \forall i$. The five tests have different alternative hypothesis, depending on different degrees of heterogeneity under the alternative hypothesis.

In the Levin and Lin (LL) tests, assume homogeneous autoregressive coefficients between individual, i.e. $\rho_i = \rho \ \forall i$ and test null hypothesis $H_o : \rho_i = \rho = 0$ against the alternative $H_a : \rho_i = \rho < 0$ .However, the LL test has some limitations. First of all, the test depends crucially upon the independence assumption across individuals and hence not applicable if cross sectional correlation is present. Second, the assumption that all cross-sections have or do not have a unit root is restrictive.

For this reason, Im et al. (2003) extend the Levin and Lin framework to allow for heterogeneity in the value of the autoregressive coefficient under the alternative hypothesis. Indeed, the alternative hypothesis can be written: $\rho_i < 0$ *for* $i = 1,2,..., N_1$ and $\rho_i = 0$ for $i = N_1 + 1,..., N$. Thus, under alternative hypothesis, some (but not all) of individual series may be characterized by a unit root. Two tests are proposed by Im et al.: a group mean t-bar statistic for $\rho_i = 0$ based on the t-statistics derived from the N augmented Dickey-Fuller regressions, and a group-mean Lagrange multiplier (LM) statistic which is based on averaging the single-country LM-statistics for $\rho_i = 0$.

The Breitung (2000) panel unit root test is based on the regression.

$$y_{it} = \eta_{it} + \sum_{k=1}^{\rho+1} \beta_{ik} x_{i,t-k} + \varepsilon_t \tag{2}$$

The test statistic examines the null hypothesis that the process is difference stationary: $H_0 : \sum_{k=1}^{\rho+1} \beta_{ik} - 1 = 0$ .The alternative hypothesis assumes that the panel series is stationary; i.e, $\sum_{k=1}^{\rho+1} \beta_{ik} - 1 < 0$ for all i. Breitung (2000) uses the following transformed vectors to construct the test statistic;

$$Y_i^* = AY_i = \left[y_{i1}^*, y_{i2}^*, \ldots, y_{iT}^*\right]' \tag{3}$$

$$X_i^* = AX_i = \left[x_{i1}^*, x_{i2}^*, \ldots, x_{iT}^*\right]' \tag{4}$$

Leading to the following test statistic:

$$\lambda_\beta = \frac{\sum_{i=1}^{N} \sigma_1^{-2} Y_i^{*'} X_i^{*'}}{\sqrt{\sum_{i=1}^{N} \sigma_1^{-2} X_i^{*'} A' A X_i^*}} \tag{5}$$

which is shown to have a standard normal distribution.

The Maddala and Wu (1999) test is a non-parametric Fisher-type test which is based on the combination of the p-values of test-statistics for a unit root in each cross-sectional unit. Both the Im-Pesaran-Shin and Fisher tests combine information based on individual unit root tests and relax the restrictive assumption of the LL test that ρ_i is the same under the alternative.

Finally, Hadri (2000) is similar to the KPSS unit root test, and has a null hypothesis of no unit root in any of the series in the panel. Like the KPSS test, the Hadri test is based on the residuals from the individual OLS regressions of y_{it} on a constant, or on a constant and a trend.

3.2. Panel Cointegration Test. Like the panel unit root tests, panel cointegration tests can be motivated by the search for more powerful tests than those obtained by applying individual time series cointegration tests.

Then if [lnm, lngdp, lnir, lner, lncpi, lnpop, lnsa] contains a panel unit root, the issue arises whether there exists a long-run equilibrium relationship between the variables. We test for panel cointegration using Pedroni's (2004) test that allows for heterogeneity in the intercepts and slopes of the cointegrating equation and Kao Test (1999). However, Giorgia Marini (2007) compare power of panel tests of cointegration by using a panel of 20 OECD countries observed over the period 1971-2004. The choice of most powerful test depends on the values of the sample statistics. This paper suggests that there are a clear-cut conclusion on the most powerful test cannot be reached.

(1) Pedroni's (2004) test

Pedroni provided seven statistics for the test of the null of no cointegration in heterogeneous panels. A group of the tests are termed "within dimension" (panel tests) and the other group as "between dimension" (group tests). The "within dimension" tests pool the data across the ''within dimension''. It takes into account common time factors and allows for heterogeneity across members. The ''between dimension'' tests allow for heterogeneity of parameters across members, and are called ''group mean cointegration statistics.'' The seven Pedroni (2004) panel cointegration test statistics that we employ are as follows:

Within dimension (panel tests):

(1) Panel v-statistic
$$Z_v = \left(\sum_{i=1}^{N} \sum_{t=1}^{T} \hat{L}_{11i}^{-2} \hat{e}_{i,t-1}^{2} \right)^{-1} \tag{6}$$

(2) Panel ρ-statistics.
$$Z_p = \left(\sum_{i=1}^{N} \sum_{t=1}^{T} \hat{L}_{11i}^{-2} \hat{e}_{i,t-1}^{2} \right)^{-1} \sum_{i=1}^{N} \sum_{t=1}^{T} \hat{L}_{11i}^{-2} \left(\hat{e}_{i,t-1} \Delta \hat{e}_t - \hat{\lambda}_i \right) \tag{7}$$

(3) Panel PP-statistic.
$$Z_{pp} = \left(\hat{\sigma}^2 \sum_{i=1}^{N} \sum_{t=1}^{T} \hat{L}_{11i}^{-2} \hat{e}_{i,t-1}^{2} \right)^{-1/2} \sum_{i=1}^{N} \sum_{t=1}^{T} \hat{L}_{11i}^{-2} \left(\hat{e}_{i,t-1} \Delta \hat{e}_t - \hat{\lambda}_i \right) \tag{8}$$

(4) Panel ADF-statistic.
$$Z_t = \left(\hat{S}^{*2} \sum_{i=1}^{N} \sum_{t=1}^{T} \hat{L}_{11i}^{-2} \hat{e}^{*2}_{i,t-1} \right)^{-1/2} \sum_{i=1}^{N} \sum_{t=1}^{T} \left(\hat{L}_{11i}^{-2} \hat{e}^{*}_{i,t-1} \Delta \hat{e}^{*}_{i,t} \right) \tag{9}$$

Between dimension (group tests):

(5) Group ρ-statistics.
$$\tilde{Z}_\rho = \sum_{i=1}^{N} \left[\sum_{t=1}^{T} \hat{e}_{i,t-1}^{2} \right]^{-1} \sum_{t=1}^{T} \left(\hat{e}_{i,t-1} \Delta \hat{e}_{i,t} - \hat{\lambda}_i \right) \tag{10}$$

(6) Group PP-statistic.
$$\tilde{Z}_{pp} = \sum_{i=1}^{N} \left[\hat{\sigma}^2 \sum_{t=1}^{T} \hat{e}_{i,t-1}^{2} \right]^{-1/2} \sum_{t=1}^{T} \left(\hat{e}_{i,t-1} \Delta \hat{e}_{i,t} - \hat{\lambda}_i \right) \tag{11}$$

(7) Group ADF -statistic.
$$\tilde{Z}_t = \sum_{i=1}^{N} \left[\sum_{t=1}^{T} \hat{S}^{*2} \hat{e}^{*2}_{i,t-1} \right]^{-1} \sum_{t=1}^{T} \left(\hat{e}^{*}_{i,t-1} \Delta \hat{e}^{*}_{i,t} \right) \tag{12}$$

where $\hat{\sigma}^2$ is the pooled long-run variance for non parametric model given as $1/N \sum_{i=1}^{N} \hat{L}_{11} \hat{\sigma}_i^2$ and $\hat{\lambda}_i = 1/2 \left(\hat{\sigma}_i^2 - \hat{S}_i^2 \right)$,where $\hat{L}_i$ is used to adjust for autocorrelation in panel parameter model, $\hat{\sigma}_i^2$ and $\hat{S}_i^2$ are the long-run and contemporaneous variances for individual i, and $\hat{S}_i^2$ is obtained from individual ADF-test of $e_{i,t} = \rho_i e_{i,t-1} + v_{i,t}$. $\hat{S}_i^{*2}$ is the contemporaneous variances from the parametric model, $\hat{e}_{i,t}$ is the estimated residual from the parametric cointegration, while $\hat{e}^{*}{}_{i,t}$ is the estimated residual from parametric model. $\hat{L}_{11i}$ is the estimated long-run covariance matrix for $\Delta\hat{e}_{i,t}$ and L_i is the ith component of low triangular Cholesky decomposition of matrix Ω_i for $\Delta\hat{e}_{i,t}$ with the appropriate lag length determined by the New-West method.

Seven of Pedroni's tests are based on the estimated residuals from the following long-run model:

$$\ln gdp_{i,t} = \alpha_i + \beta_i \ln m_{i,t} + \gamma_i \ln ir_{i,t} + \theta_i \ln er_{i,t} + \eta_i \ln cp_{i,t} + \lambda_i \ln pop_{i,t} + \pi_i \ln sa_{i,t} + \varepsilon_{i,t} \tag{13}$$

where $\varepsilon_{i,t} = \rho_i \varepsilon_{i,(t-1)} + \mu_{i,t}$ are the estimated residuals from the panel regression and lngdp, lnm, lnir, lner, lncp, lnpop and lnsa are the natural logarithms of GDP, money supply, interest rate, exchange rate, price level, populations and saving rate, respectively.

The null hypothesis tested is whether ρ_i is unity. Pedroni (2004) suggests a Phillips–Perron-type Test to test cointegration. The statistics can be compared to appropriate critical values, and if critical values are exceeded then the null hypothesis of no cointegration is rejected, implying that a long-run relationship between the variables does exist.

(2) Kao Tests (1999).

Kao tests the residuals $\hat{\varepsilon}_{i,t}$ it of the OLS panel estimation by applying DF- and ADF-type tests:

$$\hat{\varepsilon}_{i,t} = \rho_i \varepsilon_{i,(t-1)} + \mu_{i,t} \tag{14}$$

The null hypothesis of no cointegration, H_0: ρ=1, is tested against the alternative hypothesis of stationary residuals, H_1: $\rho \neq 1$. Kao presents five DF and ADF types of cointegration tests in the panel data. The test statistics are DF and ADF, which are for cointegration with the endogenous regressors, and DF which are based on assuming strict endogeneity of the regressors.

3.3. Panel Long Run Estimators. First, we will estimate the model by using pooled OLS estimator. However, pooled time series data, much like univariate time series data, tend to exhibit a time trend and are, therefore, non-stationary; i.e., the variables in question have means, variances, and covariances that are not time invariant. Therefore, we are using panel-OLS, panel-DOLS and panel-GMM to estimate our model.

For pooled model, consider the following system of cointegrated regressions

$$y_{i,t} = \alpha_i + x_{i,t}\beta_i + u_{i,t} \tag{15}$$

Pooled model assume that regressors are exogenous and simply write the error as $u_{i,t}$ rather than using the decomposition $\alpha_i + u_{i,t}$, then

$$y_i = \alpha + x_i\beta_i + u_i$$

Note that x_{it} here does not include a constant whereas in cross-section data x_i additionally included a constant term.

For panel cointegrated regression models, the asymptotic properties of the estimators of the regression coefficients and the associated statistical tests are different from those of time series cointegration regression models. Some of these differences have become apparent in recent works by Kao and Chiang (2000), Phillip and Moon (1999) and Pedroni (2000, 2004). Chen et al. (1999) investigated the finite sample properties of the OLS estimator the t-statistic, the bias-corrected OLS estimator and the bias-corrected t-statistic. They found that, in general, the bias-corrected OLS estimator does not improve over the OLS estimator. Moreover, to estimate dynamic panel models Arellano and Bond (1991) suggest that Generalized Method of Moments (GMM) gives estimators that are more efficient and consistent.

Kao and Chiang (2000) consider the following panel regression

$$y_{it} = x'_{it}\beta + z'_{it}\gamma + u_{it} \tag{16}$$

where $\{x_{it}\}$ are $k \times 1$ integrated processes of order one for all i and $x_{it} = x_{it-1} + \varepsilon_{it}$ The OLS estimator of β is

$$\hat{\beta}_{OLS} = \left[\sum_{i=1}^{N}\sum_{t=1}^{T} \tilde{x}_{it}\tilde{x}'_{it}\right]\left[\sum_{i=1}^{N}\sum_{t=1}^{T} \tilde{x}_{it}\tilde{y}_{it}\right] \tag{17}$$

However this estimator was showed by Kao and Chiang (2000) that $\hat{\beta}_{OLS}$ is inconsistent using panel data. As an alternative to OLS, to correct for serial correlation and non-exogeneity of the regressors, a panel version of the DOLS estimator can be used, based on

$$y_{it} = x'_{it}\beta + \sum_{k=-K_i}^{K_i} \gamma_{ik}\Delta x_{it-k} + \varepsilon_{it}\,, \tag{18}$$

where

$$\hat{\beta}_{DOLS} = \left[N^{-1}\sum_{i=1}^{N} \left(\sum_{t=1}^{T} z_{it} z'_{it} \right)^{-1} \left(\sum_{t=1}^{T} z_{it}\tilde{y}_{it} \right) \right]_1 \tag{19}$$

and where

z_{it} = is the 2(K+1) x 1 vector of regressors $z_{it} = (x_{it} - \bar{x}_i, \Delta x_{it-k}, \ldots, \Delta x_{it+k})$

$\tilde{y}_{it}$ = $y_{it} - \bar{y}_{it}$, and the subscript 1 outside the brackets indicates the first elements of the vector used to obtain the pooled slope coefficient.

Another methodology is GMM. Formally, the model (16) is transformed into the following difference equation:

$$y_{it} - y_{it-1} = \beta'(X_{it} - X_{it-1}) + \gamma'(z_{it} - z_{it-1}) + (u_{it} - u_{it-1}) \quad \text{i=1,…,n t=2,…,T}_\text{i} \tag{20}$$

However,from (20) the bias arises since $y_{it-1} - y_{it-2}$ is correlated with the transform error term ($u_{it} - u_{it-1}$), OLS on dynamic panel will be consistent.

But if there are valid instruments, then GMM can be used to estimate the equation. Typically, we use lags of the dependent variable, two periods back, as y_{it-2} is uncorrelated with ($u_{it} - u_{it-1}$).Thus values of $y_{it-k}, k \geq 2,$ are valid instruments.

3.4. Pa nel Vec tor Error Correction Mo del. Once the variables were cointegrated, the next step performed was the causality test. We used a panel-based (VECM) to identify the existence and direction of a long-run equilibrium relationship using the two-step procedure of Engle and Granger (1987). In the first step, we estimated the long-run model using Eq. (13) and then we obtained the estimated residual ε (the error correction term; e_{it} hereafter). In the second step, we estimated the panel Granger causality model with dynamic error correction as follows:

$$\begin{aligned}\Delta\ln gdp = {} & \pi_{igdp} + \lambda_{gdp}e_{it-1} + \sum_p \pi_{11ip}\Delta\ln gdp_{it-p} + \sum_p \pi_{12ip}\Delta\ln m_{it-p} + \sum_p \pi_{13ip}\Delta\ln ir_{it-p} + \sum_p \pi_{14ip}\Delta\ln er_{it-p} \\ & + \sum_p \pi_{15ip}\Delta\ln cp_{it-p} + \sum_p \pi_{16ip}\Delta\ln pop_{it-p} + \sum_p \pi_{17ip}\Delta\ln sa_{it-p} + \varepsilon_{it}\end{aligned} \tag{21}$$

$$\begin{aligned}\Delta\ln m = {} & \pi_{im} + \lambda_{m}e_{it-1} + \sum_p \pi_{21ip}\Delta\ln m_{it-p} + \sum_p \pi_{22ip}\Delta\ln dgp_{it-p} + \sum_p \pi_{23ip}\Delta\ln ir_{it-p} + \sum_p \pi_{24ip}\Delta\ln er_{it-p} \\ & + \sum_p \pi_{25ip}\Delta\ln cp_{it-p} + \sum_p \pi_{26ip}\Delta\ln pop_{it-p} + \sum_p \pi_{27ip}\Delta\ln sa_{it-p} + \varepsilon_{it}\end{aligned} \tag{22}$$

$$\begin{aligned}\Delta\ln ir = {} & \pi_{iir} + \lambda_{ir}e_{it-1} + \sum_p \pi_{31ip}\Delta\ln ir_{it-p} + \sum_p \pi_{32ip}\Delta\ln gdp_{it-p} + \sum_p \pi_{33ip}\Delta\ln m_{it-p} + \sum_p \pi_{34ip}\Delta\ln er_{it-p} \\ & + \sum_p \pi_{35ip}\Delta\ln cp_{it-p} + \sum_p \pi_{36ip}\Delta\ln pop_{it-p} + \sum_p \pi_{37ip}\Delta\ln sa_{it-p} + \varepsilon_{it}\end{aligned} \tag{23}$$

$$\begin{aligned}\Delta\ln er = {} & \pi_{ier} + \lambda_{er}e_{it-1} + \sum_p \pi_{41ip}\Delta\ln er_{it-p} + \sum_p \pi_{42ip}\Delta\ln gdp_{it-p} + \sum_p \pi_{43ip}\Delta\ln m_{it-p} + \sum_p \pi_{44ip}\Delta\ln ir_{it-p} \\ & + \sum_p \pi_{45ip}\Delta\ln cp_{it-p} + \sum_p \pi_{46ip}\Delta\ln pop_{it-p} + \sum_p \pi_{47ip}\Delta\ln sa_{it-p} + \varepsilon_{it}\end{aligned} \tag{24}$$

$$\begin{aligned}\Delta\ln cp = {} & \pi_{icp} + \lambda_{cp}e_{it-1} + \sum_p \pi_{51ip}\Delta\ln cp_{it-p} + \sum_p \pi_{52ip}\Delta\ln gdp_{it-p} + \sum_p \pi_{53ip}\Delta\ln m_{it-p} + \sum_p \pi_{54ip}\Delta\ln ir_{it-p} \\ & + \sum_p \pi_{55ip}\Delta\ln er_{it-p} + \sum_p \pi_{56ip}\Delta\ln pop_{it-p} + \sum_p \pi_{57ip}\Delta\ln sa_{it-p} + \varepsilon_{it}\end{aligned} \tag{25}$$

$$\Delta \ln pop = \pi_{ipop} + \lambda_{pop} e_{it-1} + \sum_p \pi_{61ip} \Delta \ln pop_{it-p} + \sum_p \pi_{62ip} \Delta \ln gdp_{it-p} + \sum_p \pi_{63ip} \Delta \ln m_{it-p} + \sum_p \pi_{64ip} \Delta \ln ir_{it-p}$$
$$+ \sum_p \pi_{65ip} \Delta \ln er_{it-p} + \sum_p \pi_{66ip} \Delta \ln cp_{it-p} + \sum_p \pi_{67ip} \Delta \ln sa_{it-p} + \varepsilon_{it} \quad (26)$$

$$\Delta \ln sa = \pi_{isa} + \lambda_{ssa} e_{it-1} + \sum_p \pi_{71ip} \Delta \ln sa_{it-p} + \sum_p \pi_{72ip} \Delta \ln gdp_{it-p} + \sum_p \pi_{73ip} \Delta \ln m_{it-p} + \sum_p \pi_{74ip} \Delta \ln ir_{it-p}$$
$$+ \sum_p \pi_{75ip} \Delta \ln er_{it-p} + \sum_p \pi_{76ip} \Delta \ln cp_{it-p} + \sum_p \pi_{77ip} \Delta \ln pop_{it-p} + \varepsilon_{it} \quad (27)$$

where Δ is the first difference operator, e_{it-1} are the error correction terms. Parameter λ_i is the speed of adjustment to long-run equilibrium. This model can be estimated using instrumental variables to deal with the correction between the error term and the lagged dependent variables.

4. Empirical Results.

4.1. The Empirical Results of the Panel Unit Root Test. Table 1 reports (summary) panel unit root tests on the relevant variables given in equation (13) above. As can be readily seen, most of the tests (with the exception of the LLC test in one case) fail to reject the unit root null for lngdp, lnm, lnir, lner and lncp in level form in table 1, but the tests do reject the null of a unit root in difference form. The table also reports the widely used Hadri-Z test statistic, which, as opposed to the aforementioned tests, uses a null of no unit root. However, for lnpop and lnsa, most of test does reject the null of a unit root in level form, which implies lnpop and lnsa are stationary at level. Thus, the evidence suggests that the variables which is lngdp, lnm, lnir, lner and lncp do evolve as non-stationary processes and the application of OLS to equations (13) above will result in biased and inconsistent estimates. It is, therefore, necessary to turn to panel cointegration techniques in order to determine whether a long-run equilibrium relationship exists among the non-stationary variables in level form.

4.2. The Empirical Re sults of Panel C ointegration Test. Having established that money, gross domestic product, interest rate, level of price and exchange rate are I(1), we next proceed to test whether a long-run relationship exists between them using Pedroni's (2004) heterogeneous panel cointegration test and Kao (1999) test. The results for the seven different panel test statistics suggested by Pedroni are reported in Table 2. The statistical significance of these test statistics is provided in parenthesis in the form of p-values. Four of the seven-test statistics suggest that money, gross domestic product, interest rate, level of price and exchange rate are cointegrated at the 5 percent level or better. However, simulations made by Pedroni (1997) show that, in small samples ($T \approx 20$), the group mean parametric t-test is more powerful than the other tests, followed by the panel v test. The Kao (1999) test also suggest that money, gross domestic product, interest rate, level of price and exchange rate are cointegrated at the 10 percent level .

TABLE 1. Results of panel unit root test base on 6 method test for all variables

	lngdp	lnm	lnir	lner	lncp	lnpop	lnsa
Series in level							
Null Hypothesis: Unit root (assumes common unit root process)							
Levin,Lim and Chu	-1.61080 (0.0536)	-8.59671 (0.0000)	-38.2424 (0.0000)	-6.17130 (0.0000)	6.28423 (1.0000)	-21.4109 (0.0000)	-13.5366 (0.0000)
Breitung	11.4836 (1.0000)	9.55260 (1.0000)	3.04682 (0.9988)	4.87818 (1.0000)	5.12495 (1.0000)	1.14834 (0.8746)	6.03686 (1.0000)
Null Hypothesis: Unit root (assumes individual unit root process)							
Im,Pesaran and Shin	8.70031 (1.0000)	2.19323 (0.9859)	-4.21829 (0.0000)	1.67140 (0.9527)	15.4172 (1.0000)	-12.4525 (0.0000)	-4.57051 (0.0000)
Fisher-ADF	92.2423 (1.0000)	171.907 (0.8225)	231.491 (0.0058)	177.835 (0.2868)	118.494 (1.0000)	494.679 (0.0000)	303.688 (0.0000)
Fisher-PP	110.745 (1.0000)	208.005 (0.1762)	212.773 (0.0478)	180.078 (0.2483)	132.804 (0.9994)	457.325 (0.0000)	277.608 (0.0000)
Null Hypothesis: Stationary							
Hadri	18.7904 (0.0000)	18.6787 (0.0000)	15.9137 (0.0000)	21.9322 (0.0000)	21.0438 (0.0000)	18.8624 (0.0000)	22.2580 (0.0000)
Series in first differences							
Null Hypothesis: Unit root (assumes common unit root process)							
Levin,Lim and Chu	-27.3702 (0.0000)	-19.8532 (0.0000)	-30.0319 (0.0000)	-20.2116 (0.0000)	-17.9086 (0.0000)	-	-
Breitung	-4.80015 (0.0000)	-0.51493 (0.3033)	-4.73304 (0.0000)	-2.26788 (0.0117)	12.3741 (1.0000)	-	-
Null Hypothesis: Unit root (assumes individual unit root process)							
Im,Pesaran and Shin	-12.8004 (0.0000)	-9.79871 (0.0000)	-15.5842 (0.0000)	-7.24137 (0.0000)	-2.14928 (0.0158)	-	-
Fisher-ADF	467.028 (0.0000)	415.096 (0.0000)	517.515 (0.0000)	323.493 (0.0000)	286.355 (0.0000)	-	-
Fisher-PP	550.089 (0.0000)	600.165 (0.0000)	756.723 (0.0000)	380.969 (0.0000)	297.601 (0.0000)	-	-
Null Hypothesis: Stationarity							
Hadri	21.7543 (0.0000)	16.8501 (0.0000)	26.8623 (0.0000)	16.8203 (0.0000)	25.8845 (0.0000)	-	-

Note: An intercept and trend are included in the test equation. P-values are provided in parentheses. The lag length was selected by using the Akaike Information Criteria.

TABLE 2. Pedroni's (2004) and Kao(1999) and panel cointegration test

Test Statistic	T-Ratio	P-Value
Pedroni's (2004)		
Panel υ-statistic	3.785402***	0.0001
Panel Phillip-Perron ρ -statistic	11.85330	1.0000
Panel Phillip-Perron t-statistic	-9.849564***	0.0000
Panel ADF t-statistic	-0.767003	0.2215
Group Phillip-Perron ρ -statistic	15.52086	1.0000
Group Phillip-Perron t-statistic	-23.46893***	0.0000
Group ADF t-statistic	-5.659836***	0.0000
Kao (1999) Test	-1.460433*	0.0721

Note: Probability values are in parenthesis;*, ** and *** denote statistical significance at the 10 percent, 5 percent and 1 percent levels, respectively.

4.3. The Empirical Results of Estimating Panel Cointegration Model. Tables 3 report the results of the long-run short-run relationship for money, gross domestic product, interest rate, level of price and exchange rate based on the pool-OLS-,OLS-, DOLS- and GMM estimators with $lngdp_{it}$ as the dependent variable. The long-run results show that all variables have the expected sign and are statistically significant at the 10% level or better. Given that the variables are expressed in natural logarithms, the coefficients can be conveniently interpreted as elasticities.

From the pool-OLS estimate show a strong positive association between money supply, interest rate, exchange rate and gross domestic product in developing countries. Inflation now has a negative sign and is significant with respect to gross domestic product.

The long run panel cointegration model based on an OLS-estimator shows that money and price level have positive impacts on gross domestic product while the interest rate and the exchange rate have negative impacts on gross domestic product at the 1 percent level of statistical significance. The results indicate that the elasticity of GDP with respect to the money supply is greater in absolute terms than that with respect to either the interest rate, the price level or the exchange rate. A 1% increase in the money supply will increase gross domestic product by 0.45%.

The long run panel cointegration model based on DOLS-estimator show that money and level of price have positive impact on gross domestic product while interest rate and exchange rate have negative impact on gross domestic product at 1 percent level of statistical significance. The result indicate that elasticity of money is greater than elasticity of interest rate, level of price and exchange rate and a 1% increase in money increase in gross domestic product by 0.38%.

Moreover, the DOLS also suggest the effect of change in the short run. The result indicate that in the short run elasticity of money is greater than elasticity of interest rate, level of price and exchange rate and a 1% increase in money increase in gross domestic product by 0.20%. However, DOLS-estimator suggests that interest rate has significant impact on gross domestic product but not expected signs.

TABLE 3. Pool-OLS, panel OLS, DOLS, GMM and panel-dynamic GMM estimates

	Pool-OLS	Panel-OLS	Panel-DOLS	Panel-GMM	Panel-Dynamic GMM
Constant	-3.092881*** (0.0000)	-1.173935*** (0.0000)	-1.217076*** (0.0000)	-3.208419*** (0.0000)	-5.589876*** (0.0000)
$\ln m_{it}$	0.830458*** (0.0000)	0.450441*** (0.0000)	0.382495*** (0.0000)	0.709406*** (0.0000)	1.022447*** (0.0000)
$\ln ir_{it}$	0.131806*** (0.0000)	-0.050122*** (0.0009)	-0.045985** (0.0150)	0.145817*** (0.0000)	0.408663*** (0.0007)
$\ln cp_{it}$	-0.208704*** (0.0000)	0.218340*** (0.0000)	0.341700*** (0.0000)	0.210510*** (0.0000)	-0.035347 (0.7668)
$\ln er_{it}$	0.023310*** (0.0049)	-0.127850*** (0.0000)	-0.138859*** (0.0000)	- 0.218252*** (0.0000)	-0.006041 (0.9006)
$\Delta(\ln\ m_{it}(-1))$			0.200186*** (0.0000)		-1.413145*** (0.0000)
$\Delta(\ln\ ir_{it}(-1))$			0.072953*** (0.0007)		-0.489145*** (0.0002)
$\Delta(\ln\ cp_{it}(-1))$			0.014538 (0.6734)		-0.949156*** (0.0006)
$\Delta(\ln\ er_{it}(-1))$			0.041368 (0.3855)		-0.778828** (0.0255)
AIC	2.195274	-0.038324	-0.106655	N/A	N/A
SIC	2.216065	0.373353	0.384039	N/A	N/A

Note: Probability values are in parenthesis;*,** and *** denote statistical significance at the 10 percent ,5 percent and 1 percent levels, respectively.

Compare AIC and SIC to select model we can see that AIC suggest DOLS while SIC suggest OLS is best model. However, BIC generally penalizes free parameters more strongly than does the Akaike information criterion. Therefore, following a traditional time-series approach to model selection based on the minimization of Schwartz's Bayesian information criterion, OLS-estimator is preferred to pooled-OLS and DOLS estimator.

The results from GMM estimator show that there is a statistically significant negative relationship between the exchange rate and gross domestic product, but a statistically significant positive relationship between money supply, interest rate and gross domestic product. However, the GMM-estimator suggests that the significant impact on gross domestic product of the interest rate has an unexpected sign. For Dynamic-GMM-estimator suggest that only money supply and interest rate has significant impact on gross domestic product.

4.4. The Empirical Results of The Panel Vector Error Correction Model. The empirical results of the panel error correction model are reported in table 4. Equation 21 shows that money supply and interest rate lagged one period has a positive and significant impact on the gross domestic product. The one period lagged error correction term is statistically significant at the 10% level. This result implies that after a shock to the system, GDP reverts to its equilibrium. The speed of adjustment is equal -0.195807 that implied in the presence of one unit deviation from the long run in period t-1, gross domestic product will change by 19.5807 percent in each period or will take 5 years to back to long-run equilibrium at 10% significantly.

It further appears (Eq. 22) that one-period lagged interest rate has positive and statistically significant impacts on money supply. Moreover, the error correction term is statistically significant but does not lie between -2 and 0. Both one-period lagged gross level of price and exchange rates have a positive impact on the interest rate while once-lagged interest rate has negative impacts (Eq. 23). The error correction term is significant at 10% level. This result implies that after a shock to the system, interest rate reverts to its equilibrium. The speed of adjustment is equal -0.847243 that implied in the presence of one unit deviation from the long run in period t-1, interest rate will change by 84.7243 percent in each period to back to long-run equilibrium at 10% significantly.

Eq. 24 further indicates that one-period lagged gross domestic product, money supply and exchange rate have positive and significant impacts on the exchange rate. Though the error correction term is statistically significant and the speed of adjustment is -0.722726, which implied that exchange rate will back to long-run equilibrium by changing 72.2726 in each period. In term of Eq. (25) one lagged of interest rate has negative and statistically significant impact on level of price. However, the error correction term is not statistically significant.

TABLE 4. Panel vector error correction model

Independent Variable	**Dependent Variable**				
	D(LNGDP)	D(LNM)	D(LNIR)	D(LNER)	D(LNCP)
Error correction term	-0.195807* (-1.827657)	0.488741*** (2.614138)	-0.847243* (-1.655784)	-0.722726*** (-2.716451)	0.129514 (0.634941)
D(LNGDP(-1))	0.064971 (0.565272)	-0.352760 (-1.569244)	-0.228064 (-0.644727)	-0.761972* (-1.707772)	-0.015077 (-0.044099)
D(LNM(-1))	0.119243* (1.794439)	-0.028908 (-0.227171)	0.427333 (1.489553)	0.942189*** (3.035950)	0.105577 (0.406353)
D(LNIR(-1))	0.092119** (2.156628)	0.237018*** (2.725685)	0.471261** (2.083707)	-0.170937 (-1.169514)	-0.146089* (-1.850999)
D(LNER(-1))	0.031863 (0.462905)	-0.089702 (-0.667750)	-0.298323* (-1.933972)	0.730564*** (4.693990)	0.163501 (1.364946)
D(LNCP(-1))	0.028210 (0.471961)	0.045612 (0.341956)	-0.591181** (-2.095397)	0.021479 (0.149404)	-0.227386 (-0.396031)

Note: The t-statistics are shown in parenthesis;*,** and *** denote statistical significance at the 10 percent ,5 percent and 1 percent levels, respectively.

5. Conclusion. The main purpose of this study was to conduct empirical tests to identify, measure, and determine the sign and direction of the dynamic casual relationships among macroeconomic variables such as money, gross domestic product, interest rate, level of price , exchange rate, population and saving rate in a large sample of developing countries. In the framework of this empirical analysis, we applied the panel cointegration technique and investigated the existence of causal relationships of the variables in use. The main finding from the panel results is that there is a long-term equilibrium relationship among these variables except population and saving rate implies that demand side are the main source to determined output which same result as Blanchard and Watson (1986) , Blanchard and Quah (1989), and Hartley and Whitt Jr (2003) which study in US ,UK and European country. However, the result is different from Ahmed and Park (1994) and Bergman (1996) which found that supply shocks are the main source of output variance. The result from long-term equilibrium implies that when a deviation from long-run equilibrium does occur, error correction will make it return to equilibrium .The empirical evidence shows that money supply has greater impacts on gross domestic product than the other variables under study. The error correction model suggests that after shock to the system, gross domestic product reverts to its equilibrium but the speed of adjustment of gross domestic product to equilibrium in developing countries by changing 19.5807 percent in each period or will take 5 years which more than money supply that will take only 1.2 years to turn back to equilibrium. This finding has strong policy implications for any monetary expansion since it found that money supply has greater impacts on gross domestic product than the other nominal variables, such as prices or exchange rates or interest rates in developing country.

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STUDY ON THE ACCOUNTING METHODOLOGY FOR THE PRODUCTIVE ACTIVITIES OF CHINESE HOUSEHOLD

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ABSTRACT. *The household sector is an important institutional department in the system of national accounts, whose productive activities occupies an important position in domestic production accounting. Based on the theory of SNA2008 (System of National Accounts, UN,2008), this paper studies the accounting methodology for the observing and no-observing productive activities of Chinese household with the entry point of the concepts and scope of the household production，to design the integrated production accounts of household, and then to discuss the accounting theory of productive activities of Chinese household.*
Keywords: Accounting Methodology; Productive Activities; Chinese Household

1. Introduction. European Commission, International Monetary Fund, Organization for Economic Co-operation and Development, United Nations, World Bank commonly revised SNA1993 (System of National Accounts 1993, abbreviation SNA1993) again, and published the fourth version of SNA in 2008，that is SNA2008.

Earlier version of SNA1993 emphasized on the accounting activities of household, it suggested: In a certain country, it should be recorded while the goods and services of household production is very important for the total supply of goods and service. In fact, the economic activities of household has been regarding as the crucial content in SNA1993, the most of sections and chapters has discussed and touched upon the production, income, consumption and saving of household. So in some of the country, their the system of national accounts also attach great importance to the economic, especially production activities of the household. As market economy developing, the production of household makes an increasing influence on the national economic activities, its accounting should be more valued.

Since the 1990s, United Nations has organized experts to discuss the accounting methods of production and service oneself of household. Canada, Germany and Japan also has begun the research of this aspect one after another, and made the trail calculation of value of unpaid production activities. In the academic field, John Devereux, Luis Locay published the paper which the title is measurement for the specialized production, production of the household and the economic growth in The American Economic Review in 1992, studied the production concept and measuring method of household, and analyzed its influence on the economic growth and designed the model for measuring the consumption and total production value of household.

Quah (1986) provided a production definition of the household, the treatment method of the connected point of production activities, and the measuring method of the total value of household production. He defined that the production of household is whole economic service activities of the household out of the market, including the employed activities with the same usage from the market by the householders.

Bivens (1986) studied the calculating method of added-value of the household production, and analyzed the influence on the production from the income, size, the householder's age of the household by the data in 1977 ~ 1978 in the United States; Farman (1953) researched the production of household department, and designed the system of accounts from the visual angle of social accounting. Fischer (1994) deliberated about the influence factors, the opportunity cost of household production, and its accounting methodology. John (1996) discussed the distribution of household labor, time measurement of housework and collecting data of working time of household; Eversole (2002) studied the production, income and distribution from the micro angle by a sample with whole household in a region.

Some domestic scholars also studied accounting of household production, such as Bin (2007) holds that unpaid services is just limited unpaid services for themselves or another members of household for their final consumption, which is provided by the institutional unit household, with process of the input of production factors and output of services, therefore the unpaid services belongs to the production with economic meaning. He advocated that unpaid production should be accounted into the production scope in order to reflect the most comprehensive productive view. Zeng (2005) insisted that unpaid services is an important part of social welfare, a quite part of the human labor is occupied by the unpaid services, so it will more fully reflect the social production and economic welfare to include the accounting unpaid services, and be more easy to compare the total production between different countries and regions or that of in different periods. Accordingly, he studied systematically the definition, characteristics and classification of household. It is not difficulty to find out that domestic scholars study household productive activities with viewpoints of focusing on unpaid services, as matter of fact, same to the another sectors of national economic system, household also has the same productive activities and results, also has the input and output of production, and as well as the consumption of materials and labors, but it has its particularity, especially with a greater proportion of non-observed (informal) production. Therefore, it is worthy to discuss and study the accounting method.

According to the SNA2008 of United Nations and the states of research on production of household in domestic and international academia, this paper will be based on the characteristics of household production, to study the scope and principals of household productive activities in China, and to establish the accounting system of Chinese household production, and also to explore the accounting methods of productive activities and achievement of household. Logical structure of the full text is to define the accounting scope of household production, to discuss the accounting methodology for observed (formal) and or non-observed (informal) production and its comprehensive accounting methods for productive results, and finally is conclusion.

2. The Define of the Accounting Scope of Household Production. In accordance with the definition of the United Nations SNA2008, household is that group of people shares the same of living facilities, such as accommodation, swimming pool, all or part of the income and wealth, and consumes certain types of goods and services, mainly houses and foods. But the UN Department of Economic and Social Affairs, and the UN Statistics division published the book Time-use Guidelines: the measurement of paid and unpaid work (UN2007), which provided the production scope of the household: productive activities which is engaged by the market un-legal household enterprise, and the member of un-legal household enterprise for final usage themselves.

Generally speaking, the production is a process of inputting and outputting, with two types of output, goods and services. The former with a tangible entity can meet the demand of household and society, its ownership can be transferred from one institutional unit to another through market, and its production will be separated to subsequent sale and resale. But services is the productive activities without the ownership of the independent existence of entities for which producer provide in accordance with the needs of the consumer, it can not be traded separately, and the demand of consumer should be met when it has been produced. Forms of service are mainly to change the status of the consumer, to change the physical condition, to change people's mental state, to change the mental states of institutional unit itself etc.

In accordance with the discussions above and the suggestions of SNA2008, we divided the China's household production into two categories: observed production and non-observed production. Observed production is the industrial activities included in the area of GDP accounting, including primary production of product, product processing and various services, such as mining, hunting, fishing, processing of agricultural product, producing of agricultural product; Non-observed production is the goods and services by which is forbidden the law on sale, distribution or possession, and the activities unauthorized or be illegal, it can be divided into two types of underground production and illegal production.

Underground production of household can be defined as the economic activities in which household engaged in order to avoid taxes, paying fees, or to avoid various types of systems and standards, and the government does not intentionally conceal knowledge of it. By this definition, it includes the economic activities engaged by the household enterprise unregistered; the hidden economic activities engaged by the household enterprise registered for avoiding added value tax, income tax, and other taxes; the concealed production activities engaged by the household enterprises registered for avoiding social security and for avoiding certain statutory standards and institutions. It is worthy of note is that self-employed household is included here in the scope of underground production for it is objectively out of the accounting system regardless of whether or not their subjective concealing.

Illegal production is defined as the economic activity of various goods and services production what is law banning the production, sale, possession, including goods of the production and sale banned by law, such as drugs, yellow books, video products; production and sale of counterfeit products; goods smuggling; stolen goods trading and transferring; the services banned by state law; production and service activities registered or permitted, such as medical practice without license, small businesses without license, illegal logging and hunting, illegal fishing, etc.

The differences between underground production and illegal production is the natures of productive activities and products, which is whether or not concealing, whether or not be illegal. The activities concealed deliberately or unconsciously, being not known to the government, is the underground production; the production process or products produced being illegal is the illegal production. Because of small-scale and flexibility of household production, so its non-observed production occupies relatively a large part of the total in China. Accordingly, we describe the scope of household production as follows (table 1):

TABLE 1. Classification of household productions for accounting scope

<table>
<tr><td rowspan="6">Observed productions</td><td colspan="2">Planting, Animal husbandry and fishery Mining</td></tr>
<tr><td>Manufacturing</td><td>Constructing</td></tr>
<tr><td>Transporting, storage</td><td>Wholesale and retail</td></tr>
<tr><td>Catering and lodging</td><td>Rental and business service</td></tr>
<tr><td>Medical service</td><td>Cultural and sports service</td></tr>
<tr><td>Resident domestic service</td><td>Other types of service</td></tr>
<tr><td rowspan="4">Non-observed productions</td><td rowspan="2">Underground production</td><td>Productions for avoiding tax and fees</td></tr>
<tr><td>Concealed productions</td></tr>
<tr><td rowspan="2">Illegal production</td><td>Illegal products</td></tr>
<tr><td>Illegal services</td></tr>
</table>

Be noted that, in the practice of national economic accounting, we treat the household as a whole body or population, that "household" is actually referred as the "household sector." Therefore, all methodologies of determination and analysis are aimed at household purposes.

3. The Accounting Methodology for the Observed Productive Activities of Household.

3.1. Design of an Integrated Matrix for Productive Activities. Productive activities of household are divided into two types of observed and non-observed production, it needs separately accounting because of different methods colleting data, and therefore we can design an integrated matrix describing the scale and the input-output structure of two types of productions in total amount as follows (See table 2).

Table 2, the subject column is the various elements exhausted in the process of productions, predicate column is all kinds of productive activities. Among of them, the classification of observed productive activities is consistent with that of regular productions in GDP accounting, including planting, animal husbandry and fishery, mining, manufacturing, constructing, transporting and storage, wholesale and retail, catering and lodging, rental and business services, medical services, cultural and sports services, resident domestic service, other types of services; Non-observed productions include underground and illegal production.

TABLE 2. A general form of integrated matrix for productive activities of household

	Observed production					Non-observed production			Total
	Act1	Act2	..	Actn	Sub-total	Under ground	ille gal	Sub-total	
element 1	f_{11}	f_{12}	..	f_{1n}	$f_{1.}$	g_{11}	g_{12}	$g_{1.}$	$t_{1.}$
element 2	f_{21}	f_{22}	..	f_{2n}	$f_{2.}$	g_{21}	g_{22}	$g_{2.}$	$t_{2.}$
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
element n	f_{n1}	f_{n2}	..	f_{nn}	$f_{n.}$	g_{n1}	g_{n2}	$g_{n.}$	$t_{n.}$
Total	$f_{.1}$	$f_{.2}$	..	$f_{.n}$	$f_{..}$	$g_{.1}$	$g_{.2}$	$g_{..}$	$t_{..}$

Note: Act is abbreviation of activity

Where:

f_{ij}, is the amount of kind i of element inputted engaging in kind j of observed household production;

g_{ij}, is the amount of kind i of element inputted engaging in kind j of non-observed household production;

$F_{i.} = \sum_{j=1}^{n} f_{ij}$, is the total amount of kind i of element inputted in all kinds of observed household production;

$G_{i.} = \sum_{j=1}^{n} g_{ij}$, is the total amount of kind i of element inputted in all kinds of non-observed household production;

$F_{.j} = \sum_{i=1}^{n} f_{ij}$, is the total amount of all kind of elements inputted in all kinds of observed household production;

$G_{.j} = \sum_{i=1}^{n} g_{ij}$, is the total amount of all kind of elements inputted in all kinds of non-observed household production;

Then there:

$$T_{i.} = \sum_{j=1}^{n} f_{ij} + \sum_{j=1}^{n} g_{ij}; \quad T_{..} = f_{..} + g_{..}$$

By the integrated matrix table 1, two of indicators can be calculated: the investment coefficient of household observed production; the investment coefficient of household non-observed household production. One of them, the formula of investment coefficient of observed production of household λ_{ij} is:

$$\lambda_{ij} = \frac{f_{ij}}{\Delta y_j} \quad (i, j = 1,2,3,\ldots\ldots n) \tag{1}$$

where: Δy_j, is added-amount of output of kind j of household observed production. λ_{ij}, is the investment coefficient of j kind of household observed production for kind i of element, means the amount of needing kind i of element while adding one unit of output of kind j of household observed production.

Then, the matrix for the investment coefficient of household observed production as follows:

$$\Lambda = \begin{pmatrix} \lambda_{11} & \lambda_{12} & \cdots & \lambda_{1n} \\ \lambda_{21} & \lambda_{22} & \cdots & \lambda_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ \lambda_{n1} & \lambda_{n2} & \cdots & \lambda_{nn} \end{pmatrix} \tag{2}$$

The sum of each row in Λ, $\lambda_{i.} = \sum_{j=1}^{n} \lambda_{ij}$, is the amount of investment required for kind i of productive elements while various types of household observed production increase one unit of the value; The sum of each column in Λ, $\lambda_{.j} = \sum_{i=1}^{n} \lambda_{ij}$, is the amount of investment required for all kinds of productive elements while kind j of household observed production increase one unit of the value; Similarly, we can define the investment coefficient of household non-observed production as follows:

$$\theta_{ij} = \frac{g_{ij}}{\Delta x_j} \tag{3}$$

In the formula: Δx_j, is the added-amount of kind j household non-observed production; θ_{ij}, is the investment coefficient of kind j of household non-observed production for kind i of element, means the amount of needing kind i of element while adding one unit of output of kind j of household non-observed production.

So then, the matrix of the investment coefficient of household non-observed production as follows:

$$\Theta = \begin{pmatrix} \theta_{11} & \theta_{12} \\ \theta_{21} & \theta_{22} \\ \vdots & \vdots \\ \theta_{n1} & \theta_{n2} \end{pmatrix} \tag{4}$$

Similarly, The sum of each row in Θ, $\theta_{i.} = \sum_{j=1}^{n} \theta_{ij}$, is the amount of investment required for kind i of production element while various types of household non-observed production increasing one unit of value; The sum of each column in Θ, $\theta_{.j} = \sum_{i=1}^{n} \theta_{ij}$, is the amount of investment required for all kinds of production element while kind j of household non-observed production increasing one unit of value; We only further study the input and output of household observed production, because of the data of non-observed productions obtained through sample surveys.By the definition above, we have：

$$f_{ij} = \lambda_{ij}\Delta y_j \qquad (i , j = 1, 2,\ldots\ldots n)$$

So then the investment matrix for household observed production F, which is the product of the investment coefficient matrix and diagonal matrix for added-amount of output for various productive activities, namely:

$$F = \Lambda\,\Delta\tilde{Y}$$
$$= \begin{pmatrix} \lambda_{11} & \lambda_{12} & \cdots & \lambda_{1n} \\ \lambda_{21} & \lambda_{22} & \cdots & \lambda_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ \lambda_{n1} & \lambda_{n2} & \cdots & \lambda_{nn} \end{pmatrix} \begin{pmatrix} \Delta y_1 & & \ldots & 0 \\ & \Delta y_2 & & \\ \vdots & \vdots & \ldots & \vdots \\ 0 & & & \Delta y_n \end{pmatrix} \qquad (5)$$

By the above all, we can undertake the series analysis of household productive activities.

(1) The accounting for added-amount of output and the total investment of production elements of various household production .Under the condition of invariable production structure, the added-amount matrix of output for kind j of household production in term of $\tau + 1$:

$$\Delta Y^{(\tau+1)} = \Lambda_{(j)}^{-1} * F_{(j)}^{(\tau+1)}$$

namely：

$$\begin{pmatrix} \Delta y_1^{(\tau+1)} \\ \Delta y_2^{(\tau+1)} \\ \vdots \\ \Delta y_n^{(\tau+1)} \end{pmatrix} = \begin{pmatrix} \lambda_{.1} & \cdots & & 0 \\ & \lambda_{.2} & & \\ & & \cdots & \\ 0 & & & \lambda_{.n} \end{pmatrix}^{-1} \begin{pmatrix} f_{.1}^{(\tau+1)} \\ f_{.2}^{(\tau+1)} \\ \vdots \\ f_{.n}^{(\tau+1)} \end{pmatrix}$$

$$= \begin{pmatrix} 1/\lambda_{.1} & \cdots & & 0 \\ & 1/\lambda_{.2} & & \\ & & \cdots & \\ 0 & & & 1/\lambda_{.n} \end{pmatrix} \begin{pmatrix} f_{.1}^{(\tau+1)} \\ f_{.2}^{(\tau+1)} \\ \vdots \\ f_{.n}^{(\tau+1)} \end{pmatrix}$$

Because of:

$$f_{.j}^{(\tau+1)} = \sum_{i=1}^{n} \lambda_{ij}.\Delta y_j^{(\tau+1)} = \lambda_{.j}.\Delta y_j^{(\tau+1)} \quad (j=1,2,\ldots n) \qquad (6)$$

In this formula： $\Delta y_j^{(\tau+1)}$， is the added-amount of gross output for kind j of household production in term of τ+1； $f_{.j}^{(\tau+1)}$， is the input amount of production elements for kind j of household production in term of τ+1； $\lambda_{.j}$， is the investment coefficient of production element for kind j of household production in term of τ. Should be written in matrix form：

$$\begin{pmatrix} f_{.1}^{(\tau+1)} \\ f_{.2}^{(\tau+1)} \\ \vdots \\ f_{.n}^{(\tau+1)} \end{pmatrix} = \begin{pmatrix} \lambda_{.1} & & \cdots & 0 \\ & \lambda_{.2} & & \\ & & \cdots & \\ 0 & \cdots & & \lambda.n \end{pmatrix} \begin{pmatrix} \Delta y_1^{(\tau+1)} \\ \Delta y_2^{(\tau+1)} \\ \vdots \\ \Delta y_n^{(\tau+1)} \end{pmatrix}$$

It is will be the previous equation (6) after deforming the formula above.

(2) The accounting for the investment amount of various productive elements in the household production.

Similarly, we can account the total investment amount for kind i of productive elements in the various production of household in term of τ+1. For

$$f_{i.}^{(\tau+1)} = \sum_{j=1}^{n} \lambda_{ij}.\Delta y_j^{(\tau+1)} \qquad (j = 1,2, \ldots n)$$

Written in form of matrix：

$$F_{(i)}^{(t+1)} = \Lambda * \Delta Y^{(t+1)}$$

Namely

$$\begin{pmatrix} f_{1.}^{(t+1)} \\ f_{2.}^{(t+1)} \\ \vdots \\ f_{n.}^{(t+1)} \end{pmatrix} = \begin{pmatrix} \lambda_{11} & \lambda_{12} & \cdots & \lambda_{1n} \\ \lambda_{21} & \lambda_{22} & \cdots & \lambda_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ \lambda_{n1} & \lambda_{n2} & \cdots & \lambda_{nn} \end{pmatrix} \begin{pmatrix} \Delta y_1^{(t+1)} \\ \Delta y_2^{(t+1)} \\ \vdots \\ \Delta y_n^{(t+1)} \end{pmatrix}$$

Deforming the equation of matrix, then：

$$\Delta Y^{(t+1)} = \Lambda^{-1} * F_{(i)}^{(t+1)}$$

So then

$$\begin{pmatrix} \Delta y_1^{(t+1)} \\ \Delta y_2 \\ \vdots \\ \Delta y_n \end{pmatrix} = \begin{pmatrix} \lambda_{11} & \lambda_{12} & \cdots & \lambda_{1n} \\ \lambda_{21} & \lambda_{22} & \cdots & \lambda_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ \lambda_{n1} & \lambda_{n2} & \cdots & \lambda_{nn} \end{pmatrix}^{-1} \begin{pmatrix} f_{1.}^{(t+1)} \\ f_{2.}^{(t+1)} \\ \vdots \\ f_{n.}^{(t+1)} \end{pmatrix} \qquad (7)$$

By equation (7)，we can account the amount of kind i of productive element investment for various productions in term of τ+1.

TABLE3. The data of observed production of a local household (100 million yuan)

		Investment of various productions				Total
		P.Ah.F	Manufacturing	Construction	Service	
Productive element		10	8	8	15	41
	Manufacturing	20	10	10	8	48
	Construction	8	22	12	18	60
	Service	22	16	6	14	58
	Total	60	56	36	55	207
New added amount		360	280	200	320	1160

Note: P.Ah.F is the abbreviation of Planting, Animal husbandry and fishery; The data of the table above is only to prove the usefulness of the matrix, not to clarify the other economic explanation.

3.2. Practical Application of the Integrated Matrix. To exemplify the accounting functions of the integrated matrix (table 2), there is a table 3 of data assumed of household production of a certain region in a certain period as follows.

The investment coefficient matrix calculated of observed production of the local household by the data from table 3 as follows:

$$\Lambda = \begin{pmatrix} \lambda_{11} & \lambda_{12} & \cdots & \lambda_{1n} \\ \lambda_{21} & \lambda_{22} & \cdots & \lambda_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ \lambda_{n1} & \lambda_{n2} & \cdots & \lambda_{nn} \end{pmatrix} = \begin{pmatrix} 10/360 & 8/280 & 8/200 & 15/320 \\ 20/360 & 10/280 & 10/200 & 8/320 \\ 8/360 & 22/280 & 12/200 & 18/320 \\ 22/360 & 16/280 & 6/200 & 14/320 \end{pmatrix}$$

$$= \begin{pmatrix} 0.028 & 0.029 & 0.04 & 0.047 \\ 0.056 & 0.036 & 0.05 & 0.025 \\ 0.022 & 0.079 & 0.06 & 0.056 \\ 0.061 & 0.057 & 0.03 & 0.044 \end{pmatrix}$$

Then the Investment coefficient vector of various kinds of observed production as follows：

（0.167，0.201，0.18，0.172）

Thus, the total amount of investment required separately of all productive elements of the local production for planting, animal husbandry and fishery, manufacturing, constructing and services as follows:

$$\begin{pmatrix} 0.167 & 0 & 0 & 0 \\ 0 & 0.201 & 0 & 0 \\ 0 & 0 & 0.18 & 0 \\ 0 & 0 & 0 & 0.172 \end{pmatrix} \begin{pmatrix} 360 \\ 280 \\ 200 \\ 320 \end{pmatrix}$$

Namely：（193.72，233.06，208.8，199.52）

Similarly: the investment of various kinds of productive elements can be calculated as follows:

$$\begin{pmatrix} f_{1.}^{(\tau+1)} \\ f_{2.}^{(\tau+1)} \\ \vdots \\ f_{n.}^{(\tau+1)} \end{pmatrix} = \begin{pmatrix} 0.028 & 0.029 & 0.04 & 0.047 \\ 0.056 & 0.036 & 0.05 & 0.025 \\ 0.022 & 0.079 & 0.06 & 0.056 \\ 0.061 & 0.057 & 0.03 & 0.044 \end{pmatrix} \begin{pmatrix} 360 \\ 280 \\ 200 \\ 320 \end{pmatrix} = \begin{pmatrix} 41.32 \\ 48.24 \\ 59.96 \\ 58 \end{pmatrix}$$

It means that the investment required of the local production for the productive element of planting, animal husbandry and fishery, manufacturing, constructing and services is separately 41.32 million Yuan, 48.24 million Yuan, 59.96 million Yuan and 58 million Yuan in the accounting period.

4. The Accounting Methodology for the Non-Observed Productive Activities of Household. With hidden features, we consider to adopt sampling survey to account the non-observed productive activities of household. The basic idea is to first measure the number of household to engage in non-observed economic activities among the all household, and then to infer the total amount of non-observed production of all household.

The first step: to inferred the proportion of household of non-observed production. To designate the scope of household population, and to extract a number of household to compose a sample by random sample, and then to observe the proportion to engage in non-observed production in the sample of household in order to infer that of household population.

The estimation of the proportion to engage in non-observed production, we can use the cluster sampling method. Settings: the whole households in a region (such as a province, a large administrative region) studied is regarded as a population, the whole households of the sub-units (such as a county, a county-level city) in a region is regarded as a group. There are R groups in the population, sampling r groups from the population by the principle of random sampling, then the proportion p of household engaging non-observed production can be determined through the investigation, whereby it can be inferred of that of household population. At this point, the formula for average sampling error is as follows:

$$\mu_p = \sqrt{\frac{\delta_p^2}{r}\left(\frac{R-r}{R-1}\right)} \tag{8}$$

Where: R, is the number of groups in a population; R, is the number of groups in a sample; δ_p^2 , is the variance between groups, its formula calculated is:

$$\delta_p^2 = \frac{\sum(p_i - P)}{r}$$

p_i is the percentage of each group of the population, could be substituted by that of sample in practice. P is the percentage of population, could be substituted by that of sample in practice also.

So the estimating formula for percentage of population P is:

$$p \pm t\mu_p$$

This is the proportion of household to engage in non-observed production among the whole households.

The second step: to inferred total amount of non-observed production. It can be interfered by multi-stage random sampling or classification sampling after obtaining the number of household of non-observed production.

Under the multi-stage random sampling, setting: the total number of primary units in household population is N, the number of sampling primary units is n. Assume of that the primary units of the same size, the same number of basic units of, namely, M; the second stage, and taking basic units of m from the primary units drawn up. Then, the number of units in the two-stage sampling size is m×n.

If y_{ij} is the production value of basic unit j in primary unit i, $\bar{y}_i$ is the average of sample units taken in primary units i， $\bar{Y}_i$ is the average of all basic units in the primary unit i; then the estimator of the average of the population(the total amount (or gross) of non-observed production) is:

$$\hat{\bar{Y}} = \bar{\bar{y}} = \frac{1}{nm}\sum_i \sum_j Y_{ij} = \frac{1}{n}\sum_i \bar{y}_i$$

It can be testified that $\bar{\bar{y}}$ is an unbiased estimator of population average $\bar{\bar{Y}}$;

Correspondingly, the formula of average sampling error in interval estimation is:

$$\mu_y = \sqrt{\frac{s_1^2}{n}(1-f_1) + \frac{s_2^2}{nm}(1-f_2)}$$

Where:

s_1^2 is the sample variance of primary units, $s_1^2 = \frac{1}{n-1}\sum_i (\bar{y}_i - \bar{\bar{y}})^2$;

s_2^2 is the sample variance of basic units in primary

$$s_2^2 = \frac{1}{n(m-1)}\sum_i (\bar{y}_{ij} - \bar{y}_i)^2\ ;\ f_1 = \frac{n}{N};\quad f_2 = \frac{m}{M}$$

So the interval estimator of population average is:

$$\bar{y} \pm t\mu_y$$

which is the total amount of non-observed production of the population under two-stage random sampling， namely gross of added-value. Similarly the interval estimator of population average under the classification sampling is:

$$\bar{x} \pm t\mu_x$$

In this formula, $\bar{x}$ is the sample average, μ_x is average sampling error, its formula calculated is：

$$\mu_x = \sqrt{\frac{\sum n_i \sigma_i^2}{n^2}(1-\frac{n}{N})}$$

N is the number of units in a population; n is the number of units in a sample; n_i is the number of units of each group; σ_i^2 is the variance of each group.

The operability of this methodology can be illustrated through a case.For accounting the amount of non-observed production of household in a region, the whole household is divided as 180 groups by the structure of all productive units of the population, the sample is constructed of 18 groups according to the proportion 10% under randomly replacement clustering sample for the proportion of non-observed production of household, the data of sample are obtained as follows (see table 4):

TABLE 4. The proportion of household of non-observed production under clustering sampling

Serial number	proportion（%）	Serial number	proportion（%）	Serial number	proportion（%）
1	2.51	7	2.30	13	2.13
2	2.21	8	2.31	14	3.05
3	1.63	9	3.20	15	2.19
4	1.51	10	2.41	16	2.06
5	1.70	11	2.55	17	3.01
6	1.90	12	3.21	18	1.99

Note: the proportion is that of household of non-observed production; the data is of the table above is only to prove the usefulness of the methodology, not to clarify the other economic explanation.

According to the data of table 4, calculating the mean of the sample percentage as follows:

$$p = \frac{\sum p_i}{r} = 2.3261\%$$

variance between groups

$$\delta_p^2 = \frac{\sum (p_i - P)^2}{r} = 0.271\%$$

then, average sampling error under clustering sampling is：

$$\mu_p = \sqrt{\frac{\delta_p^2}{r}\left(\frac{R-r}{R-1}\right)} = \sqrt{\frac{0.00271}{18}\left(\frac{180-18}{18-1}\right)} = 1.6864\%$$

So then, the proportion of household of non-observed production in the population can be estimated under guaranteed 95% of the probability as following：

$$2.3261\% \pm 1.96 \times 1.6864\%$$

After that, we can infer the gross of non-observed production of the population by classification sampling. Setting the data of sample classified by the characteristics of production as table 5:

By the table5, the mean of the sample is：

$$\bar{x} = \frac{\sum \bar{x}_i n_i}{n} = \frac{5226.2}{298} = 17.54$$

$$\mu = \sqrt{\frac{\sum n_i \sigma_i^2}{n^2}(1 - \frac{n}{N})} = \sqrt{\frac{36543.4}{298^2}(1 - \frac{298}{2980})} = 0.6086$$

So then, the gross of non-observed production in the population can be estimated under guaranteed 95% of the probability as following：

$$17.54 \pm 1.96 \times 0.6086$$

Similarly, we also could infer the gross of non-observed production in the population by the multi-stage sampling.

TABLE 5. The amount of non-observed production of household under classification sampling

	Sampling units n_i	Mean of added-value $\overline{x}_i$ (100 million)	Variance of added-value σ_i^2	$n_i \overline{x}_i$	$n_i\sigma_i^2$
Productions for avoiding tax and fee	158	21.3	118.4	3365.4	18707.2
Concealed productions	38	19.6	96.6	744.8	3670.8
Productions for Illegal products	36	6.8	36.9	244.8	8812.8
Productions Illegal services	66	13.2	81.1	871.2	5352.6
Total	298	-----	-----	5226.2	36543.4

5. Integrated Accounting of Household Production. Household production including observed and non-observed production, its productive results is the amount of added-value, and its income is sales of material goods, service income, and mixed income, in addition to subsidy of production tax, etc. After accounting the observed and non-observed production separately, we could design a integrated matrix of household production to comprehensively reflect the production results of household population in the term of period (see table 6).

The Table.6 above comprehensively describes the productive results of household production in a certain period to activities. The rows are the all incomes of sales of goods, services, mixed and the net productive tax; the columns are all kinds of production including non-observed production activities. This integrated matrix fully reflects the total achievement and structure of all household productive activities, it could be adopted to analyze the proportion of material and service productions in the whole production of household, and measured the distribution of household production on the primary, secondary industry and tertiary industry in a region.

Furthermore, to extend the analysis of household production activities, we can design a complicated and integrated the matrix to describe the productive achievement, income formation, income using and capital stock of household (see table 7).

TABLE 6. Integrated matrix of productive achievement of household in china

Classification /code			Observed production												Non-observe production	
			p.Ah.f.	Mining	manufacturin	Constructing	Transporting,	Wholesale	Catering and	Rental and business	Medical	Cultural and	Resident	Other	Underground production	Illegal productions
			1a	2a	3a	4a	5a	6a	7a	8a	9a	10a	11a	12a	1b	2b
Sales of goods	town	1A	0.1	0.1	16.2	--	--	--	--	--	--	--	--	1.2	…	…
	countryside	2A	28.9	0.2	0.5	--	--	--	--	--	--	--	--	0.8	…	…
Service income	town	1B	0.1	0.2	1.2	0.5	9.5	12	31	13.2	9.8	2.3	6.5	2.6	…	…
	countryside	2B	5.6	2.3	1.2	2.6	0.9	1.5	2.3	0.4	0.1	0.2	0.6	0.8	…	…
Mixed income	town	1C	0.1	0.1	3.6	0.9	0.3	0.6	1.2	0.6	0.1	0.1	0.6	0.2	…	…
	countryside	2C	0.3	0.2	0.9	0.3	0.2	0.6	0.4	0.5	0.1	0.2	0.1	0.1	…	…
Net productive tax		1D	0.9	0.1	0	0	0	0	0	0	0.1	0	0	0	…	…
Other productive income		1E	0.1	0	0	0.1	0.2	0.1	0	0.2	0	0	0	0.2	…	…
Total			36.1	3.2	23.6	4.4	11.1	14.8	34.9	14.9	10.2	2.8	7.8	5.9	…	…

Note: the data of table above is adjusted China Yearbook of Rural Household Survey 2008, Unit: 100Yuan/year person; is only to prove the usefulness of the matrix, not to clarify the other economic explanation.

$$\mathbf{Z} = \begin{pmatrix} Z_{11} & Z_{12} & Z_{13} & Z_{14} \\ Z_{21} & Z_{22} & Z_{23} & Z_{24} \\ Z_{31} & Z_{32} & Z_{33} & Z_{34} \\ Z_{41} & Z_{42} & Z_{43} & Z_{44} \end{pmatrix}$$

Z reflects the distribution of productive achievement of household on the various sectors of national economy. Other sub-matrix are also decomposed similarly. The integrated matrix above comprehensively sketch the view of production, distribution, consumption and capital formation, become the important tool of statistical analysis and accounting.

6. Conclusion. In the system of national accounts, being an important institutional sector, the production of household sector and their results plays an important role in domestic production accounting. This paper, by the theoretical basis of the United Nations SNA2008, from the viewpoint of concept and scope of household production, has explored the methodology for the activities of observed, non-observed production and comprehensive accounting, and designed the accounts for household production, presented the accounting methods for the achievement of non-observed production. Because of productive particularity and difficulty of collect data, the methodology proposed in the paper needs to be further tested and improved in practice.

TABLE 7. Exemplifying of integrated matrix of household accounting

		Goods & services	Productive activities	Form of added-value	Transferring income	Income using	capital: Fixed	capital: financial	Total ?
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	
Goods & services	1	Fee of goods transportation **A**	Intermediate consumption **B**			Consumer spending **Γ**	Gross fixed capital formation **E**		$G_{1.}$
Productive activities	2	Output of goods **Z**							$G_{2.}$
Form of added-value	3	Production subsidy **Q**	Added-value **H**						$G_{3.}$
Transferring income	4				Property income, gift **T**			Savings increase **Φ**	$G_{4.}$
Income using	5				Disposable income **Ψ**				$G_{5.}$
Fixed capital	6		Depreciation of fixed assets **Ω**					Net Fixed capital formation**Π**	$G_{6.}$
Financial capital	7						Net assets of lent **M**		$G_{7.}$
Total ?		G_1	$G_{.2}$	$G_{.3}$	$G_{.4}$	$G_{.5}$	$G_{.6}$	$G_{.7}$	----

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ANALYSIS OF CLINICAL DECISION SUPPORT SYSTEMS ADOPTION FACTORS BY DECISION-MAKING TRIAL AND EVALUATION LABORATORY

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ABSTRACT. *The aim of study is to explore the factors that influence the medical professionals' behavioral intention to use while introducing a new Clinical Decision Support System (CDSS). The Technology Acceptance Model (TAM) and Unified Theory of Acceptance and Use of Technology (UTAUT) are widely applied to examine the new technology acceptance by the users; nevertheless, this model omit the system diverse and user's profession. On the other hand, causal analysis greatly affects the efficiency of decision-making, and it is usually analyzed by structural equation modeling (SEM); however, the method is often misapplied. The study sampled on 15 medical experts, adopted DEcision-Making Trial and Evaluation Laboratory (DEMATEL) to calculate the causal relationship and interaction level between the significant UTAUT variables, provide the important keys for developing, promoting, and managing a new CDSS to resolve the complicated problems in practical experience. The study found that social influence plays no impact on the medical professional's adoption towards the CDSS.*
Keywords: Clinical Decision Support Systems; Decision-Making; DEMATEL; Technology Acceptance Model (TAM); Unified Theory of Acceptance and Use of Technology (UTAUT)

1. Introduction. Computer with programmed syntax is capable to provide answers that before only human beings could accomplish. Artificial intelligence (AI) has been focused on problem solving and processing capabilities that support problem solving (Clocksin, 2003). Clinical Decision Support System (CDSS), a specialized Expert System (ES), have different interpretations but the same purpose. ES is a computer program that performs decision-making or problem solving functions in a very specialized and narrowed problem area (Subramanian et al., 1997). In medical area, CDSS is a computer system that utilized for clinical use in patient care, which mimic the decision-making behavior of a human expert and allow computer power to be applied to tasks which require the processing of human knowledge. According to Newman-Toker and Pronovost (2009), the diagnostic based CDSS will prevent human errors while diagnosing health the problem to the patients.

Researches in the CDSS are limited in the area of computer science and rarely seen in the causal modeling analysis from social science perspective. Technology acceptance by users in the area of medicine has received less attention in the past, and therefore, lacking the models/factors that impact the CDSS adoption to the medical professionals.

Causal relationship analysis significantly affects the efficiency of decision-making. Previous studies in examine the causal model mainly adopt the Structural Equation

Modeling (SEM). The collected statistical data, however, allow researchers to modify the model frequently to arrive at good model fitness, and SEM is often misapplied when the data are merely fitted to an SEM and the theory is then extended from the analytical result based on presumed hypotheses (Wei et al., 2010).

Based on the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003), an amended Technology Acceptance Model (TAM) (Davis, 1989), this study aims to identify the relationship and influence among several research constructs towards the adoption of CDSS for medical professionals. However, the TAM assumes that most of the external variables are independent, that is, there is no existing causal relationship. In addition, TAM only focuses on public technology system, and the empirical study cannot obtain a large number of samples. Some technology systems, for example, CDSS are highly professional and complicated, not all the subjects will be able to completely understand the technology system, and when some variables do not meet the independent assumption, and coupled with the difficulty of obtaining a large number of samples, the TAM will not be able to correctly analyze the causal relationship by SEM, which results in the wrong conclusion (Lee et al., 2010).

In recent years, a number of scholars have proposed Multiple Criteria Decision-Making (MCDM) theory to strengthen the comprehensiveness and reasonableness of the decision-making process (Liou and Tzeng, 2010; Tzeng et al., 2005; Yang et al., 2008). To improve the above-mentioned drawbacks, the partial UTAUT is treated as an MCDM model to address on dependent relationships, and the DEcision-Making Trial and Evaluation Laboratory (DEMATEL) technique is applied to find the core variables that affecting the intention of medical professional using the CDSS. This may further provide the information for system developer in designing the CDSS, as well to provide the important key for marketing practitioner while promoting new CDSS in assisting the medical doctors to resolve the complicated clinical problems.

2. DEMATEL. Using the DEMATEL method, this study analyzes the causal relationships and interaction influence level between UTAUT variables, and understands factors that influence the adoption of CDSS to the medical professionals.

DEMATEL technique (Fontela and Gabus, 1976; Gabus and Fontela, 1973) was used to study complicated world problems regarding issues such as race, hunger, environmental protection, energy, etc. (Fontela and Gabus, 1976). It was developed in the belief that the proper use of scientific research methods could facilitate comprehension of the specific problematique, the cluster of intertwined problems, and contribute to recognition of practical solutions by a hierarchical structure. The methodology, according to the characteristics of objective affairs, can verify the interdependence among the variables/attributes/criteria and confine the relation that reflects the characteristics with an essential system and evolution trend (Chiu et al. 2006; Huang and Tzeng, 2007). The method is a practical and useful tool, especially for visualizing the structure of complex causal relationships with matrices or digraphs. The matrices or digraphs show a contextual relation between the elements of the system, in which a numeral represents the strength of influence of each element. Thus, the DEMATEL technique is able to convert the relationship between the causes and effects of criteria into an intelligible structural model of systems (Wei et al., 2010).

Recently, DEMATEL technique has been widely applied in a number of disciplines, including airline safety (Liou et al., 2008), e-learning (Tzeng et al., 2005), decision-making (Hajime and Kenichi, 2007; Lin and Wu, 2008; Tseng, 2009), knowledge management (Shi et al., 2005; Wu, 2008), operations research (Ou Yang et al., 2008; Zhang et al., 2008), business policy (Wu and Lee, 2007), selecting systems (Tsai and Chou, 2009), agriculture (Kim 2006), technology innovation (Huang and Tzeng, 2007; Lee et al., 2010; Yamashina et al., 2005), marketing and consumer behavior (Hsu et al., 2007; Wei et al., 2010), and others. The structure of DEMATEL and the steps of calculation are described as follows:

Step 1: Calculate the direct-influence matrix by scores (depending on the views of the experts) and evaluate the relationship among elements (or called variables/attributes/criteria) of mutual influence, using the scale ranging from 0 to 4 (indicating "No influence (0)," to "Very high influence (4)"); the digraph portrays a contextual relationship between the elements of the system as shown in Fig. 1. For example, an arrow from '*a*' to '*e*' represents that '*a* affects *e*', and its influence score is 4. Subjects are asked to indicate the direct effect they believe each element *i* exerts on every other element *j*, as indicated by d_{ij}. The matrix $\boldsymbol{D}$ of direct relations is thus obtained, which shows the pair-wise comparison of causal relationship. Assume there are *n* variables that impact the system, the direct-influence matrix $\boldsymbol{D}$ is illustrated in Eq. (1).

$$\boldsymbol{D}=\begin{bmatrix} 0 & x_{12} & \cdots & x_{1n} \\ x_{21} & 0 & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{n1} & x_{n2} & \cdots & 0 \end{bmatrix} \tag{1}$$

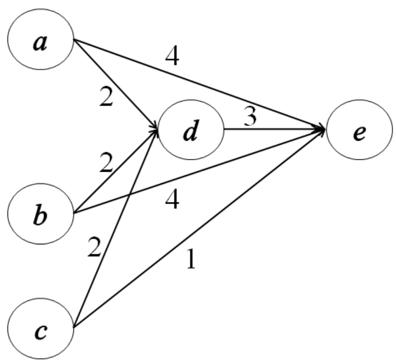

FIGURE 1. The directed graph

Step 2: Normalizing the direct-influence matrix: on the basis of the direct-influence matrix $\boldsymbol{D}$, the normalized direct-relation matrix $\boldsymbol{X}$ is acquired by using Eqs. (2) and (3).

$$\boldsymbol{X}=k\boldsymbol{D}. \tag{2}$$

$$k = \max_{i,j}\left\{\frac{1}{\max_i \sum_{j=1}^{n} d_{ij}}, \frac{1}{\max_j \sum_{i=1}^{n} d_{ij}}\right\}, \quad i, j \in \{1,2,\ldots,n\}. \tag{3}$$

Step 3: Attaining the total-influence matrix: once the normalized direct-influence matrix $\boldsymbol{X}$ by summation for i or j is obtained, the total-influence matrix $\boldsymbol{T}$ is arrived at through Eq. (4), in which the $\boldsymbol{I}$ is denoted as the identity matrix.

$$\begin{aligned}\boldsymbol{T} &= \boldsymbol{X}+\boldsymbol{X}^2+\boldsymbol{X}^3+\cdots+\boldsymbol{X}^k \\ &= \boldsymbol{X}(\boldsymbol{I}+\boldsymbol{X}+\boldsymbol{X}^2+\cdots+\boldsymbol{X}^{k-1})[(\boldsymbol{I}-\boldsymbol{X})(\boldsymbol{I}-\boldsymbol{X})^{-1}] \\ &= \boldsymbol{X}(\boldsymbol{I}-\boldsymbol{X}^k)(\boldsymbol{I}-\boldsymbol{X})^{-1},\end{aligned} \tag{4}$$

Then $\boldsymbol{T}=\boldsymbol{X}(\boldsymbol{I}-\boldsymbol{X})^{-1}$, when $k\to\infty$, $\boldsymbol{X}^k=[0]_{n\times n}$, where $\boldsymbol{X}=\left[x_{ij}\right]_{n\times n}$, $0 \le x_{ij} < 1, 0 < \left(\sum_{j=1}^{n} x_{ij}, \sum_{i=1}^{n} x_{ij}\right) \le 1$ and at least one summation $\sum_{j=1}^{n} x_{ij}$ or $\sum_{i=1}^{n} x_{ij}$ equals 1, but not all, then $\lim_{k\to\infty} \boldsymbol{X}^k = [0]_{n\times n}$.

Step 4: Analyzing the results: in the stage, the sum of rows (given influence) and the sum of columns (received influence) are separately expressed as influential vector $\boldsymbol{d}$ = $(d_1,\ldots,d_i,\ldots,d_n)'$ by factor j (j = 1, 2,..., n) and influential vector $\boldsymbol{r}$ = $(r_1,\ldots,r_j,\ldots,r_n)'$ by factor i (i = 1, 2,..., n) using Eqs. (5)-(7). Then, when $i, j \in \{1,2,\ldots,n\}$ and i = j the horizontal axis vector ($\boldsymbol{d}$ + $\boldsymbol{r}$) is made by adding vector $\boldsymbol{d}$ to vector $\boldsymbol{r}$, which exhibits total important influence of each criterion. Similarly, the vertical axis vector ($\boldsymbol{d}$ − $\boldsymbol{r}$) is made by deducting vector $\boldsymbol{d}$ from vector $\boldsymbol{r}$, which may separate criteria into a cause group and an affected group. In general, when $\boldsymbol{d}_i - \boldsymbol{r}_i$ is positive, the criterion is to belong to the cause group. On the contrary, if the $\boldsymbol{d}_i - \boldsymbol{r}_i$ is negative, the criterion is to belong to the affected group. Therefore, the causal-and-effect graph can be achieved by plotting the data set of $\{(\boldsymbol{d}_i + \boldsymbol{r}_i, \boldsymbol{d}_i - \boldsymbol{r}_i) \mid i = 1, 2, \ldots, n\}$, providing valuable approaching for making decisions.

$$\boldsymbol{T} = \left[t_{ij}\right]_{n\times n}, \quad i, j \in \{1,2,\ldots,n\}, \tag{5}$$

$$\boldsymbol{d} = \left[\sum_{j=1}^{n} t_{ij}\right]_{n\times 1} = \left[t_i\right]_{n\times 1} = \left[d_i\right]_{n\times 1}, \tag{6}$$

$$\boldsymbol{r} = \left[\sum_{i=1}^{n} t_{ij}\right]_{n\times 1}' = \left[t_j\right]_{n\times 1} = \left[r_j\right]_{n\times 1}, \tag{7}$$

where vector $\boldsymbol{d}$ = ($d_1, \ldots, d_i, \ldots, d_n$) and vector $\boldsymbol{r}$ = ($r_1, \ldots, r_j, \ldots, r_n$) express the sum of rows and the sum of columns based on total-influence matrix $\boldsymbol{T}$ = $[t_{ij}]_{n\times n}$, separately.

3. Empirical Study. This study examine the relationship of following factors among the medical professional on the intension of using CDSS, which includes: performance expectancy (PE) (x_1), effort expectancy (EE) (x_2), social influence (SI) (x_3), attitude towards the use of CDSS (AU) (x_4), and behavior intention of using CDSS (BI) (x_5). Fifteen medical doctors were invited to present their opinions on the pair-wise comparison in terms of influences and directions between each factor, and DEMATEL was adopted to analyze the causal relationship. According to the fifteen medical experts, the direct-influence matrix is obtained as shown in Table 1.

Based on the direct-influence matrix, according to Eq. (3), k=8.583333. The normalized direct-influence matrix, as shown in Table 2, is then retrieved based on Eq. (2). Subsequently, the total-influence matrix was calculated as displayed in Table 3, and the degree of influence as presented in Table 4.

TABLE 1. The direct-influence matrix

$\boldsymbol{D}$	x_1	x_2	x_3	x_4	x_5
x_1	0	0.166667	0	4.166667	1.333333
x_2	0.333333	0	0	3.75	1.416667
x_3	0.25	0.083333	0	0.666667	0.083333
x_4	0	0	0.083333	0	4.416667
x_5	0	0	0	0	0

TABLE 2. The normalized direct-influence matrix

$\boldsymbol{X}$	x_1	x_2	x_3	x_4	x_5
x_1	0	0.019417	0	0.485437	0.15534
x_2	0.038835	0	0	0.436893	0.165049
x_3	0.029126	0.009709	0	0.07767	0.009709
x_4	0	0	0.009709	0	0.514563
x_5	0	0	0	0	0

TABLE 3. The total-influence matrix

$\boldsymbol{T}$	x_1	x_2	x_3	x_4	x_5
x_1	0.000896	0.019482	0.004803	0.494757	0.413325
x_2	0.038995	0.0008	0.004432	0.456517	0.406188
x_3	0.029553	0.010292	0.000938	0.096585	0.065707
x_4	0.000287	9.99E-05	0.009718	0.000938	0.515201
x_5	0	0	0	0	0

TABLE 4. The influence of concern factors

Factors	Symbols	d_i	r_i	$d_i + r_i$	$d_i - r_i$
PE	x_1	0.933262	0.069732	1.002994	0.863531
EE	x_2	0.906932	0.030673	0.937605	0.876259
SI	x_3	0.203074	0.019891	0.222966	0.183183
AU	x_4	0.526243	1.048796	1.57504	-0.52255
BI	x_5	0	1.40042	1.40042	-1.40042

It was necessary to set a threshold value p for explaining the structural relation among factors while simultaneously keeping the complexity of the whole system to a manageable level. In this study, the threshold value p was set as 0.1. Only those factors whose effect in the total-influence matrix was greater than 0.1 were considered have causal relations; thus, the network relation map (NRM) was illustrated in Fig. 2. Finally, the cause-and-effect relations among the factors/criteria were generated in Table 5. Several results were obtained from Fig. 2 and Table 5, which were summarized as follows:

(1) The key causal factors whose values of ($d_i - r_i$) were positive, including PE (x_1) and EE (x_2), were intensely affecting others. These factors were acted as independent variables.

(2) The main effect factors whose values of ($d_i - r_i$) were negative, such as AU (x_4) and BI (x_5), were intensely affected by the others. These factors were played the part of dependent variables.

(3) The key causal factors whose values of ($d_i + r_i$) and ($d_i - r_i$) were very small, i.e. SI (x_3), which shows low prominence and low relation. This factor is filtered out due to below the threshold value p, and shows insignificant relationship with others.

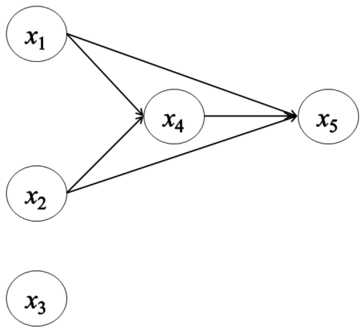

FIGURE 2. The network relation map

TABLE 5. Cause-and-effect relationship

Cause Factors	Effect Factors
PE (x_1)	AU (x_4), BI (x_5)
EE (x_2)	AU (x_4), BI (x_5)
SI (x_3)	—
AU (x_4)	BI (x_5)
BI (x_5)	—

4. Discussion and Implication. Among the factors that influencing the medical professional on the use of CDSS, it can be seen from the analysis result of DEMATEL, PE (x_1) and EE (x_2) have high impact levels towards AU (x_4) and BI (x_5). Among these relationships, the impact level on AU (x_4) is higher than BI (x_5), which indicate there are other factors may influence behavior intention even after the subjects show positive attitude toward using CDSS. In addition, it is significant that SI (x_3) shows no impact on AU (x_4) nor BI (x_5), which is inconsistent to the UTAUT.

Based on the results of the study, several conclusions can be drawn. Firstly, PE is significant impact on AU and BI, which is consistent to the study of Davis (1989). Wei (2006) has later affirmed that the correlation between PE and AU and states the individuals have certain positive attitude on the system would made a better satisfaction. Garg et al. (2005) conclude that the performance of the CDSS have a relationship with the attitude towards the use of it. If the practitioners realized that the CDSS performs well, the attitude of using it will be higher. Confirmed by Stacey et al. (2006), if users felt comfortable using the decision support system, this would enhance the reuse intention. A few studies verified the use of CDSS improves the medical professional's job performance. Kawamoto et al. (2005) conclude that CDSS significantly improved clinical practice, which affirmed by Dreisetl et al. (2007) that the CDSS significantly improve the medical experts' performance in terms of accuracy and efficiency in diagnosis, making doctors have a higher attitude towards the use of the CDSS. Bergman and Fors (2005) also show the physicians had a higher attitude towards the use of the CDSS when they realized that the performance of CDSS was acceptable.

The positive relationship between EE and AU on the CDSS is supported by Davis (1989), Davis et al. (1989), Moore and Benbasat (1991), Plouffe et al. (2001), and Thompson et al. (1991) who asserted that the higher level of perceived ease of use is, the greater the willingness of consumer to adopt the system is. It can be concluded that the users had a higher ease of use expectation, and the system was easy for them to employ so they adopted and integrated the system more easily into their daily work. It can also be concluded that there was a positive attitude towards the system regarding the effort expectation from the users of the CDSS. Stacey et al. (2006) found that the nurses have positive attitude towards the use of the CDSS when they are aware the system does not take too much effort from them and it was easy to learn. The study of Liu et al. (2006) stated the success of clinicians to use the CDSS is because of the following cases: They understood what it was for, the prevailing clinical culture patronized it, their patients or peer group supported it, it was fast, and it was linked to the electronic patient record (EPR).

It is notable that this study has found the insignificant relationships on both SI to AU, and SI to BI towards the use of CDSS. This shows medical doctors are trained and skillful professional who are less possible to be influenced by social norms in their professional field. Doctors tend to experience the value of CDSS from their own medical practice instead of being influenced socially. Roberts and Henderson (2000) observed in their study that SI did not have an impact on AU in government employees, which addressed to a similar failure of a subjective norm instrument in UTAUT and TAM2. To address the comment of Davis et al. (1989) "more sophisticated methods for assessing the specific types of social influence processes at work in a computer acceptance context are clearly needed," this study adopted the method of DEMATEL to explore the influence level of SI on AU and BI, and found no impact.

Lastly, this study confirmed the positive relationship between AU and BI towards the use of CDSS. The result can be supported by Eagly and Chaiken (1993), who prove that beliefs and attitudes correlate positively with behavior. Our study shows a good acceptance inside the medical professional regarding the CDSS. Chismar and Wiley-Patton (2003) apply the TAM in their study and conclude that physicians' behavior intention towards the use of the CDSS related positively with their attitude on the system. A recent article from Trivedi et al. (2009) reported on a survey of factors affecting clinicians' acceptance of CDSS and revealed that even though a majority of the clinicians were not explicitly following clinical support suggestions provided, they did feel that such systems were of benefit and reported that they would even be more so if they had more time to make use of them (Sittig et al., 2006).

5. Concluding Remarks. This research used DEMATEL to analyze the factors that influencing the use of CDSS in medical professionals, and significantly found the user attitude and intention is not being affected by the social influences. This is contradict with the UTAUT model and further proved the UTAUT can be varied depend on sampled objective and systems.

In this study, the DEMATEL technique is adopted to explore the cause-and-effect relationship. Comparing with the SEM, it reduces the model specifications errors, minimize the occurrence of capitalization on chance error, maintain the mature of confirmatory and over-fitting model will not be occurred. Causal analysis largely influences the effectiveness of decision-making and operation actions. This study demonstrated that the DEMATEL method may be an efficient, complementary, and effective approach for examine the causal relationship.

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SEMIPARAMETRIC ESTIMATION FOR THE VARYING-ELASTICITY PRODUCTION FUNCTION WITH FRONTIER EFFICIENCY: AN APPLICATION TO CHINA

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ABSTRACT. *The conventional aggregate production function model such as Cobb-Douglas requires strong assumptions such as the constant elasticity and the full efficiency of the technique. The varying-elasticity production functions are useful extension of classical linear models, and DEA involves the use of linear programming methods to estimate the efficiency without restrictive assumptions. However, the varying-elasticity production function does not take frontier efficiency into account, while the DEA model is being short of the form of production function. In this paper, we combine the advantages of the DEA model and the varying-elasticity production function, as well as the advantages of the parametric model and the nonparametric varying-coefficient model, to estimate the frontier varying-elasticity. As China's provinces' empirical results show, the frontier elasticity is significant different from the normal one, frontier efficiency may reduces the capital elasticity and enhances the labor elasticity simultaneity.*
Keywords: Semiparametric Varying-coefficients Model; Data Envelope Analysis; Output Elasticity

1. Introduction. Production functions are a fundamental component of all economics. Production functions relate productive inputs (e.g. capital, labor) to outputs, reflect the effect and influence of production factor on output at certain technological conditions. Cobb-Douglas production function is preferred for its simple structure, meaningful parameter and easy estimation. Assuming two factors production, physical capital (K) and labor (L), the Cobb-Douglas production function is as follow:

$$Y = AK^{\alpha} L^{\beta} \tag{1}$$

However, the conventional economic growth model such as Cobb-Douglas production function requires unrealistically strong assumptions, such as the constant elasticity and the full efficiency of the technique.

Being a classical linear model, the parameters α and β are fixed for model (1). Varying coefficient models are a useful extension of classical linear models. They arise naturally when one wishes to examine how regression coefficients change over different groups characterized by certain covariates such as age. The potential of such a modeling technique got fully explored by the seminal work (Cleveland et al., 1991; Hastie and Tibshirani,1993; Fan and Zhang, 1999; Huang et al., 2002; You and Chen, 2006). Iwata, Khan, and Murao (2003), Xu and Wu (2007) applied a nonparametric method to estimate the varying elasticity of the capital and the labor. Ahmad(2005), Xu and Watada (2007), Zhang and Xu (2009), Luo, Yang and Zhou (2009) introduces the nonparametric varying-coefficients model to estimate varying output elasticity of capital and labor force.

Without restrictive assumptions, DEA involves the use of linear programming methods to construct a non-parametric piecewise frontier over the data. Modern efficiency measurement begins with Farrell (1957) who drew upon the work of Debreu (1951) and Koopmans (1951) to define a simple measure of firm efficiency which could account for multiple inputs. Frontiers have been estimated using many different methods over the past 50 years. The two principal methods are: data envelopment analysis (DEA) and stochastic frontiers, which involve mathematical programming and econometric methods, respectively. DEA involves the use of linear programming methods to construct a non-parametric piecewise frontier over the data, so as to be able to calculate efficiencies relative to this surface.

However, the varying-elasticity production function does not take frontier efficiency into account, while the DEA model is being short of the form of production function. Following Zhang and Gu (2010), In this paper, we combine the advantages of the DEA model and the varying-elasticity production function, as well as the advantages of the parametric model and the nonparametric varying-coefficient model, to estimate the frontier varying-elasticity. The paper is organized as follows. In the following section contains a description of estimation methodology, both for the semiparametric varying-coefficient model and for the DEA model. The estimation and comparison of the empirical results are given and discussed in Section 3. The final section contains concluding remarks.

2. Estimation Methodology. With the improvement of computing facilities over the last three decades, there has been an upsurge of interest and effort in nonparametric models as researchers have realized that parametric models are inadequate in capturing the relationship between the response variable and its associated covariates in many practical situations. Varying-coefficient models, including generalized additive models as well as dynamic generalized linear models as special cases, are linear in the regresses but their coefficients are permitted to change smoothly as function of other variables. Ahmad (2005), Xu and Watada (2007), Zhang and Xu (2009), Luo et al. (2009) allowed the coefficients to change as the function of time.

By combining the semiparametric varying-coefficients model with C-D production function, we could construct a varying-elasticity Production function model below:

$$Y=\mathrm{e}^{\sum_{j=1}^{m}\lambda_j Z_{ji}} K^{\alpha(H)} L^{\beta(H)} \tag{2}$$

We can deduce econometric model (3) by taking logarithm and adding random item to model (2)

$$\ln Y_i = \sum_{j=1}^{m} \lambda_j Z_{ji} + \alpha(H_i)\ln K_i + \beta(H_i)\ln L_i + \varepsilon_i \qquad i = 1,2,...,n \tag{3}$$

Obviously, model (3) is typical semiparametric varying-coefficients model. One should note that in model (3) we have not restricted α(H) and β(H) to have a fixed impact on the dependent variable, and assume that the functions α(H) and β(H) possess about the same degrees of smoothness and hence they can be approximated equally well in the same interval. Different to the former research, The cross section data is used in this paper other than time series, and the coefficients are allowed to change as the function of human capital in model (3) in this paper.

There are many approaches to estimating the unknown parameters and the varying coefficient functions, such as Backfitting estimation (Hua et al., 2003), Efficient estimation （Ahmad，2005）, and Profile estimation（Fan and Huang, 2005）. Profile least squares is a useful approach and it is utilized in this paper.

Suppose that we have a random sample of size n $\{(Z_i, K_i, L_i, Y_i), i = 1, ..., n\}$. For any given $\boldsymbol{\gamma}$, (3) can be written as:

$$(\ln Y_i)^* = \alpha(H)\ln K_i + \beta(H)\ln L_i + \varepsilon_i \tag{4}$$

Where $(\ln Y_t)^* = \ln Y_t - \sum_{i=1}^{m} \gamma_i Z_i$, this transforms the varying-coefficient partially linear model (3) into the varying-coefficient model (4). The local linear regression technique is applied to estimate the coefficient functions, For H is in a small neighborhood of H_0, approximate the functions α(H) and β(H) Locally as:

$$\alpha(\mathrm{H}) \approx \alpha(\mathrm{H}_0) + \alpha'(\mathrm{H}_0)\ (\mathrm{H}-\mathrm{H}_0) \equiv a_0 + b_0(\mathrm{H}-\mathrm{H}_0) \tag{5}$$

$$\beta(\mathrm{H}) \approx \beta(\mathrm{H}_0) + \beta'(\mathrm{H}_0)\ (\mathrm{H}-\mathrm{H}_0) \equiv a_1 + b_1(\mathrm{H}-\mathrm{H}_0) \tag{6}$$

Denote $X_{1i} = \ln K_i$， $X_{2i} = \ln L_i$， This leads to the following weighted local least-squares problem, find (a_0, b_0), (a_1, b_1)so as to minimize

$$\text{Min} \ \sum_{i=1}^{n} \{(\ln Y_i)^* - \sum_{j=0}^{1} (a_j + b_j (H - H_0) X_{ji})\}^2 K_{\mathbf{h}} \tag{7}$$

Where K is a kernel function, h is a bandwidth and $K_{\mathbf{h}} = K(\bullet / h)/h$. We give more weight to contributions from observations very close to than to those coming from observations that are more distant. We choose the kernel function of Gaussian and choose Bandwidth h with the method of cross-validation in this paper.

Denote

$$\mathbf{Y} = (Y_1, ..., Y_n)^T, \quad \mathbf{Z} = (Z_1, ..., Z_n)^T, \quad \mathbf{Z}_i = (Z_{i1}, ..., Z_{im})^T$$

$$\mathbf{X} = (X_1, ..., X_n)^T, \mathbf{X_i} = (X_{i1}, X_{i2})^T, \quad \mathbf{a}(H) = (\alpha(H), \beta(H))^T$$

$$W = diag(K_{\mathbf{h}}(H_1 - H), ..., K_{\mathbf{h}}(H_n - H))$$

$$\mathbf{M} = \begin{pmatrix} \mathbf{a}^T(H)X_1 \\ \vdots \\ \mathbf{a}^T(H)X_n \end{pmatrix} \qquad \mathbf{D} = \begin{pmatrix} X_1^T & \dfrac{H_1 - H}{h} X_1^T \\ \vdots & \vdots \\ X_n^T & \dfrac{H_n - H}{h} X_n^T \end{pmatrix}$$

Then (4) can be written as

$$\mathbf{Y} - \mathbf{Z}\boldsymbol{\gamma} = \mathbf{M} + \boldsymbol{\varepsilon} \tag{8}$$

The solution for $\mathbf{M}$ is:

$$\hat{\mathbf{M}} = \begin{pmatrix} (X_1^T\ 0)\{\mathbf{D^T W D}\}^{-1}\mathbf{D^T W} \\ \vdots \\ (X_n^T\ 0)\{\mathbf{D^T W D}\}^{-1}\mathbf{D^T W} \end{pmatrix}(\mathbf{Y - Z}\gamma) = \mathbf{S(Y - Z}\gamma) \tag{9}$$

The matrix S is a smoothing matrix, substituting (9) into (8), applying least squares to the linear model, we obtain

$$\hat{\gamma} = \{\mathbf{Z^T(I - S)^T(I - S)Z)^{-1}Z^T(I - S)^T(I - S)Y} \tag{10}$$

$$\hat{\mathbf{M}} = \mathbf{S(Y - Z}\hat{\gamma}) \tag{11}$$

The solution to the problem (7) is given by:

$$(\hat{a}_1, \hat{a}_{2,} h\hat{b}_1, h\hat{b}_2) = \{\mathbf{D^T W D}\}^{-1}\mathbf{D^T W(Y - Z}\hat{\gamma}) \tag{12}$$

3. Data Description and Empirical Results.

3.1. Data Description. The main variables contain Gross Domestic product (Y), Capital (K), Labour force (L), Human Capital (H), and Economic Structure (Z). We choose the 30 provinces of China at the year 2003 and the year 2008. In order to eliminate the influence of inflation, we calculate the true data on the base year of 1952. Gross Domestic Product, which stands for output in the paper, is calculated by expenditure approach. The number of labour force is calculated by total employed persons at the year-end. In this paper, we follow Zhang (2004) to measure the capital, and follow Tang (2006) to measure the human capital. The Economic Structure is defined as the ratio of labour force in the third industry to the whole country.

3.2. Estimation of Frontier Efficiency with DEA Model. Efficiency measurement has been a subject of tremendous interest as organizations have struggled to improve productivity. Reasons for this focus were best stated fifty years ago by Farrell (1957) in his classic paper on the measurement of productive efficiency. Twenty years after Farrell's seminal work, and building on those ideas, Charnes et al. (1978), responding to the need for satisfactory procedures to assess the relative efficiencies of multi-input multi-output production units, introduced a powerful methodology which has subsequently been titled data envelopment analysis (DEA). Since the advent of DEA in 1978, there has been an impressive growth both in theoretical developments and applications of the ideas to practical situations. Banker et al. (1984) (BCC), extended the earlier work of Charnes et al. (1978) by providing for variable returns to scale (VRS). Wade D et al (2009) provide a sketch of some of the major research thrusts in data envelopment analysis (DEA) over the past three decades.

The CRS assumption is only appropriate when all DMU's are operating at an optimal scale (i.e one corresponding to the flat portion of the LRAC curve). Imperfect competition, constraints on finance, etc. may cause a DMU to be not operating at optimal scale. Banker, Charnes and Cooper (1984) suggested an extension of the CRS DEA model to account for variable returns to scale (VRS) situations. The use of the CRS specification when not all DMU's are operating at the optimal scale will result in measures of TE which are confounded by scale efficiencies (SE). The use of the VRS specification will permit the calculation of TE devoid of these SE effects.

The VRS linear programming problem can be provide as:

$$\mathrm{Max}_{\theta,\lambda}\theta,\ \mathrm{st}\ -\mathrm{y_i}+\mathrm{Y}\lambda\ge 0,\ \theta\mathrm{x_i}-\mathrm{X}\lambda\ge 0,\ \mathrm{N1}'\lambda=1,\lambda\ge 0 \tag{13}$$

where N1 is an N×1 vector of ones. This approach forms a convex hull of intersecting planes which envelope the data points more tightly than the CRS conical hull and thus provides technical efficiency scores which are greater than or equal to those obtained using the CRS model. The VRS specification has been the most commonly used specification in the 1990's.

Many studies have decomposed the TE scores obtained from a CRS DEA into two components, one due to scale inefficiency and one due to "pure" technical inefficiency. This may be done by conducting both a CRS and a VRS DEA upon the same data. If there is a difference in the two TE scores for a particular DMU, then this indicates that the DMU has scale inefficiency, and that the scale inefficiency can be calculated from the difference between the VRS TE score and the CRS TE score.

In this paper, we use the BCC model to calculate the efficiency, with inputs of capital labor force, human capital and economic structure, and output GDP. The results of the efficiencies are showed in table 1: (1) The difference of frontier efficiency for the year 2003 and 2008 is small. (2) Guizhou, Hebei, Jilin, Liaoning, and Ningxia are under the adequate efficiency 1, Shanxi, Tianjin and Zhejiang are at near the adequate efficiency. (3) Six provinces, Anhui, Beijing, Gansu, Guangdong, Shan-xi, and Shanghai have a higher efficiency between 0.5 and 0.8, and the residual provinces are under 0.5.

3.3. Frontier Elasticity. We can deduce model (14) by adding restriction α(H)+β(H)=1 to model (2):

$$Y=\mathrm{e}^{\sum_{j=1}^{m}\lambda_j Z_{ji}}K^{\alpha(H)}L^{1-\alpha(H)} \tag{14}$$

Varying elasticity production function model allows the variety of the elasticity of output to vary over different human capital levels. Then, is there any difference between normal elasticity and frontier elasticity? In this paper, we consider two production functions: varying elasticity production function and frontier varying elasticity production function.

Benchmark Model A_0: Varying elasticity production function model

$$Y=\mathrm{e}^{\sum_{j=1}^{m}\lambda_j Z_{ji}}K^{\alpha_1(H)}L^{1-\alpha_1(H)} \tag{15}$$

Frontier Model A_1: Frontier varying elasticity production function model

$$FY=\mathrm{e}^{\sum_{j=1}^{m}\lambda_j Z_{ji}}K^{\alpha_2(H)}L^{1-\alpha_2(H)}\quad FY=Y/FE \tag{16}$$

FE is the frontier efficiency estimated by DEA model. Suppose the linear structure is defined by constant (C) and Economic Structure (Z). The detail results for models A_0 and A_1 are displayed in table 1. The comparisons for the elasticity of capital and labor force, as well as the comparison of productivity according to the varying elasticity production function and the frontier varying elasticity production function are showed in figures 1-6.

TABLE 1. Empirical results

Province	Frontier Efficiency (FE)		Elasticity for Model A_0 (15)				Frontier Elasticity for Model A_1(16)			
			Capital	Labor	Capital	Labor	Capital	Labor	Capital	Labor
	2003	2008	2003	2003	2008	2008	2003	2003	2008	2008
Anhui	0.616	0.713	0.665	0.335	0.459	0.541	0.712	0.288	0.712	0.288
Beijing	0.711	0.632	0.243	0.757	0.640	0.360	0.163	0.837	0.163	0.837
Fujian	0.454	0.531	0.669	0.331	0.641	0.359	0.653	0.347	0.653	0.347
Gansu	0.555	0.539	0.591	0.409	0.338	0.662	0.681	0.319	0.681	0.319
Guangdong	0.545	0.516	0.708	0.292	0.896	0.104	0.524	0.476	0.524	0.476
Guangxi	0.482	0.433	0.669	0.331	0.675	0.325	0.647	0.353	0.647	0.353
Guizhou	1.000	1.000	0.571	0.429	0.337	0.663	0.663	0.337	0.663	0.337
Hainan	0.405	0.444	0.709	0.291	0.772	0.228	0.524	0.476	0.524	0.476
Hebei	1.000	1.000	0.713	0.287	0.751	0.249	0.522	0.478	0.522	0.478
Henan	0.378	0.414	0.671	0.329	0.732	0.268	0.595	0.405	0.595	0.405
Heilongjiang	0.399	0.425	0.709	0.291	0.815	0.185	0.524	0.476	0.524	0.476
Hubei	0.400	0.390	0.670	0.330	0.725	0.275	0.662	0.338	0.662	0.338
Hunan	0.252	0.287	0.673	0.327	0.732	0.268	0.581	0.419	0.581	0.419
Jilin	1.000	1.000	0.726	0.274	0.837	0.163	0.521	0.479	0.521	0.479
Jiangsu	0.329	0.319	0.671	0.329	0.755	0.245	0.604	0.396	0.604	0.396
Jiangxi	0.355	0.363	0.709	0.291	0.720	0.280	0.523	0.477	0.523	0.477
Liaoning	1.000	1.000	0.751	0.249	0.892	0.108	0.526	0.474	0.526	0.474
Neimenggu	0.452	0.423	0.669	0.331	0.733	0.267	0.637	0.363	0.637	0.363
Ningxia	1.000	1.000	0.657	0.343	0.684	0.316	0.720	0.280	0.720	0.280
Qinghai	0.310	0.232	0.558	0.442	0.408	0.592	0.649	0.351	0.649	0.351
Shandong	0.310	0.324	0.675	0.325	0.731	0.269	0.572	0.428	0.572	0.428
Shanxi	0.938	1.000	0.726	0.274	0.834	0.166	0.521	0.479	0.521	0.479
Shan-xi	0.637	0.687	0.677	0.323	0.739	0.261	0.564	0.436	0.564	0.436
Shanghai	0.836	0.806	0.391	0.609	0.804	0.196	0.274	0.726	0.274	0.726
Sichuang	0.338	0.275	0.660	0.340	0.425	0.575	0.719	0.281	0.719	0.281
Tianjin	0.915	0.835	0.778	0.222	0.912	0.088	0.541	0.459	0.541	0.459
Xinjiang	0.353	0.420	0.414	0.586	0.311	0.689	0.877	0.123	0.888	0.112
Xinjiang	0.254	0.305	0.707	0.293	0.785	0.215	0.524	0.476	0.524	0.476
Yunnan	0.314	0.420	0.213	0.787	0.285	0.715	0.120	0.880	0.103	0.897
Zhejiang	0.930	0.904	0.672	0.328	0.706	0.294	0.589	0.411	0.589	0.411

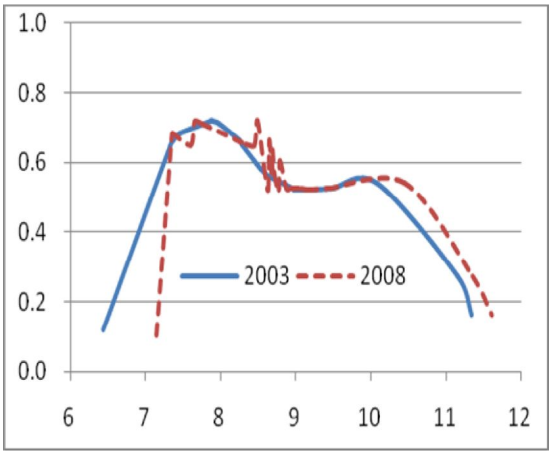

FIGURE 1. Frontier elasicity of capital

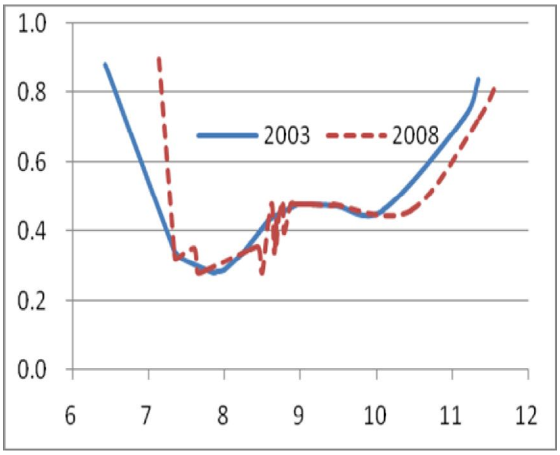

FIGURE 2. Frontier elasicity of labor

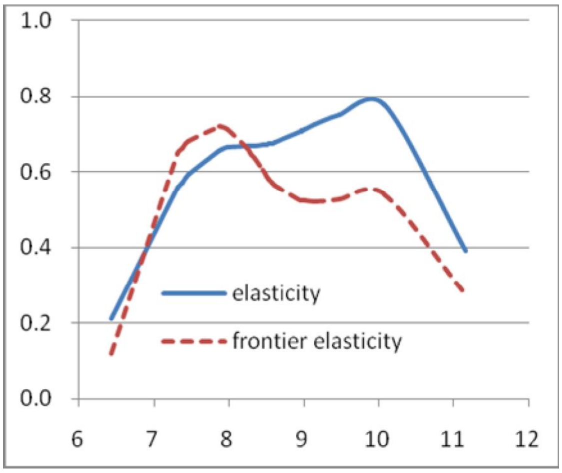

FIGURE 3. Elasticity of capital for 2003

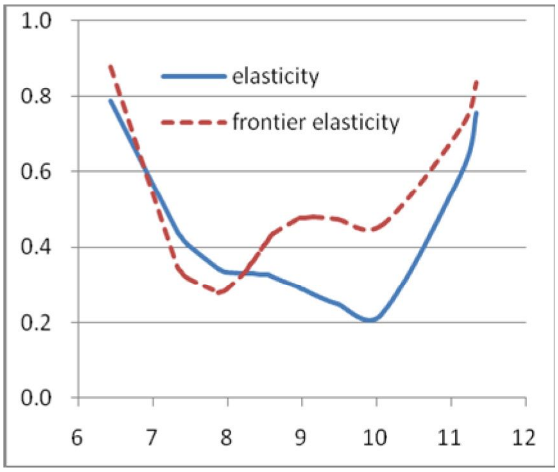

FIGURE 4. Elasticity of labor for 2003

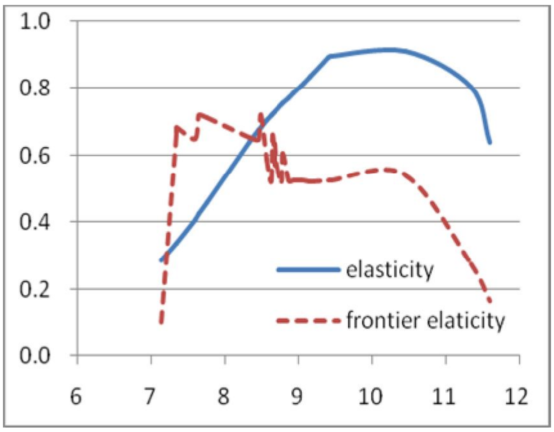

FIGURE 5. Elasticity of capital for 2008

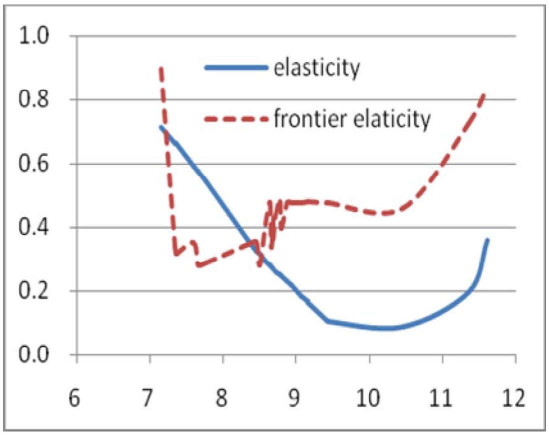

FIGURE 6. Elasticity of labor for 2008

The figures 1-6 indicate, the varying elasticity as well as the frontier varying elasticity of capital performs an inverted U-shape trend, and the varying elasticity as well as the frontier varying elasticity of labour force performs U-shape trend.

As can be seen from the figures 1-2, the difference of frontier elasticity for the year 2003 and 2008 is small. However, the results for the frontier varying elasticity production function are differently from that of the varying elasticity production function. As can be seen from figures 3-6, as the rising of human capital, the frontier elasticity of capital is significant less than the normal one, and the frontier elasticity of labour force is significant bigger than the normal one. The results indicate that, the missing of frontier efficiency will overestimate the varying elasticity of capital, and underestimate the varying elasticity of labour force. In other words, the frontier efficiency reduces the varying elasticity of capital and enhances the varying elasticity of labour force simultaneity.

4. Conclusions. Cobb-Douglas production function is preferred for its simple structure, meaningful parameter and easy estimation. However, the conventional economic growth model such as Cobb-Douglas production function requires unrealistically strong assumptions, such as the constant elasticity and the full efficiency of the technique.

Varying coefficient models are a useful extension of classical linear models. They arise naturally when one wishes to examine how regression coefficients change over different groups characterized by certain covariates. Without restrictive assumptions, DEA involves the use of linear programming methods to construct a nonparametric piecewise frontier over the data to estimate the efficiency.

However, the varying-elasticity production function does not take frontier efficiency into account, while the DEA model is being short of the form of production function. In this paper, we combine the advantages of the DEA model and the varying-elasticity production function, as well as the advantages of the parametric model and the nonparametric varying-coefficient model, to estimate the frontier varying-elasticity.

The empirical results find out the below conclusions: (1) The difference of frontier efficiency for the year 2003 and 2008 is small, Guizhou, Hebei, Jilin, Liaoning, and Ningxia are under the adequate efficiency 1, Shanxi, Tianjin and Zhejiang are at near the adequate efficiency, Anhui, Beijing, Gansu, Guangdong, Shan-xi, and Shanghai have a higher efficiency between 0.5 and 0.8, and the residual provinces are under 0.5. (2) The varying elasticity as well as the frontier varying elasticity of capital performs an inverted U-shape trend, and the varying elasticity as well as the frontier varying elasticity of labour force performs U-shape trend. (3) The difference of frontier elasticity for the year 2003 and 2008 is small, however, as the rising of human capital, the frontier elasticity of capital is significant less than the normal one, and the frontier elasticity of labour force is significant bigger than the normal one. The empirical results indicate that the frontier efficiency may reduces the varying elasticity of capital and enhance the varying elasticity of labour force simultaneity.

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MEASURING SOFT CONSENSUS IN UNCERTAIN LINGUISTIC GROUP DECISION-MAKING BASED ON DEVIATION AND OVERLAP DEGREES

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ABSTRACT. *In this paper, we consider the consensus measurement in group decision making with uncertain linguistic information. We proposed a method to calculate the similarity of uncertain linguistic terms based on deviation and overlap degrees. The deviation and overlap have the similarity information of uncertain linguistic terms from different aspect. We have discussed the concept of overlap and develop 3-tuple representation model of uncertain linguistic terms. Upon this work, we proposed a formula to calculate the overlap degree. At last, the consensus measure in uncertain linguistic group decision making was given out.*

Keywords: Consensus Measure; Group Decision Making; Uncertain Linguistic Terms; Coincidence; Deviation; Overlap

1. Introduction. Group decision-making (GDM) problems with linguistic information arise from a wide range of real-world situations (Chang et al., 2007; Chen and Arieh, 2006; Cheng and Lin, 2002; Chuu, 2009; Dong et al., 2009; Wang and Chuu, 2004; Wang, 2009; Wu and Chen, 2007). The reaching of consensus in group decision-making problems is a common and important task in group decision processes. Literatures show that several different approaches were developed to measure the degree of consensus in the GDM. Herrera et al. (1996, 1997) proposed a consensus model in group decision-making under linguistic assessment on preference relations, along with the study of consensus-reaching process and linguistic consistency measures. Eklund et al. (2007) provided another dynamic consensus model for decision-making within committees based on a degree of consensus. Herrera-Viedma et al. (2007) presented a consensus model guided by both consensus and consistency measure, and the consensus reaching process as well. Herrera-Viedma et al. (2004) presented two types of measures of consensus between the experts in multi-granular linguistic GDM problems, e.g. consensus degrees and proximity measures. In Cabrerizo et al. (2010) analyzed the different consensus approaches in fuzzy group decision-making problems and discussed their advantages and disadvantages. However, no specific work has been dedicated to measuring consensus under uncertain linguistic assessment in GDM.

Because of time pressure, lack of knowledge, estimation inaccuracies due to limited cognition, and people's limited expertise related with problem domain, the linguistic preference information provided by decision-maker (DM) may be in the form of uncertain linguistic variables (Xu, 2004; Xu, 2006). Nowadays, the GDM problem with uncertain linguistic terms deserves more attention (Fan and Liu, 2010).

Consensus measure is used to measure the closeness among DM's opinions in order to obtain the consensus level in the consensus process (Cabrerizo et al., 2010). There are two type consensus measures e.g. hard consensus measure and soft consensus measure. Hard consensus is a full and unanimous agreement among DM's opinions, which is far from achieved in real situations, while soft consensus is the consensus degree among DM's opinions, which is more flexible and reflect the large spectrum of possible partial agreements. Soft measures are based on the concepts of coincidence (Herrera et al., 1997). The classical soft consensus measures can be computed according to three different coincidence criteria (Cabrerizo et al., 2010): (1) strict coincidence among preferences; (2) soft coincidence among preferences; (3) coincidence among solution. The above three coincidences criteria are computed in the form of exact linguistic variables.

Because the concept of coincidence is the core of consensus measures, how to measure the coincidence between linguistic variables is the basis of consensus measurement in linguistic group decision making (LGDM). Therefore, the critical issue of measuring consensus in uncertain linguistic group decision making (ULGDM) is to find the computation method of coincidence degree in form of uncertain linguistic variables.

In this contribution, we devote the main effort to the method to calculate the coincidence between uncertain linguistic variables. And upon the coincidence criteria, we present the consensus measures in uncertain linguistic group decision.

2. Preliminaries.

2.1. Uncertain Linguistic Variable and ULGDM. In this section, we first review the basic concepts in uncertain linguistic group decision making. In a classical ULGDM situation, there is a problem to solve, a solution set of possible alternative $X=\{x_1,\dots,x_n\}$, and a group of two of more DMs, $E=\{e_1,\dots,e_m\}$, characterized by their own idea, attitudes, motivations, expertise and knowledge, who express their preference relations $P=\{P^1,\dots,P^m\}$ about the set of alternative X, using uncertain linguistic term set $\tilde{S}=\{[s_i,s_j]\mid s_i,s_j\in S, i<j\}$ to achieve a common solution (Xu, 2004; Xu, 2006 ; Xu, 2004). For example, a set of seven terms S could be $S=\{$ $s_{-3}=$ extremely poor, $s_{-2}=$ very poor , $s_{-1}=$ poor, $s_0=$ fair, $s_1=$ good, $s_2=$ very good, $s_3=$ extremely good $\}$. In this case, the expert e_1 using "moderately good " that can be represented by $[s_0,s_1]$ to express the preference degree of alternative x_1 over alternative x_2, i.e. $p^1_{12}=[s_0,s_1]$. If the expert is very different to express his/her preference information, in other word, he/she "doesn't know" which alternatives is preferred, then this situation can be represented by uncertain linguistic term $[s_{-3},s_3]$.

Xu (2004, 2006) has proposed the uncertain linguistic variable on the continuous linguistic term set. Suppose that $S=\{s_i\mid i=-t,\dots,t\}$ is a pre-established finite and totally ordered discrete linguistic label set, where s_i represents a possible value for a linguistic variable. The extended continuous linguistic term set of S is $\bar{S}=\{s_\alpha\mid \alpha\in[-t,t]\}$. If $s_\alpha\in S$, then s_α is called an original linguistic term, otherwise, it is called a virtual linguistic term (Xu, 2006). The concepts of deviation degree and similarity degree between two linguistic variables are defined in (Xu, 2005).

Let $\tilde{s}=[s_\alpha,s_\beta]$, where $s_\alpha,s_\beta\in\overline{S}$, s_α and s_β are the lower and upper limits, respectively, then $\tilde{s}$ is called an uncertain linguistic variable (Xu, 2004; Xu, 2006). Denote the set of $\tilde{s}$ as $\tilde{S}$. The operations $\tilde{s}_\alpha\oplus\tilde{s}_\beta$ and $\lambda\tilde{s}_\alpha$ are defined as bellow (Xu, 2006):

(1) $\tilde{s}_\alpha\oplus\tilde{s}_\beta=[s_{\alpha_1},s_{\beta_1}]\oplus[s_{\alpha_1},s_{\beta_1}]=[\max\{s_{-t},\min\{s_{\alpha_1+\alpha_2},\ s_t\}\},\max\{s_{-t},\min\{s_{\beta_1+\beta_2},s_t\}\}]$;

(2) $\lambda\tilde{s}_\alpha=\lambda[s_\alpha,s_\beta]=[s_{\lambda\alpha},s_{\lambda\beta}]$, where $\lambda\in[0,1]$.

Obviously, the greater $\beta-\alpha$ is, the greater the imprecision of $[s_\alpha,s_\beta]$ will be. Specially, if $s_\alpha=s_\beta$, then $[s_\alpha,s_\beta]$ is reduced to a exact linguistic labels s_α or s_β. We define $\tilde{s}=[s_\alpha,s_\alpha]=s_\alpha$ as convention.

The distance between uncertain linguistic variable are defined in (Xu, 2006): Let $\tilde{s}_1=[s_{\alpha_1},s_{\beta_1}]$, $\tilde{s}_2=[s_{\alpha_2},s_{\beta_2}]\in\tilde{S}$, then the distance between $\tilde{s}_1$ and $\tilde{s}_2$ is defined as follows

$$d(\tilde{s}_1,\tilde{s}_2)=\frac{1}{2}[|\alpha_1-\alpha_2|+|\beta_1-\beta_2|] \quad (1)$$

The actual meaning of uncertain linguistic term $[s_\alpha,s_\beta]$ is that the DMs can not provide clearer judgment among multiple linguistic labels $(s_\alpha,s_{\alpha+1},\ldots,s_\beta)$ (Fan and Liu, 2010). So in our opinion, $[s_\alpha,s_\beta]$ provided by DMs stands for the discrete label set $\{s_\alpha,s_{\alpha+1},\ldots,s_\beta\}$, where $s_i\in S,\ i=\alpha,\alpha+1,\ldots,\beta$. The operations upon $\tilde{S}$, such as ULOWA, ULHA, et al. (Xu, 2004; Xu, 2006), are used for aggregation of uncertain linguistic assessment, and the results derived from these operations are used for ranking the alternatives.

2.2. Coincidence among Preferences. It has been addressed above that the consensus measures are based on the concept of coincidence. As two types of consensus measures, coincidence can be classed into two types: strict coincidence and soft coincidence.

Similarity criteria among preference are used to compute the coincidence concept (Herrera et al., 1996; Herrera et al., 1997; Herrera-Viedma et al., 2007; Cabrerizo et al., 2010; Herrera et al., 1997). There are only two possible results are assumed in the case of strict coincidence: the total coincidence (value 1) or null coincidence (value 0). In the case of soft coincidence, a similarity function is defined to compute the similarity between two linguistic labels as follows(Cabrerizo, et al., 2010):

$$\rho(s_\alpha,s_\beta)=1-\frac{|\alpha-\beta|}{2t} \quad (2)$$

3. Similarity between Uncertain Linguistic Terms. In the case of classical GDM with linguistic assessment, the deviation degree is enough to reflect the similarity between two linguistic labels, and so the similarity degree can be calculated only by means of deviation. But the situation is changed in the uncertain linguistic environment. For the ULGDM, the deviation can not capture the whole information of the similarity degree of two uncertain linguistic terms, it only partly represent the similarity information. The main cause is that two uncertain linguistic terms may intersect. We call this situation as overlap of uncertain linguistic terms. Therefore, in this paper, we think that the similarity degree between two uncertain linguistic terms should have to be computed upon the concepts of deviation and overlap.

3.1. Deviation between Uncertain Linguistic Terms. On the basis of distance of uncertain linguistic variables in (1), we can define deviation degree.

Definition 3.1. Let, $\tilde{s}_1 = [s_{\alpha_1}, s_{\beta_1}], \tilde{s}_2 = [s_{\alpha_2}, s_{\beta_2}] \in \tilde{S}$ be two uncertain linguistic terms, then we define the deviation degree between $\tilde{s}_1$ and $\tilde{s}_2$ as follows:

$$d(\tilde{s}_1, \tilde{s}_2) = \frac{|\alpha_1 - \alpha_2| + |\beta_1 - \beta_2|}{2 \cdot 2t} \quad (3)$$

Where $2t+1$ is the cardinality of linguistic term set S.

Obviously, $0 \le d(\tilde{s}_1, \tilde{s}_2) \le 1$. If $\tilde{s}_1 = \tilde{s}_2$, then $d(\tilde{s}_1, \tilde{s}_2) = 0$, and if $\tilde{s}_1 = s_{-t}$, $\tilde{s}_2 = s_t$, then $d(\tilde{s}_1, \tilde{s}_2) = 1$. The smaller the value of $d(\tilde{s}_1, \tilde{s}_2)$, the smaller the deviation degree of uncertain linguistic terms $\tilde{s}_1$ and $\tilde{s}_2$.

3.2. Overlap between Uncertain Linguistic Terms. The concept of overlap between two uncertain linguistic terms has the similarity information that the deviation hasn't. For example, suppose S with 9 cardinalities and two pairs of uncertain linguistic terms $[s_1, s_4]$ and $[s_2, s_5]$, $[s_1, s_5]$ and $[s_2, s_6]$, the deviation of this two pairs is the same value 1/8 according to (3), but we can find intuitively the similarity of $[s_1, s_5]$ and $[s_2, s_6]$ are greater than the similarity of $[s_1, s_4]$ and $[s_2, s_5]$, because the overlap of former pair is larger than the latter, see figure 1.

FIGURE 1. Overlap of two uncertain linguistic terms

In this section, we discuss the uncertain linguistic terms and the overlap between them, and provide a computation method of overlap degree of uncertain linguistic terms.

Definition 3.2. Let $\tilde{s} = [s_\alpha, s_\beta] \in \tilde{S}$, $[s_\alpha, s_\beta]$ is called original uncertain linguistic term (OULT) if and only if $s_\alpha, s_\beta \in S$. Otherwise $[s_\alpha, s_\beta]$ is called virtual uncertain linguistic term (VULT).

In the following, for distinction and convenience, we denote OULT as $[s_i, s_j]_d$ or $\hat{s}$, VULT as $[s_\alpha, s_\beta]_c$ or $\tilde{s}$, the set of OULT as $\hat{S}$, and the set of VULT as $\tilde{S}$.

In general, original uncertain linguistic term is used by decision-maker to evaluate alternatives, and the virtual uncertain linguistic term can only appear in operation and ranking process.

If a decision-maker uses the $[s_i, s_j]_d$ to express their opinion, it means that he/she cannot provide clearer judgment/assessment on the alternatives within multiple linguistic terms $\{s_i, s_{i+1}, \ldots, s_j\}$, which is a discrete set. While a VULT usually appears as the aggregation result, which stands for continuous linguistic term set $\{s_k \mid s_\alpha \le s_k \le s_\beta; s_\alpha, s_k, s_\beta \in \overline{S}\}$. The advantage of this representation model is to avoid the loss of information during the aggregation process. This is another main difference between OULT and VULT in addition to the usages of them. For this reason, we can also call OULT as discrete uncertain linguistic term (DULT) and VULT as continuous uncertain linguistic term (CULT).

Definition 3.3. Let $\hat{s}_1 = [s_{i_1}, s_{j_1}]_d$, $\hat{s}_2 = [s_{i_2}, s_{j_2}]_d \in \hat{S}$, then the overlap degree between them is defined as follows:

$$o(\tilde{s}_1,\tilde{s}_2)=\frac{|[s_{i_1},s_{j_2}]_d\cap[s_{i_2},s_{j_2}]_d|}{|[s_{i_1},s_{j_2}]_d\cup[s_{i_2},s_{j_2}]_d|} \quad (4)$$

Where $[s_{i_1},s_{j_1}]_d$ and $[s_{i_1},s_{j_1}]_d$ respectively stand for the sets $\{s_{i_1},s_{i_1+1},\ldots,s_{j_1}\}$ and $\{s_{i_2},s_{i_2+1},\ldots,s_{j_2}\}$, $|\,|$ is the cardinality of set. Take the figure 1 for example, the overlap degree of $[s_1,s_4]_d$ and $[s_2,s_5]_d$ is 3/5, and that of $[s_1,s_5]_d$ and $[s_2,s_6]_d$ is 2/3 > 3/5.

Obviously, $0\le o(\hat{s}_1,\hat{s}_2)\le 1$. If $\hat{s}_1\cap\hat{s}_2=\varnothing$, then $o(\hat{s}_1,\hat{s}_2)$ =0, and if $\hat{s}_1=\hat{s}_2$,then $o(\hat{s}_1,\hat{s}_2)=1$.

Notice: The overlap is the intersection of two original uncertain linguistic terms not the intersection of two virtual uncertain linguistic terms because decision-makers express their opinion with original terms. Since a VULT stands for continuous label set, the overlap degree between two VULTs cannot calculated by (4). For two VULTs, intuitively, we can calculate the overlap degree by means of proportion of intersection length of two intervals, i.e. $o(\tilde{s}_1,\tilde{s}_2)=\dfrac{\mu([s_{\alpha_1},s_{\beta_1}]\cap[s_{\alpha_2},s_{\beta_2}])}{\mu([s_{\alpha_1},s_{\beta_1}]\cup[s_{\alpha_2},s_{\beta_2}])}$, where $\mu([s_\alpha,s_\beta])=\beta-\alpha$.

But the result by this formula is not inconsistent with (4). Take the figure 1 for example, the overlap degree of $[s_1,s_4]_d$ and $[s_2,s_5]_d$ is 3/5 by (4), while the overlap degree of $[s_1,s_4]_c$ and $[s_2,s_5]_c$ obtained by above formula is 1/2 < 3/5. The reason of this inconsistent is the difference between the measure of discrete set and the measure of continuous set. Therefore, in order to keep the consistency, VULTs should be "transformed" to OULTs when computation of overlap degree between two VULTs and that between a OULT and a VULT. To solve this problem, we introduce 3-tuple representation model of continuous uncertain linguistic terms.

Based on the concept of symbolic translation(Herrera and Martinez, 2000), we proposed another representation of a continuous uncertain linguistic term $[s_\alpha,s_\beta]_c$ by means of 3-tuple $<[s_i,s_j]_d,a,b>$, where $[s_i,s_j]_d$ is an OULT and $a,b\in[-0.5,0.5)$:

(1) $[s_i,s_j]_d$ represents the discrete uncertain linguistic term of information;

(2) a is a numerical value expressing the value of the translation from the lower index value α to the closest index label i in the S, i.e. the symbolic translation;

(3) b is a numerical value expressing the value of the translation from the upper index value β to the closest index label j in the S, i.e. the symbolic translation;

This model defines a set of transformation function between continuous uncertain linguistic terms and 3-tuple and between interval values and 3-tuple. Also it provides a means to transform a continuous uncertain linguistic term to an approximate discrete uncertain linguistic term.

Definition 3.4. Let $[s_\alpha,s_\beta]_c\in\tilde{S}$ be a continuous uncertain linguistic term, then the 3-tuple that expresses the equivalent information to $[s_\alpha,s_\beta]_c$ is obtained with the following function:

$$\Delta:\tilde{S}\to\hat{S}\times[-0.5.0.5)\times[-0.5.0.5) \quad (5)$$

$$\Delta([s_\alpha,s_\beta]_c)=<[s_i,s_j]_d,a,b>$$

$$\text{with}\begin{cases}[s_i,s_j]_d, & i=round(\alpha),\ j=round(\beta)\\ a=\alpha-i, & a\in[-0.5,0.5)\\ b=\beta-j, & b\in[-0.5,0.5)\end{cases} \quad (6)$$

Where $round(\cdot)$ is the usual round operation, s_i has the closest index label to "α", s_j has the closest index label to "β", "a" and "b" are the value of the symbolic translation.

Suppose a symbolic aggregation operation over uncertain terms assessed in $S=\{s_0,s_1,\ldots,s_8\}$ that obtained as it result $\tilde{s}=[s_{3.8},s_{6.3}]$, then the representation of this counting of information by means of a 3-tuple will be $\Delta([s_{3.8},s_{6.3}]_c)=<[s_4,s_6]_d,-0.2,0.3>$. Graphically, it is represented in Fig. 2.

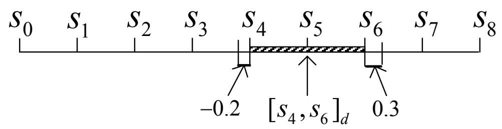

FIGURE 2. Example of uncertian linguistic term translation computation

Proposition 3.1. Let $S=\{s_0,\ldots,s_g\}$ be a linguistic term set and $<[s_i,s_j]_d,a,b>$ be a 3-tuple. There is always a Δ^{-1} function such that from 3-tuple it returns its equivalent continuous uncertain linguistic term $[s_\alpha,s_\beta]_c\in\tilde{S}$.

Proof. it is trivial, we consider the following function:

$$\Delta^{-1}:\hat{S}\times[-0.5,0.5)\times[-0.5,0.5)\rightarrow\tilde{S} \quad (7)$$

$$\Delta^{-1}([s_i,s_j]_d,a,b)=[s_{i+a},s_{j+b}]_c$$

With the transformation function Δ, we can convert continuous uncertain linguistic terms to their approximate discrete linguistic terms. And then the overlap degree between two CULTs and between a DULT and a CULT can be obtained through (4).

Remark: From Definition 4 and Proposition 1, it is obvious that the conversion of a $[s_\alpha,s_\beta]_c$ with $s_\alpha,s_\beta\in S$ into a 3-tuple consist of adding zeros as symbolic translation

$$[s_\alpha,s_\beta]_c \text{ with } s_\alpha,s_\beta\in S \;\Leftrightarrow\; <[s_\alpha,s_\beta]_d,0,0>.$$

With Definition 3 and 4, the overlap degrees between two CULTs and between a DULT and a CULT can be calculated.

3.3. Soft Coincidence of Uncertain Linguistic Terms. With deviation and overlap degrees, we define the similarity measure to compute soft coincidence of uncertain linguistic terms.

Definition 3.5. Let $\tilde{s}_1,\tilde{s}_2\in\tilde{S}$, $\hat{s}_1,\hat{s}_2$ is the approximate discrete uncertain terms of $\tilde{s}_1,\tilde{s}_2$ obtained by Δ, then the similarity measure between $\tilde{s}_1$ and $\tilde{s}_2$ is defined as follows:

$$\rho(\tilde{s}_1,\tilde{s}_2)=\gamma(1-d(\tilde{s}_1,\tilde{s}_2))+(1-\gamma)o(\hat{s}_1,\hat{s}_2) \quad (8)$$

Where $\gamma\in[0,1]$ is the weight of $d(\tilde{s}_1,\tilde{s}_2)$, which reflects the relative importance degree between the deviation and the overlap with respect to the decision-maker. $1-\gamma$ is the weight of $o(\hat{s}_1,\hat{s}_2)$. The basic idea of this similarity measure is that the smaller $d(\tilde{s}_1,\tilde{s}_2)$ and the larger $o(\hat{s}_1,\hat{s}_2)$ are, the larger similarity $\rho(\tilde{s}_1,\tilde{s}_2)$ is. Since $\rho(\tilde{s}_1,\tilde{s}_2)$ is the linear combination of $d(\tilde{s}_1,\tilde{s}_2)$ and $o(\hat{s}_1,\hat{s}_2)$, it follows (1) $0\le\rho(\tilde{s}_1,\tilde{s}_2)\le 1$; (2) $\rho(\tilde{s}_1,\tilde{s}_2)=1$ if and only if $\tilde{s}_1=\tilde{s}_2$; (3) $\rho(\tilde{s}_1,\tilde{s}_2)=\rho(\tilde{s}_2,\tilde{s}_1)$.

4. Soft Consensus Measures in Uncertain Linguistic Group Decision Making. Once the similarity function to measure the soft coincidence defined, the measurement of consensus can be easily carried out. In this paper, we focus on two types of consensus measure: consensus degrees and proximity measures (Herrera et al., 1996; Herrera et al., 1997; Herrera-Viedma et al., 2007; Herrera-Viedma et al., 2004; Cabrerizo et al., 2010). The consensus degrees assess the agreement among all the experts' opinions, while the proximity measures are used to compute the coincidence between the individual opinions and the group opinion.

4.1. Consensus Degrees. At the beginning of computing the consensus degrees, we need to obtain a soft similarity matrix $SM^{kl}=[sm_{ij}^{kl}]_{n\times n}$ of preference relations for each pair of DMs (e_k,e_l) $k,l=1,\ldots,m$. According to Definition 5, the SM^{kl} is obtained as follow: $sm_{ij}^{kl}=\rho(p_{ij}^k,p_{ij}^l)$. And then, a collective similarity matrix $SM=[sm_{ij}]$ is obtained by aggregating all the similarity matrices using the arithmetic mean $sm_{ij}=\phi(sm_{ij}^{kl};k=1,\ldots,m-1;.$ $l=k+1,\ldots,m)$.

The consensus degrees are computed at three levels.

Level 1. consensus degree on pairs of alternatives (x_i,x_j): $cop_{ij}=sm_{ij}$;

Level 2. consensus degree on alternatives x_i: $ca_i=\sum_{j=1,j\neq i}^{n}(cop_{ij}+cop_{ji})\big/(2n-2)$;

Level 3. consensus degree on the relation: $CR=\sum_{i=1}^{n}ca_i\big/n$.

4.2. Proximity Measures. To compute the proximity measures, we need to obtain the collective preference relation $P^c=[p_{ij}]_{n\times n}$. To do so, the ULOWA (Xu, 2004) operator can be used. For each DM e_k $k=1,\ldots,m$, a proximity matrix $PM^k=[pm_{ij}^k]_{n\times n}$ is obtained: $pm_{ij}^k=\rho(p_{ij}^k,p_{ij}^c)$.

The proximity measures are computed at three levels.

Level 1. proximity measure of e_k on pairs of alternatives (x_i,x_j) to the group's one:

$$pp_{ij}^k=pm_{ij}^k;$$

Level 2. proximity measure of e_k on alternatives x_i to group's one:

$$pa_i^k=\sum_{j=1,j\neq i}^{n}(pp_{ij}^k+pp_{ji}^k)\big/(2n-2);$$

Level 3. proximity measure of e_k on his/her preference relation to group's one:

$$pr^k=\sum_{i=1}^{n}pa_i^k\big/n.$$

5. Conclusion. In this paper, the consensus measurement in uncertain linguistic GDM was discussed. We have proposed a method to calculate the similarity of uncertain linguistic terms based on deviation and overlap degrees. In order to compute the overlap degree of uncertain linguistic terms, the 3-tuple representation model was developed, and the transformation function was given out. At last, based on the work of Herrera et al., the consensus measure in the uncertain linguistic group decision making was given out.

On the basis of the proposed similarity function of uncertain linguistic terms, the soft consensus measurement was given out, which consist of consensus degrees and proximity measures. The proposed similarity function considers not only the deviation degree of a pair of uncertain linguistic terms but also the overlap degree of them that is a necessary component of the soft consensus measurement of uncertain linguistic terms. For two pairs of uncertain linguistic terms, the overlaps of each pair contain a part of important information of coincidence concept and reflect the coincidence degrees of each pair especially when the deviations of each pair are the same. As an extreme situation, for two pairs of uncertain linguistic terms which have the same deviation, the former consensus measure only based on deviation cannot distinguish the consensus degree of them, but the proposed consensus measure can do. So the proposed consensus measurement is better and more precise than the former consensus measurement only based on deviation, when we apply it in the uncertain linguistic group decision making.

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EMPIRICAL RESEARCH ON FOOD SAFETY SATISFACTION OF RESIDENTS

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ABSTRACT. *The issue of food safety has always been a focus problem of the society. Especially after some serious food safety events happened, such as Sanlu powder event, the government has paid more attention to it and has taken a series of measures already. Based on sample data of food safety satisfaction of residents in Hangzhou, using factor analysis and structural equation model, this paper studies the degree of food safety satisfaction of residents in Hangzhou and finally makes some suggestions.*

Keywords: Food Safety; Satisfaction; Index; Structural Equation Model

1. Introduction.

1.1. Problem. Food safety issue has been a big concern of China's food safety supervision and regulation system. The occurrence of some serious food safety accidents like melamine case, has exposed the imperfection of the current food safety and supervision system, which directly shows us the severe problems in food safety. Nevertheless, these severe problems of the food safety are not only harmful to people's health, but also detrimental to the market order as well as the stability of our society. It is estimated that there are about two hundred thousand to four hundred thousand people poisoned by food every year in China (Han, 2007). The food safety issue is like a time bomb around us, which could be detonated at any moment.

In this grim situation, The Food Safety Law of the People's Republic of China (National People's Congresses, 2009) was adopted at the 7th Session of the Standing Committee of the 11th National People's Congress of the People's Republic of China on February 28, 2009 and came into force on June 1, 2009. On October 22, 2009, General Administration of Quality Supervision, Inspection and Quarantine (AQSIQ) issued the decision to amend The

Regulations of Food Labeling to further strengthen the supervision and management of food labeling.

Two regulations promulgated in succession indicate that the government puts more efforts into the areas of food safety by applying technical regulations and standards to monitor and administer food production, processing, transportation and sales, which also plays an important role in China's implementation of food safety standardization strategy. However, the United States, Japan and some other developed countries, in the process of food standardization, put an emphasis on both strategies of flexibility of market and the international standardization, and the coordination of scientific research and standardization, that is, to encourage scientific research experts to do research with the aim to improve health. And to develop research on the degree of food safety satisfaction which would reflect the effects of the policies adopted by the government and it's monitoring of the production and processing is a good expression of such kind of research. In fact, it is also a key basis to build up and improve the food safety standards system and solve the food safety problem. Therefore, it is urgent to do research of food safety satisfaction in the area of food consumption.

1.2. Research Methods. This article uses structural equation model to analysis the relationship among influenced factors of residents' food safety satisfaction. Structural equation model is a popular method in social science research. Structural equation model combines the ideas and methods of factor analysis, path analysis and multiple linear regression analysis. It includes measurement model and structural model. Measurement model is to obtain the relationship between observation indicators and latent variables; structure model is to calculate the relationship between different latent variables. Equation uses the maximum likelihood estimation method to estimate, and the test of goodness of fit measures the goodness-of-fit of model by using likelihood ratio chi-square, CFI、NFI、IFI、RMSEA tests.

1.3. Variable Selection. Codex Alimentarius Commission (CAC) defined the food safety as: food in the planting, breeding, processing, packaging, storage, transportation, sale, consumption and other activities meet the national mandatory standards and requirements and there is no toxic and hazardous substances which may harm or threat human health to cause the consumers death or to bring such risks to consumers and their future generations(Gao and Yan, 2009). According to the definition of food safety and present status of food markets of Hangzhou, we summarize twenty factors that may affect food safety from food processing, management control, hazardous substances, quality status and social supervision. These factors are Quality, Freshness, Hygiene Condition, Nutrient Composition, Additives, Heavy Metals, Pesticide Residues, Food Packing, Brand Manufacturer, Source of Food Production, Production Processing, Storage and Transportation, Government Policies, Regulatory Systems, Relevant Law, Law Enforcement, Technical Certification, Licensing Certification, Media Supervision and Public Opinion.

2. Questionnaire Pilot Survey, Sample Distribution and Analysis of General Satisfaction.

2.1. Evaluation and Testing of Validity and Reliability. Firstly we complete the questionnaire design through the selected variables studied above and conduct pre-survey and the data of 100 respondents (about 1/4 of the total sample) is obtained. Then we use SPSS17.0 software to do project analysis, factor analysis and reliability tests to examine the questionnaire reliability and validity.

2.1.1. Project Analysis. Data of 20 satisfaction indexes are added to get total score, and the upper 27% quartile is 71, the lower 27% quartile is 57% quartile is 71.By using independent sample T-test to test scores, the results of the T value are significant ($P < 0.05$), indicating that all the 20 items are identifiable and are able to identify the response level of different respondents.

2.1.2. Factor Analysis. After the project analysis, we use factor analysis to examine the structure validity of the questionnaire. As shown in the output results, KMO value is 0.840, Bartlett ball test value is 1087.754, P value is 0, and the output five factors can explain the 20 variables with cumulative percentage of 68.61%.

2.1.3. Reliability Test. Then we test the consistency coefficient of each factor level and total scale table, see Table 1.

TABLE 1. Reliability statistics

Management Control		Food Processing		Hazardous Substances	
Cronbach's Alpha	N of Items	Cronbach's Alpha	N of Items	Cronbach's Alpha	N of Items
0.905	6	0.778	6	0.834	3
Quality Status		**Social Supervision**		**Total**	
Cronbach's Alpha	N of Items	Cronbach's Alpha	N of Items	Cronbach's Alpha	N of Items
0.759	3	0.764	2	0.912	20

As shown in Table 1, all the Alpha coefficients of 5 subscales are higher than 0.7, while the Alpha coefficient of total scale is higher than 0.9, indicating the reliability of this scale are quite good.

Item analysis, factor analysis and reliability test results show that the reliability and validity of the questionnaire are quite good, so formal investigations can be conducted.

2.2. Sample Distribution. We did survey of residents' food safety satisfaction in Hangzhou city in July 2009, and 400 questionnaires were sent out and 383 available questionnaires were retrieved. The response rate is 97.75%. We use the survey data to be the source data of this research.

In all respondents, male-to-female ratio is 47:53. Among them, under 18 years old account for 5.0% of total number of residents; 18-30 years old are the largest, account for 50.7%; the percentages of 31-40, 41-50 ,51-60 years old residents are 19.0 %, 18.0% and 5.0% respectively, and the residents aged over 60 account for 1.6% of the total number of residents. The questionnaires are collected form all ages, with universal representation. The respondents' monthly family income of 2000-2000 yuan or below, 6000 yuan and 6000-10000 yuan account for 19.6%, 37.1% and 15.4% respectively.

3. Establishment of Structural Equation Model.

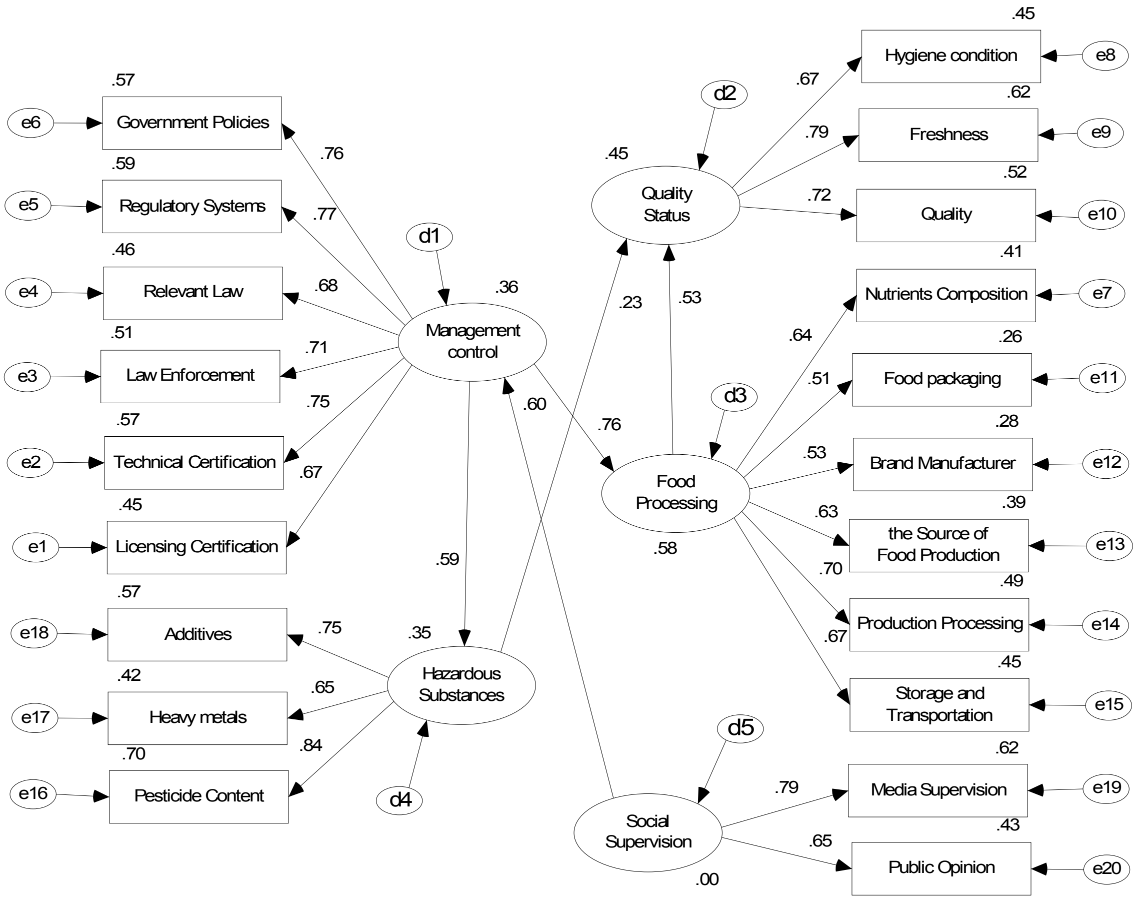

FIGURE 1. Structural equation model

3.1. Initial Model Construction. According to this study, we set up five latent variables in the model: food processing, management control, content of hazardous substances, quality status and social supervision. The five latent variables are interrelated and conditioned each other, and then we establish the following assumptions:

H_1: "management control" has positive impact on "food processing ";

H_2:"management control" has positive impact on "content of hazardous substances";

H_3:"social supervision" has positive impact on "management control";

H_4:"content of hazardous substances" has positive impact on "quality status";

H_5:"food processing" has positive impact on "quality status".

In setting up the initial model, we define one-to-one correspondences between latent variables and observed variables. AMOS 7.0 software is used to model. First we set up cause-and-effect relationship path diagram, then run program to get results, see Figure 1.

3.2. Model Fitting. After setting up the initial model, firstly model's coefficients are tested in order to investigate whether they accord with the model assumptions. Result of model parameters fitting shows that all the P values of parameters are significant, indicating that the assumption is supported. Next, in order to examine the goodness-of-fit of the model, we observe the indicators obtained by AMOS output results and the results are shown in Table 2.

TABLE 2. Results of model test and goodness-of-fit

Model	CMIN	DF	P	CMIN/DF	CFI	PCFI	NFI	IFI	RMSEA
Default model	439.869	165	0.000	2.666	0.909	0.790	0.863	0.910	0.066

According to Table 2, we can observe model fitting result. After observing absolute fitting results, we can find Chi-square value does not reach to an acceptable level of significance, the ratio (slightly larger than 2) of chi-square value to degrees of freedom is decent; and also after observing relative fitting results, NFI value is close to 0.9, IFI value greater than 0.9; the alternative indicators, CFI is close to 0.9, PCFI is greater than 0.5, RMSEA value is less than 0.08. The various evaluation indicators show that the model fitting result is good.

3.3. Investigation of Model Correction. Although from the part of model evaluation, the satisfaction model of food safety fits well, but we still need to discuss whether the model could be still improved. By amending the model state, we can see that the way which can increase the model fitting result includes adding the covariance relationship in the model and the covariance of measurement error. By using these kinds of amendments, the chi-square value can be reduced in certain degree, but not significant and only is improved statistically. So we give up these amendments, adhere to the initial design of the model.

3.4. Discussion and Analysis of Model Results. The coefficient between the latent variables reveals the extent to which the change of a certain variable could affect other variables. For example, in Figure 1, the regression coefficient of food processing and quality status is 0.53, which means a 1% raise in food processing factor will directly cause a 0.53% increase in quality status, etc. In addition, by analysis of the relationship between the observed variables and latent variables in food safety satisfaction index, we can find observed variables that have a significant relationship with latent variables, and could also carry out comparisons between the internal observed variables in different factors. For example, in the relationship between the management control factor and observed variables, the largest coefficient is regulatory systems (0.77), then government policies(0.76), technical certification(0.75), law enforcement(0.71), relative laws(0.68) and licensing certification(0.67).As above described, an effective regulatory system is very important to the supervision of food safety management practice. Otherwise, food safety policies that the government has taken are an important safeguard to residents' confidence.

4. Measurement of General Satisfaction Index. After the model of residents' food safety satisfaction is verified, the measurement of the total satisfaction index of residents' food safety can be conducted. Residents' food safety satisfaction index includes three indicators: the third indicator is individual index of residents' food safety satisfaction, which is calculated by the various observed variables; the second indicator is influencing factors of residents' food safety satisfaction index, which is calculated by various latent variables; the first indicator is the total satisfaction index of residents' food safety, which is calculated basing on the third indicator and the second indicator. The individual satisfaction index of residents' food safety is calculated as following: an index value divided by the maximum scale 5, then taking the mean, when using hundred-mark system the result should multiplied by 100, every individual index should be equal-weighted. Influencing factors of residents' food safety are the sum the individual index in all factors, and then calculate the simple arithmetic mean. The general satisfaction index of residents' food safety is a calculation of arithmetic average of influencing factor index.

The results show that general satisfaction index of residents' food safety was 63.89, which tallies basically with food safety general satisfaction (3.06), verifying the validity of the evaluation system in this article. By observing five structure variables which influence the general satisfaction index of residents' food safety, we can find that the first is the social supervision (67.5), and then follows by food processing (66.20), quality status (65.25), and management control (64.17). The second to the forth are very close. The last is hazardous substances (56.33). The satisfaction index of hazardous substances has the lowest score, which shows that the residents are more sensitive to the indexes of addiitive , heavy metals and pesticide residues, and there is a certain gap to their expectations. The individual indicators also reflect same regularity as structural variables, that is, the score of three harmful substances indicators are lower, reflecting that the residents hope the government intensify law enforcement and punish the acts which endanger food security.

Then we draw scatter diagram of food safety satisfaction index and importance index: the horizontal axis is the satisfaction index, the vertical axis is the correlation coefficient of individual satisfaction and general satisfaction, which is used for the reflection of importance, and the average of the two indexes divides the scatter diagram into four quadrants: quadrant Ⅰ is high important and high satisfaction; quadrant Ⅱ is high important and low satisfaction; Quadrant Ⅲ is low important and low satisfaction; Quadrant Ⅳ is low important and low satisfaction. Every item is placed in four quadrants respectively, see Figure 2.

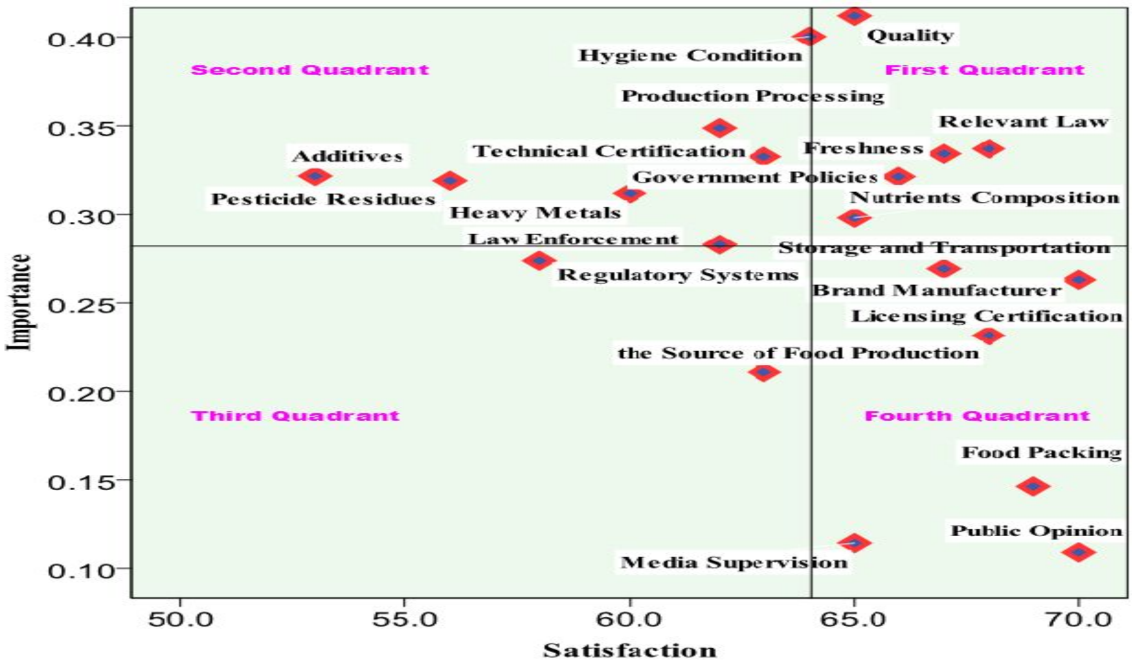

FIGURE 2. Residents' food safety satisfaction index importance scatter

The first quadrant is the top-priority area, the second quadrant is a priority improving area, the third quadrant is the irrelevant area and the fourth quadrant area is the maintaining superiority area. Through the quadrant map that we can visually see the current specific conditions of the degree of urban and rural residents' satisfaction indicators and key indicators for food safety in Hangzhou, thus the government can do targeted work.

The first quadrant gets high significant and high satisfaction scores, 'government policies', 'freshness', 'nutrients composition' and 'quality status' fall into this quadrant, proving the degree of residents' satisfaction matches their evaluation of the importance. It indicates that the urban and rural residents' food security satisfaction index in Hangzhou has more satisfaction in these five aspects, and it should be maintained in the future. However, in the edge of this quadrant there is an indicator—the relatively high degree of importance and on the mean of satisfactions indicators. That is the 'hygiene condition' indicator, and this index is that residents think most importantly, but not has too high satisfaction.

In quadrant 2, the importance is high and the satisfaction is low, 'heavy metals', 'additives', 'food processing', 'technical certification' and 'regulatory systems' indicators fall into this area, this quadrant represents the improve opportunities and the residents satisfaction significantly lower than their rational evaluation of the importance. The indicators in this quadrant are very important.

Both the importance and satisfaction in third quadrant are low, this quadrant represents the satisfaction varies directly with the importance , that is the satisfaction of the residents matches their rational evaluation of the importance .The 'law enforcement' and 'the source of food production' fall into the area.

In quadrant 4, the importance is low and the satisfaction rating is high, the ‘storage and transportation’, ‘media supervision’, ‘public opinion’, ‘brand’ and ‘food packaging’ indicators fall into this area, that is , the satisfaction of the residents exceed their rational evaluation of importance. This shows that the government achieve a high degree of satisfaction in the management of these indicators, and should be maintained.

5. Conclusions and Recommendations.

5.1. Conclusions. After measuring and analyzing the satisfaction of food safety of residents in Hangzhou, the following conclusions are drawn:
(1) The general index of food safety satisfaction of residents in Hangzhou is 63.89.
(2) The residents in Hangzhou are most satisfied with social supervision parameter and most dissatisfied with harmful substance content. Among harmful substances, the food additive has the lowest satisfaction.
(3) Sophisticated system of regulation, reasonable law enforcement and efficient food certification technique are of paramount importance to vindicate the safety of food production and consumption market.

5.2. Recommendations. According to the above-mentioned conclusions, we put forward the following suggestions：

(1) Enhance the transparency of food information and establish food security information platform.

Lots of consumers failed to know the specific situation of food detection because of the information asymmetry in food area. In order to make the detection information known by the public, it is recommended to put warning signs of food safety information in supermarkets, farm fairs and convenience stores to reveal some problematic foods, and try our best to alert consumers to food safety.

In addition, the government department concerned can cooperate with Qianjiang Evening News, The Sound of the West Lake and other main media; establish food safety information platform; release detection information and warning information; and disclose illegal enterprises.

(2) Publicize Food Safety Law and popularize knowledge on food safety.

Make efforts in the “Food Safety Law” propaganda. Primary and secondary education and propaganda in every community, the publicity through traditional newspapers, radio and television and the emerging network, mobile video interaction, the use of various resources continually promotes the publicity of food safety knowledge, and strive to create a good atmosphere that all the people concerned about food safety and increase residents personal defense awareness of food safety risks, improve the ability to identify counterfeit and shoddy food.

(3) Strengthen the penalties on food safety problems as well as the dimension of legal sanctions.

The promulgation of Food Safety Law has improved the food safety accident treatment mechanism and enhanced the efforts in punishing illegal activities in food production and management, and established long-term mechanism and legal barriers to protect food safety. On this basis, the government department concerned should strictly enforce the regulations pinpointing the issue of food safety laws in Food Safety Law and Criminal Laws, destroy harmful food, revoke the business licenses of the illegal operators and give civil and criminal penalties to the persons responsible.

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STUDY ON OPTIMUM PERCENTAGES OF NSP ENZYME PREPARATION AND DIETARY FIBER FOR THE TRUE CRUDE FIBER DIGESTIBILITY OF GEESE

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ABSTRACT. *In order to investigate the effect of dietary fiber and NSP enzyme preparation on the true crude fiber digestibility of geese, eight diet treatments were made up of 4 levels of dietary crude fiber and 4 levels of NSP enzyme preparation, according to* $U_8(8^2)$ *of uniform design experiment method. The results suggested that true crude fiber digestibility increased the maximum (23.67%), when the levels of crude fiber was 5.00%. True crude fiber digestibility showed a quadratic curve pattern. When dietary crude fiber level was 3.00%, and NSP enzyme preparation level was 0.33%, True crude fiber digestibility gained the maximum（30.82%）. True crude fiber digestibility could get maximum value (33.43%), when the dietary fiber is 6.54% and NSP enzyme preparation is 0.37%.*

Keywords: Statistical Simulation; Uniform Design; Dietary Fiber; NSP Enzyme; Geese; True Crude Fiber Digestibility

1. Introduction. The level of dietary fiber shows much higher following the lower of the digestion rate on dietary organics so as to decrease the effective nutrient value (F.Yang, 2001). In order to confirm the appropriate level of dietary fiber, it is necessary to consider not only the relationship between dietary fiber level and the utilization of dietary energy (Liu et al., 2009), but the relationship between dietary fiber level and the utilization of other nutrients of diets (He et al., 2004; Liu et al., 2008). Until now, there is nearly no researches on the effect of dietary fiber level, however, the researches on the relationship between dietary fiber and the utilization of dietary energy on geese mainly focus on the resource of dietary fiber; and the parameters could only indicate the apparent crude fiber digestibility, but could not show the actual condition of animal body (Zhang, 1995). With the development of biological technology, NSP (non-starch polysaccharides) enzyme preparation could increase the utilization rate of dietary fiber for geese so as to increase the utilizibility of dietary crude fiber (Peng, 2003; Wang et al., 2002; Yang et al., 2005; Hew et al., 1998). This experiment aims to combine the dietary fiber and NSP enzyme preparation, and research their influence on the true crude fiber digestibility of diets in growing geese so as to increase the efficiency of diets with the reasonable application of NSP enzyme preparation. Moreover, the experimental method is the regression equation by which the proper levels of NSP enzyme preparation and dietary fiber to the true crude fiber digestibility could be found, in order to provide the scientific basis for the utilization of diets during the feeding geese and create the efficient way to feed the environmental geese by biological agents and agricultural byproducts.

2. Material and Method.

2.1. Ex perimental P lan. According to $U_8(8^2)$ of uniform design experiment method, dietary fiber and NSP enzyme preparation level of diets are considered as two factors with the representation of dietary crude fiber instead of dietary fiber. Eight diet treatments were made up of 4 levels of dietary fiber (3.00%, 5.67%, 8.33%, 11.00%), and 4 levels of NSP enzyme preparation recruitment (0, 0.133%, 0.267%, 0.400%), each treatment has five replicates are shown in Table 1.

TABLE 1. Experimental plan

Treatment	Dietary fiber level（x_1）	NSP enzyme preparation level（x_2）
Treatment 1	1 （3.00）	4 （0.40）
Treatment 2	2 （5.67）	8 （0.40）
Treatment 3	3 （8.33）	3 （0.27）
Treatment 4	4 （11.00）	7 （0.27）
Treatment 5	5 （3.00）	2 （0.13）
Treatment 6	6 （5.67）	6 （0.13）
Treatment 7	7 （8.33）	1 （0）
Treatment 8	8 （11.00）	5 （0）

2.2. NSP Enzyme Pr eparation. NSP enzyme preparation contains cellulase 741U/g, xylanase 1744 U/g and β-glucanase 38 U/g.

2.3. Ex perimental Diets. Adjust the treating level of dietary fiber by rice hull and corn stalk, and control the addition of dietary fiber and NSP enzyme preparation according to experimental plan, so as to meet the principle of the equal amount of dietary protein and energy. The Ingredient composition and nutrient content of experimental diets is shown in Table 2.

2.4. Treatment o f Testing Ge ese and Fee ding M anagement. A total of 45 (Langde× Huoyan) crossbred male geese (42 days of age), fixing the plastic bottle to put the excrement bag, were randomly divided into 9 groups of 5 replicates of 1 goose each. Marked each goose and one goose in each coop, at the same time, one group was used to test endogenous energy, fed by commercial diet; the others were used for metabolism experiment by the way of TME, fed by the testing diets for two days and then be fasted for 36 hours. After fasting 36 hours, the treated geese are forced to feed according to the standard of 25g DM per kg body weight, then, be fasted 48 hours. The geese are fed with the accordance of 30gDM per KG body weight by testing diets (the continuing hungry geese of endogenous group are used to test the endogenous nutrients and energy). Finally, all the tested geese are collected the excrement and they are free to drink during fasting.

TABLE 2. Ingredient composition and nutrient content of experimental diets

Ingredient composition, %	Treatment1	Treatment 2	Treatment 3	Treatment 4	Treatment 5	Treatment 6	Treatment 7	Treatment 8
Rice hull	0.06	3.87	8.60	13.07	-	3.42	9.31	13.25
Corn stalk	0.06	3.87	8.60	13.07	-	3.42	9.31	13.25
Corn	59.62	59.81	53.08	41.81	63.23	57.23	45.12	41.73
Wheat bran	9.05	10.29	4.95	-	9.76	14.69	-	-
Soybean meal	15.29	14.11	15.45	1.77	14.31	12.94	1.75	1.76
Fish meal	2.00	2.07	3.00	3.00	2.00	2.25	3.00	3.00
Fired Soybean	0.02	0.07	-	21.00	-	0.08	20.87	21.00
Corn oil	0.17	0.61	2.98	3.20	-	1.10	2.73	3.20
Corn starch	4.98	1.54	-	-	2.10	1.41	0.07	0.00
L-Lys（78%）	0.35	0.36	0.30	0.20	0.37	0.37	0.20	0.20
DL-Met（98%）	0.23	0.23	0.23	0.22	0.22	0.22	0.23	0.22
NaCl	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Zeolite	2.50	-	-	-	2.50	-	2.41	-
CaCO3	0.67	0.61	0.50	0.40	0.68	0.63	0.46	0.40
CaHPO4	1.51	1.46	1.35	1.31	1.50	1.40	1.34	1.31
Bentonite	2.39	-	-	-	2.50	-	2.50	-
Premix	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Choline chloride	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
NSP enzyme preparation	0.400	0.400	0.267	0.267	0.133	0.133	-	-
Nutrient content, %				Nutritional level				
Crude fiber	3.00	5.67	8.33	11.00	3.00	5.67	8.33	11.00
Metabolizable energy（MJ/kg）	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50
Crude protein	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
Ca	0.76	0.76	0.76	0.75	0.76	0.76	0.75	0.75
Effective P	0.41	0.41	0.41	0.40	0.41	0.41	0.40	0.40
Lys	0.96	0.95	0.95	0.95	0.96	0.95	0.95	0.95
Met+Cys	0.67	0.67	0.67	0.66	0.67	0.67	0.67	0.66

* Provided per kg of diet: Vitamin A 30000 IU, Vitamin D_3 5000 IU, Vitamin E 20 IU, Vitamin K_3 8mg, Vitamin B_1 5 mg, Vitamin B_2 10 mg, Niacin acid 60 mg, Vitamin B6 5mg, Pantothenic acid 10 mg, Pyridoxine 3 mg, Biotin 0.1 mg, Choline 1200 mg, Folic acid 1 mg, Vitamin B_{12} 20 μg, Cu 5 mg, Fe 100 mg, Mn 80 mg, Zn 100 mg, Se 0.1 mg, Co 0.15 mg, I 0.4 mg.

2.5. The Collection of Excrement and the Preparation of Sample. After 48-hour fasting, samples of the excrement was taken, and added 10% sulfuric acid as well as formaldehyde accroding to the ratio of 3% (V/W) in case of the lost of NH3 and termination of biolysis. After experiment, the excrements were dried in drying oven by 65℃～70℃ and sealed up with smash. The samples are stored at 4℃ until subsequent analyses.

2.6. Testing Parameter and Method.

2.6.1. Water. The water content in excrement and feedstuffs is tested by the method of A.O. A. C. (1990).

2.6.2. Crude Fiber. The crude fiber content in excrement and feedstuffs is tested by the method of A.O.A.C. (1996).

3. Data Analysis. Statistical analysis was carried out using the RSREG procedure of SAS (version 9.1, 2002–2003; SAS Institute, Cary, NC) to determine significant differences ($P < 0.05$). The RSREG procedure uses the method of least squares to fit quadratic response surface regression models and to obtain information about the fit in the form of an ANOVA. Response surface regression models were generated for each of the dependent variables. Two-dimensional response surface plots of each predicted parameter were also generated.

3.1. Experiment Results and Analysis.

3.1.1. The Experiment Results. The influence of NSP enzyme preparation and dietary fiber to the true crude fiber digestibility of diets of geese was shown in Table 3.

TABLE 3. The influence of NSP enzyme preparation and dietary fiber to the true crude fiber digestibility of geese

Treatment	True crude fiber digestibility（%）
Treatment 1	30.41±3.26
Treatment 2	33.14±6.71
Treatment 3	31.59±2.19
Treatment 4	27.42±3.98
Treatment 5	28.00±4.68
Treatment 6	29.43±4.06
Treatment 7	21.23±4.56
Treatment 8	15.75±5.02

* Note : The data in the table are mean ± SD.

TABLE 4. Related parameters and regression equation of the true crude fiber digestibility

Item	Regression equation	R^2	Optimum solution	Factor and marginal utility
True crude fiber digestibility	$\hat{y}$=18.17+2.20x_1+43.71x_2+1.83x_1*x_2-0.22x_1^2-75.36x_2^2	0.65	x_1=6.54 x_2=0.37	d$\hat{y}$/dx_1=2.20+1.83x_2-0.44x_1 d$\hat{y}$/dx_2=43.71+1.83x_1-150.72x_2

TABLE 5. Normal equation of the true crude fiber digestibility

Parameter	Normal equation
True crude fiber digestibility	$\hat{y}$=0.97x_1+0.96x_2+0.29x_1*x_2-1.38x_1^2-0.69x_2^2

3.2. The Regression Equation, Analysis and Parameters. From the experimental results, make the dualistic and quadric regression equation and analyze the relationship of true crude fiber digestibility versus dietary fiber and NSP enzyme preparation. The results of regression equation as it shown in table 4 shows that the regressive sum of square is 0.65, so it arrives the significant level ($p<0.01$) and the lack of fit is not significant while the model is suitable. As it shown, it is reliable to express the influence of NSP enzyme preparation and dietary fiber on the true crude fiber digestibility. The regression coefficient can not be deleted in order to further optimize by regression equation.

3.3. The In teraction and Proper C ombination of Die tary Fi ver and NSP Enz yme Preparation to the True Crude Fiber Digestibility. It could get the normal equation as it shown in Table 5 through the standardization of regression equation shown in Table 4. The difference of the dimensions could be eliminated by normal equation and it could be seen the influence of the different level to the variables by analyzing the coefficient's absolute level from the normal equation directly (Ruan, 2003).

The absolute value of the equation coefficient could be indicated by $x_1>x_2>x_1x_2$, which could explain the extent of influence to the true crude fiber digestibility. Moreover, the most extent of influence is the dietary fiber, then NSP enzyme preparation, and the least is their interaction effect.

Through the conduction of dietary fiber (x_1) and NSP enzyme preparation (x_2) by regression equation, it could get the relationship between the true crude fiber digestibility and the other two factors. The regression model of the true crude fiber digestibility could get maximum value (33.43%), when the dietary fiber is 6.54% and NSP enzyme preparation is 0.37%.

3.4. The In fluence R egularity of Dietary Fiber or NSP Enz yme Preparation t o the True Crud e Fiber Digesti bility. Reducing dimensions of the regression equation of the true crude fiber digestibility, it could get the regularity of the influence from the unit factor, dietary fiber or NSP enzyme preparation to the true crude fiber digestibility. Make one variable fixed on the designed level and then analyze the effects from the other variable so as to get different sub-regression models useful to analyze the effect of the optimum addition.

3.4.1. The I nfluence of Dietary Fiber Level to the Tru e Crude Fiber Digestibility. At the same level of NSP enzyme preparation, the true crude fiber digestibility indicates the trend of increase firstly and then decrease with the increased amount of the dietary fiber. It could get the optimum level of the dietary fiber and the true crude fiber digestibility when the dietary fiber is in the range from 3.00% to 11.00%.

The true crude fiber digestibility could get the maximum value, 23.67%, when the dietary fiber locates on the level of 5.00%; also, it could get the maximum, 29.33%, when the NSP enzyme preparation is 0.13% and dietary fiber is 5.54%. Furthermore, when the NSP enzyme preparation could get the level of 0.27% and dietary fiber is 6.12%, the true crude fiber digestibility arrive the maximum, 32.73%. While, the true crude fiber digestibility could also get the maximum, 33.37%, when NSP enzyme preparation is 0.40% and the dietary fiber is 6.66%.

3.4.2. The Influence of NSP Enzyme Preparation to the True Crude Fiber Digestibility. At the same level of dietary fiber, the true crude fiber digestibility appears the trend of increase firstly and then decrease when the addition of NSP enzyme preparation increases. When the addition range locates from 0 to 0.40%, the true crude fiber digestibility could get the optimum value.

When the level of the dietary fiber and NSP enzyme preparation is 3.00% and 0.33% respectively, the true crude fiber digestibility could get the maximum 30.82%. Also, the true crude fiber digestibility arrive the maximum, 33.28%, when the dietary fiber is 5.67% and NSP enzyme preparation is 0.36%. While, when the level of dietary fiber is 8.33% and NSP enzyme preparation is 0.39%, the true crude fiber digestibility is 32.76%. The true crude fiber digestibility can be the maximum (29.23%) when the dietary fiber and NSP enzyme preparation is 11.00% and 0. 40% respectively.

4. Conclusion. First, the true crude fiber digestibility has the regularity of quadratic curve relationship and maximum when the level of dietary fiber within the range from 3.00% to 11.00%. When the dietary fiber is 5.00%, the true crude fiber digestibility gets the maximum, 23.67%.

Second, the true crude fiber digestibility has the regularity of quadratic curve relationship and maximum when the level of NSP enzyme preparation within the range from 0 to 0.40%. When the dietary fiber is 3.00% and the level of NSP enzyme preparation is 0.33%, the true crude fiber digestibility gets the maximum, 30.82%.

Third, true crude fiber digestibility could get maximum value (33.43%), when the dietary fiber is 6.54% and NSP enzyme preparation is 0.37%.

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THE EFFECTS OF AUTHENTICITY ON SOUVENIR PURCHASING BEHAVIOR

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ABSTRACT. *It is common to find a denoted local souvenir, labeling with abroad manufacturer. A conceptual framework is advanced for exploring the impact of globalized authenticity on souvenir purchasing. This study suggests that varied level of authenticity is decided by modes of tourist with different kind of souvenir. As purchasing cultural souvenir, pleasure-seeking tourist will adopt globalized authenticity toward commercial souvenir. But serious tourist will buy cultural souvenir with objective authenticity.*
Keywords: Authenticity; Pleasure-Seeking Tourist; Souvenir

1. Introduction. Souvenirs made in foreign countries and sold in tourist destination are not uncommon. As souvenir shops are competing to attract tourists, the trend is inevitable that souvenir is manufactured in a labor-inexpensive country. Thus, it is not surprise to find “The jade of grasshopper on cabbage” was made in Indonesia at national Palace Museum (NPM) in Taiwan. But most of these souvenirs are highly related to commercial souvenirs. For example, a coffee mug marked with local logos and words or a replica of famous art work was not made with the original materials or size. Thus, in order to understand the complicated souvenir purchasing behavior, souvenir categories, modes of traveler, and authenticity are necessarily to be taken into consideration.

The “made-in-Indonesia” souvenir was challenged for disservice against Taiwan’s image to Chinese tourists. Does inauthentic souvenir matter? Do inauthentic souvenirs affect Chinese tourist experience in Taiwan? The answer relies on the concept of authenticity and modes of tourist. Authenticity has been a controversial issue in tourism literature (Wang, 1999; Pearce and Moscardo,1986). There are two different streams of views on authenticity: one emphasizes on authenticity in tourism while the other regard it unfavorably.

One stream of works centered on the importance of authenticity. It has long been hold that tourist quest for authentic experiences and places especially in heritage tourism (Timothy and Boyd, 2005). Most tourists seek indigenous people for native living style in real place and in real history. Some visitors such as pilgrim are extremely concerned for authentic sites and rituals (Errington and Gwertz, 1989). Authenticity is a critical issue in heritage tourism and a determinant factor to influence tourist choice of destination (Moscardo and Pearce, 1986). The perception of real experience could affect tourist satisfaction (Moscardo and Pearce, 1986). To reflect the need of authenticity for tourist, tour operators and marketers starts to use “real”, “authentic” and “genuine” in their text (Timothy and Boyd, 2005).

But, another stream of work doubts about the existence of authenticity. Tourism was thought of as a superficial, peripheral, and trivial activity to the concerns of modern society (Boorsin, 1964). Seeking for authentic experience for tourist was ignored and overlooked by some sociological elitists such as Boorstin and MacCannell. By examining mass tourism, Boorstin (1964) regarded tourism as pseudo-events, because the tourist is seeking for staged attractions, contrived experiences, satisfying with commoditized products, cultures, and images. So, he suggested that tourists are unable to have authentic experience.

Likewise, MacCannell (1973) suggested “staged authenticity” to conclude the obviously inauthentic experience. Drawing on the notion of front stage and back stage from Goffman, a structural division of social hierarchy, MacCannell contended that the front stage, where host meeting guest and patron interacting with service providers, could be a “false reality” for show and performance, while the back stage a “real reality” for performers and showers (Goffman, 1959; MacCannell, 1973). Therefore, he concluded that tourists, who were bored with their inauthentic life of routine work, were motivated to quest for genuine, spontaneous and authentic experience, to mingle with natives, to see the real life as it is, only failed to meet these motivations (MacCannell, 1973).

2. Problem Statement and Preliminaries. What are the essential factors to affect the concept of authenticity? What elements comprise of authenticity on souvenir? To date, there is very limited consensus on authenticity in tourism (Cohen,1988; Pearce and Moscardo, 1986; Wang, 1999; Reisinger, 2006). Consequently, the concept of authenticity deserves a wider understanding. In addition, little literature has been published on souvenir authenticity. Therefore, the purpose of this study is first to explore the concept of authenticity in tourism and then apply it to souvenir purchasing to figure out the notion of souvenir authenticity.

3. The Concept of Authenticity. Authenticity has been an agenda in tourism literature (Wang, 1999). However, there is no consensus among tourism researchers. Boorstin (1964), a sociologist, maintained first that tourists enjoyed “pseudo-events” because there is no authentic tourist experience. Taking mass tourist travels as example, he suggested that tourist experienced only “environmental bubble” of the familiar hotel and inauthentic contrived attractions, isolated from the host environment and the local people (Boorstin, 1964, p.77). Further, to illustrate the inauthentic tourist experience with restricted sensuality and aesthetic sense, Turner and Ash (1975) indicated the decaying Balinese cultures and arts, converting from indigenous and complicated arts to simplified and western modes to cater to mass tourists.

Modern people live in an inauthentic world (Cohen, 1988). Thus, to escape from the routine work and quest for authentic self and society in elsewhere have been critical motivations for tourists (MacCannell,1976). MacCannell, challenging Boorstin’s inauthentic and superficial points, contended that all tourists like ancient pilgrims, quest for authentic experience and sacred places in other time and other places. Tourists travel looking for “real life” of others, which have some fascinated quality lacking in their daily places (MacCannell, 1973). But he found that the “real lives” always happened at backstage, where tourists are not welcome to intrude (MacCannell, 1973). To meet tourist’s needs and secure the real lives, a contrived and artificial backstage, “staged authenticity” termed by MacCannell, was invented (Urry, 2002).

Although both Boorstin and MacCannell are concerned with authenticity, they do not clearly define the concept of authenticity. Boorstin proposed “environmental bubble”, while MacCannell argued “staged authenticity”. They leave the concept of authenticity ambiguous.

4. Typology of Authenticity. To clear this ambiguous, three conventional types of authenticity (objective, constructive, and existential) were proposed in tourism literature (Reisinger and Steiner, 2006; Wang, 1999). Objective authenticity addressed the authentic original for objects (Wang, 1999). Constructive authenticity address the authentic setting evaluated by tourists; while existential authenticity refers to self authenticity aroused by activity (Wang, 1999).

4.1. Objective Authenticity. The origin of authenticity came from museum, where expert examine “whether objects of art are what they appear to be or are claimed to be, and therefore …worth the admiration they are being giving” (Trilling, 1972). The concept of objective authenticity drawing from museum-linked definition is applied to evaluate toured objects by tourists for toured objects themselves are presumed to possess the quality of authenticity (Wang, 1999; Harvey, 2004). For example, tourist judges cultural products such as arts, rituals and relics as authentic in terms of made by local people, made from local material.

There are specific criteria to measure objective authenticity. Therefore, the tourists themselves are unable to affect the level of authenticity. The authentic experience which tourist obtains is still inauthentic, if it does not meet the criteria of authenticity (Wang, 1999). Thus, such vigor term of objective authenticity, adopted by curators and ethnographers, is an appropriate application for cultural products that are made from natural material by hand before modernity Western impact (Cohen, 1979). When museum-related concept of authenticity is applied to cultural tourism products such as art, festivals, rituals, apparels, and buildings, the criteria of traditional, original, genuine, real and unique are always employed to determine the level of authenticity (Sharpley, 1994).

4.2. Constructive Authenticity. In opposition to object authenticity, Cohen argued that authenticity is a socially constructed interpretation of the realness of the objects (Cohen, 1979). Namely, authentic experiences come from constructed reality by beliefs, attitudes, and powers, not from inherent realness (Cohen, 1988). Therefore the constructive authenticity is a contextual, negotiable, ideological, or expectant one of object (Bruner, 1991; Silver, 1993). Peach and Moscardo (1986) also maintained that whether a tourism setting is real or not depends on judgment of tourist instead of a real property. Even the interaction between host and tourists constructs the concept of authenticity toward cultural and heritage products (Adams, 1996). Every tourist constructs authenticity subjectively by different beliefs and attitudes. Thus, mass tourist can have a different authentic experience toward the same toured objects. The meaning and interpretation of the settings vary depending on the contexts and the individuals.

4.3. Existential Authenticity. Contrary to both objective and constructive authenticity, existential authenticity refers to individual feelings caused by liminal process of tourist activity (Wang, 1999). "In such a liminal experience, people feel they themselves are much more authentic and more feely self-expressed than in everyday life, not because they find the toured objects are authentic but simply because they are engaging in non-ordinary activities, free from the constraints of the daily" (Wang, 1999). Intuitively, existential authenticity involves a state of being of true to oneself, which forming true self to resist self missing in the public field (Berger, 1973). Wang (1999) employed existential authenticity to tourist activity, differentiate it from object-related and constructive authenticity.

In general, Wang's typology of authenticity is sound. But can we directly apply his model to souvenir? Both constructive authenticity (referred to setting) and existential authenticity (related to activity) have little connection with souvenir. Only objective authenticity, referred to toured object, has directly relation with souvenir. However, the nature of toured object is not quite the same with souvenir. Moreover, the souvenir shopping has been a required activity in tour schedule (Cai et al, 2004). Therefore, light could be shed on souvenir authenticity which is still largely unknown and uninvestigated.

5. Souvenir Authenticity. Souvenir shopping is seldom included in travel motive, but it is a popular activity tourist frequently participates in (Cook, 1995, Kim and Littrell, 2001). Taiwanese tourists who traveled abroad in 1999 reported shopping souvenirs as their second most important items only to tobacco and wine (Lehto et al., 2004). But for Chinese leisure travelers, shopping for gifts and souvenirs wins first, following by lodging, food, and entertainment (Cai et al., 2001). Thus, shopping for gift and souvenir explains a significant amount of tourist's total expenditure.

Souvenir, commercially produced, serves as a remembrance, a concrete remainder of extraordinary experience, special moments and events for tourist (Gordon, 1986). Tourists escape from their mundane, ordinary places, looking for extraordinary place or destination. Souvenir is evidence that they have been there, which is psychologically important for tourists (Anderson and Littrell, 1995). Its presence extends the fleeting, transitory experience to eternity (Gordon, 1986).

To understand the myriad of souvenirs, Gordon (1986) classified souvenirs into five categories. The first are pictorial images, containing postcards, poster, photographs, illustrated books, and pictures, which are tangible reminders that prove tourist's presence there (Gordon, 1986). The second type is piece-of-the-rock, including rocks, grasses, shells and driftwood, pine cones, stuffed moose or deer heads, sperm whale, teeth, and stuffed alligators, which are parts of the whole destination environment (Gordon, 1986). The third type is symbolic shorthand, including replicas of well-known attractions, miniaturized icons images, which are mainly manufactured instead of natural material (Gordon, 1986). Markers are the fourth type, consisting of T shirts, coffee mugs, coasters, which are irrelevant to a particular place, people, or event (Gordon, 1986). For example, a key-ring inscribed with "Ali Mountain" becomes marked for Taiwan, helping preserve pleasant memories with Taiwan. Finally, local products are the fifth type, including an array of indigenous objects such as foods, liquor, cooking utensils, clothing, handicrafts (Gordon, 1986).

Pictorial image, piece-of-rock, and local products all share the attribute of local ways of living, including food, drinking, architecture, plant, handcrafted products, entertainment. Thus, this study reclassifies them as cultural souvenir. Likewise, both symbolic shorthand and markers lose its primitive unique by mass manufactured and miss original style by catering to tourists. They are termed commercial souvenir in this study. Consequently, Gordon's typology of souvenir will be reduced to two types in this study: cultural and commercial souvenirs.

6. Level of Souvenir Authenticity. Cohen argued that the notion of authenticity is a socially negotiable construct and proposed an emergent authenticity to replace the museum-related authenticity. He suggested that emergent authenticity is a gradual emergence concept from the tourist perspective to host culture. Certain contrived setting, once viewed as inauthentic, could become authentic over time. Disneyland, for instance, once an example of contrived theme park, is growing to be an eminent representation of American culture (Cohen, 1979). In the near future, Disneyland will eventually turn out to be an American cultural destination.

In addition, Cohen (1979) also suggested that tourist is different from ethnologist, for the former hold less strict criteria of authenticity than the latter. This did not mean that tourist does not care for authenticity. It implied that the degree of intensity of questing authenticity varied, according to the degree of estrangement of modernity (Cohen, 1979). Thus, at a given staged attraction or environment, there is no consensus on the impression of the scene. One tourist with loose criteria will respond to the staged with positive attitude while the other with rigor criteria will not accept it as authentic attraction with negative attitude (Cohen, 1979).

Likewise, Wang (1999) contained that objective, constructive, and existential authenticities are co-existing. He suggested that the existential authenticity is most powerful to account for tourist experience. We can infer that objective authenticity is better than constructive authenticity to explain toured object, while constructive is better than existential to justify toured settings.

Drawn from Cohen's emergent authenticity and Wang's authenticity category, this study extend them into levels of authenticity for souvenir purchasing, which is comprised of high, intermediate, and low level of authenticity. Based on Cohen's emergent authenticity, this study suggests that different tourist own different level of authenticity and level of authenticity varied in different settings. Similarly, grounded on Wang's work, this study argues that authenticity is comparable in term of toured object, setting, and activity. Thus, many comparable level of authenticity can be arranged on a continuum in terms of tourist and souvenir category. This study will discuss the three important levels of authenticity: high level, intermediate, and low level of authenticity.

6.1. The High Level of Authenticity. The curators and ethnographers always employ the strictest standard to distinguish authenticity from fake. For example, McLeod explained authentic African art as "… and piece made from traditional materials by a native craftsman for acquisition and use by members of local society that is made and used with no thought that it ultimately may be disposed of for gain to Europeans or other aliens" (McLeod, 1976).

McLeod emphasize the absence of modernity as a basic judgment of authentic for it is relevant to tradition, local, primitive. Similar to these views, Cornet contained authenticity as "Any object created for a traditional purpose and by a traditional artist, with conforming to traditional form" (Cornet, 1975).

To define a craft's authenticity, Anderson and Littrell (1995) purposed eight criteria: uniqueness and originality, workmanship, aesthetics, cultural and historical integrity, tourist function and use, craftsperson and materials, shopping experience, and genuineness or truth in advertising.

To solve the authentic problems of Maori culture products and services, the Aotearoa Maori Tourism Federation established three criteria: "from the mind of a Maori, by the hand of a Maori, and that the producer or provider has a genealogical and spiritual connection to a tupuna Maori" (Asplet and Cooper, 2000).

Revilla and Dodd (2003) found that the tourist relates Talavera pottery authenticity with its appearance and utility, traditional characteristics and certification, difficult to obtain, locally produced, and low price.

6.2. Intermediate Level of Authenticity. As the destination is thronged with tourist, many local cultural products will be inevitably manufactured in quantity to meet the rising demand. To cater to tourist with more charming characteristics, contrived cultural products are purposely embellished to look real, leading to change the meaning of original products (Cohen, 1979). For limited authentic local cultural products, tourists finally accept the fake airport art as if it were an authentic one (Graburn, 1967).

6.3. Low Level of Authenticity. Visiting friends and relatives, visiting Disneyland, and going to resort such as seaside, skiing, health, spa, have little to do with authenticity. For those pleasure-seeking tourists, they will delightfully accept low level of authenticity. The tourist seeks for entertainment in the pleasure settings. Since they seek for entertaining, relaxing experience, they can take the make-believe (Cohen, 1979). Likewise, they find great pleasure from the played games even though they are aware of the inauthenticity of the games (Feifer, 1985).

7. Modes of Tourist. Cohen (1979) proposed modes of touristic experience on the basis of depth of experience: existential, experimental, experiential, recreational, and diversionary. The existential tourists leave modernity for the primitive other place, they avoid beaten track and go to native. They hold high criteria of authenticity, however, they are likely unable to distinguish authentic from fake on attraction or atmosphere (Cohen, 1979). So, they are most like to be the victims of what MacCannell term staged authenticity (Cohen, 1979). Second, the experimental tourist travel many primitive other places to find out their selective one (Cohen, 1979). The third, experiential tourists tend to involve true life of others (Cohen, 1979). Both experimental and experiential are similar to existential, sharing with vigor authenticity.

The fourth, recreational tourists, motivated with restoration and recuperation, tend to loosely accept authentic replica, buying fake experience resemble to genuine (Cohen, 1979). Finally, diversionary tourists, irrespective of authenticity, chiefly focus on funny, cute or lovely experience (Cohen, 1979). We can conclude that recreational and diversionary tourists incline to put less important on authenticity.

Based on Cohen's typology of tourist on level of authenticity, this study argue to classify tourist into two types: serious tourist and pleasure tourist. The notion of serious tourist is borrowed from "serious leisure", involving those tourists who have special interest and devote substantial effort to seek in term of authenticity (Robert, 1996). In post modern, Urry (2002) argued that tourist seeks for play, pleasure and pastiche. This study adopts his notion of pleasure tourist to replace with Cohen's divisionary and recreational tourists. Thus, the typology of tourist consists of serious, who hold high level of authenticity and pleasure ones with low level of authenticity.

8. Relating Modes of Tourist to Souvenir Authenticity. The souvenir authenticity model considers both modes of tourist and categories of souvenir simultaneously to explore souvenir authenticity, differing from the traditional concept of individual authenticity standard such as toured objects, settings, services. For instance, Boorstin (1964) explored authenticity by pseudo-events, while MacCannell (1973) by staged settings. In addition, this study argues that the concept of souvenir authenticity is a continuum from high level to low level. Therefore, the level of souvenir authenticity is decided by modes of tourist and type of souvenir. The modes of tourist affect the level of souvenir authenticity. As purchasing cultural souvenir, pleasure-seeking tourist will judge souvenir with intermediate level of authenticity. However, they will adopt low level of authenticity toward commercial souvenir. Serious tourist will use high level of authenticity to by cultural souvenir. But, they will apply intermediate level of authenticity to commercial souvenir.

9. Conclusion. This above analysis of souvenir authenticity leads to a conclusion, indicating that the degree of souvenir authenticity corresponds to modes of tourist. Serious tourist tends to adopt vigor authenticity whereas the pleasure-seeking are less concern for authenticity. Furthermore, even the serious tourist will only adopt intermediate level toward the commercial souvenir. In addition, the pleasure-seeking Chinese tourist will not concern for souvenir's authenticity.

The primary objective of this study is to discuss the role of authenticity within the tourist mode and souvenir categories on souvenir shopping behavior. The souvenir shopping model provides the method of merging the tourist mode, souvenir group, and authenticity literatures. As the international tourism is booming, understanding tourist behavior from cultural aspect emerges as a pressing issue for tourism research. Cultural aspects are needed to explore in the future. Culture is referred to the collective mental schemes pervaded in every aspect of social interaction which tell the member of a particular society from the others (Hofstede, 1980). That is, culture is the results of shared behavior, but culture is a conditioning factor of further behavior as well. Recognizing this, nations, organizations, and groups will have their own culture. Accordingly, future studies might test this souvenir model with different samples of international travelers.

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STUDY ON THE CONSTRUCTION OF SECURITY EARLY WARNING MODEL FOR COAL INDUSTRY INVESTMENT AND FINANCIAL BASED ON LOGISTIC MODEL

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ABSTRACT. *Coal industry plays a important role in the local economic development. Recently, coal enterprise in China have many security problems in the process of investing and financing. So strengthening China coal energy investment and financial security construction and forewarning the security statement, then taking the relevant countermeasures to control risk, ensuring well-balanced working of coal energy market and demand of power have positive theoretical and practical meanings. This paper mainly studies the coal industry investment and financial risks early warning research. We study the investment and finance risks sources in three aspects, including the financing situation of the coal industry, investment conditions and the macroeconomic environment. We pick up three main component factors as independent variables to construct Logistic Model to predict investment and financial risks in the coal industry with accuracy rate 71.4%. Finally the relevant countermeasures are proposed.*
Keywords: Coal Industry Investment and Financial Security; Security Early Warning; Factor Analysis; Logistic Model

1. Background. Coal energy has a long history of exploitation and use in China, Because of relatively rich reserve and china's energy structrue, Coal will occupy the main position in the energy production and consumption in china.

At present there Contains considerable security risks in the process of financing and investment for China's coal enterprises, there are a large funding gap in the coal corporate finance and investment, As a result of the development of financial markets, financial products and investment products are diversifing, while the whole world economic is uncertainty, the energy sector financial risks have increased quikly,so strengthening China coal energy investment and financial risks construction and forewarning the risk state,then taking the relevant countermeasures to control risk,ensuring well-balanced working of coal energy market and demand of power have positive theoretical and practical meanings.

2. Research Methods and Sample and Variable Selection. As the security warning indicator contains quantitative and qualitative indicators, the author use Logistic model of nonlinear regression to calculate the models curve. In order to reasonably estimate and the interpretate a regression model, we need to deal with multicollinearity between the variables. The author select factor analysis to solve the linear problem of regression analysis.

In this paper the author select 2003 to 2009 quarterly data of the coal companies whose main business income over 500 million on the website of http://cyk.cei.gov.cn. The author selects sample enterprises' debt ratio, equity ratio, capital cost rates as a measure of financial security, return on total assets of choice,selects return on assets, OPE, total asset growth rate, fixed asset investment expansion, and assets ultilization as an investment security indexes, and selecets GDP growth and CPI as macro-indicators of environmental safety.

3. Logistic Model Independent Variables Calculation Based on Factor Analysis.

3.1. Correlatio Analysis of the Original Indicator Variables. Using SPSS 13.0 software, we can draw a correlation matrix, such as Table 1 shows that the majority of the correlation coefficient index>0.5, showing that target a certain degree linearity interdependent relationship that is multicollinearity. Multicollinearity relationship often increase the standard error of estimated parameters, thereby reducing the stability of the model, sometimes also appear contrary with the actual situation. Therefore, to reasonably estimates

TABLE 1. Correlation matrix

	debt ratio	equity ratio	capital cost rates	return on assets	OPE	total asset growth rate	fixed asset investment expansion	assets utilization	GDP growth	CPI
Correlation: debt ratio	1.000	0.735	0.999	0.385	0.404	0.620	0.403	0.596	0.207	-0.095
equity ratio	0.735	1.000	0.718	0.734	0.847	0.960	0.843	0.955	0.234	0.006
capital cost rates	0.999	0.718	1.000	0.376	0.392	0.600	0.392	0.576	0.199	-0.103
return on assets	0.395	0.734	0.376	1.000	0.880	0.673	0.882	0.678	0.253	0.147
OPE	0.404	0.847	0.392	0.880	1.000	0.851	1.000	0.864	0.302	0.175
total asset growth rate	0.620	0.960	0.600	0.673	0.851	1.000	0.847	0.999	0.305	0.113
fixed asset investment expansion	0.403	0.843	0.392	0.882	1.000	0.847	1.000	0.860	0.305	0.178
assets utilization	0.596	0.955	0.576	0.678	0.864	0.999	0.860	1.000	0.312	0.126
GDP growth	0.207	0.234	0.199	0.253	0.302	0.305	0.305	0.312	1.000	0.941
CPI	-0.095	0.006	-0.103	0.147	0.175	0.113	0.178	0.126	0.941	1.000

and explain logistic regression model, we need transform The highly relevant information variables integrated into the main components of low relevance through factor analysis,then we use the principal component replace the original variable to participation of the principal componene regression.

3.2. The Original Target (variable) Dimensionless. The nature of the different indicators for the comprehensive, first the author put the indicators into the non-dimensional processing, and the raw data normalized. Standardized value = (Xn-mean) / standard deviation. Compared with the original data, the value of standardized are uniform and the right size (within plus or minus 5).

3.3. To Determine the Suitability of the Used Original Variables in Factor Analysis. The purpose of factor analysis is comprehensive from the original number variables representative into a small number meaningful factors variables, which must have an underlying premise that the original variables should have a strong relationship. Table 1 has shown that these variables have a stronger relationship, KMO and Bartlett's Test can be used to compare the size of correlation coefficient between the original variables and the partial correlation coefficient, it is one of the methods to judge the suitability of the original variables for factor analysis. KMO value is closer to 1, which means the stronger correlation between variables, more suitable for factor analysis. Table 2 show the observations value of the variable Bartley sphericity test statistic, in general, KMO values is greater than 0.8, it represents a very suitable for factor analysis, while the probability 0.000given by Bartlett test, less than the significance level 0.05, therefore reject Bartlett sphericity test of the null hypothesis, that means that it is suitable for factor analysis.

TABLE 2. KMO and bartlett's test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of sampling Adequacy		0.811
Bartlett's Test of Sphericity	Approx. Chi-Square	800.435
	df	45
	Sig.	0.000

3.4. Extraction of Factors. Before factor loading matrix was calculated through principal component analysis method, the number of factors should be determined first, the goal is to contain more financial information through the lower number of factors, In this process characteristic value criteria should be followed. The standard requires that access the data which characteristic value $\geqslant$ 1 as the initial factor, criteria that each factor retained should explain at least one variable of the variance. In this paper, the factor function of Data Reduction in has been used to analyze normalized data to calculate the 10 components characteristics value and contribution rate of the extent. Table 3 shows the results of the initial characteristic value, variance and the contribution rate. From the calculated the characteristic value and contribution rate, we can find that the variance of three factors in 10 variables is greater than 1, the author extract this three factors as main factors, the cumulative contribution rate of 94.651%, indicating that through extraction factor, less information of original variables, is lost, factor analysis results are satisfactory.

TABLE 3. Total variance explained

	debt ratio	equity ratio	capital cost rates	return on assets	OPE	total asset growth rate	fixed asset investment expansion	Assets utilization	GDP growth	CPI
Correlation: debt ratio	1.000	0.735	0.999	0.385	0.404	0.620	0.403	0.596	0.207	-0.095
equity ratio	0.735	1.000	0.718	0.734	0.847	0.960	0.843	0.955	0.234	0.006
capital cost rates	0.999	0.718	1.000	0.376	0.392	0.600	0.392	0.576	0.199	-0.103
return on assets	0.395	0.734	0.376	1.000	0.880	0.673	0.882	0.678	0.253	0.147
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assets utilization	0.596	0.955	0.576	0.678	0.864	0.999	0.860	1.000	0.312	0.126
GDP growth	0.207	0.234	0.199	0.253	0.302	0.305	0.305	0.312	1.000	0.941
CPI	-0.095	0.006	-0.103	0.147	0.175	0.113	0.178	0.126	0.941	1.000

3.5. Factor Rotation and Naming of the Main Factor. We use the three extraction main factors F1, F2, F3 to establish the original factor loading matrix, see Table 4, as a typical representative of each factor variable is not very prominent, so we are not easy to explain the factor. In order to understand the real meaning of public factors, this study uses the varimax method of orthogonal rotation method for converting rotation. It means that he load on each factor is as far as possible close to the direction of persons 1. The purpose of factor rotation is that we can re-distribute the proportion of variance explained by the various factors through changing the location of axis. It does not change the fitting degree between the model and the data, not to change the common factor variance of each variable. Table 5 Rotated Component Matrix. The intermediate side of table 5 shows the original factors' variance contribution rates, the right side shows rotated factor variance contribution rate, the final cumulative contribution rate and the original results is same. However, the contribution rates of each factor have changed, become more uniform. Rotation results show that three factors include the sufficient information of raw data.

After rotating we know how each variable affect each of the public factor, and thus determine the information reflected through each of the common factor. We can observe that the three factors are in certain high-load index (absolute value> 0.6). The higher the factor loading, indicating the stronger correlation between variables and the factor index, namely, the more amount of information contained in the index, The factors can be simplify explaned through the rotated factor loading matrix.

Table 5 shows that the first factor F1 have a larger load on the index of OPE,total asset growth rate, fixed asset investment expansion, and assets ultilization, and these indicator reflects the security situation in the coal industry enterprises investment, so we call the main factor F1 as a safe investment factors. The second main factor F2 have a larger load on the index of debt ratio, equity ratio, capital cost rates, and these indicators reflects the financial security of the coal industry, so we call the main factor F2 as the security financing factors. The third factor F3 mainly have a larger load on the index of GDP growth rate and CPI indexes, and these indicators reflects the macroeconomic environment encountered by the coal company, so we call the main factor F3 as macro-economic and environmental security factors. Table 6 shows the three main factor component score covariance matrix, we can find that the three main factors are not linear relationship, so the design goals of the factor analysis is realized.

TABLE 4. Component matrix

	component		
	1	2	3
debt ratio	0.264	0.956	0.009
equity ratio	0.808	0.563	0.013
Capital cost rates	0.248	0.957	0.003
Return on assets	0.876	0.109	0.091
OPE	0.969	0.142	0.121
Total asset growth rate	0.829	0.457	0.104
Fixed asset investment expansion	0.968	0.140	0.124
assets utilization	0.843	0.429	0.113
GDP growth	0.164	0.161	0.970
CPI	0.081	-0.131	0.985

TABLE 5. Rotated component matrix

	component		
	1	2	3
debt ratio	0.702	-0.369	0.595
equity ratio	0.969	-0.174	0.011
Capital cost rates	0.688	-0.376	0.602
Return on assets	0.815	0.088	-0.342
OPE	0.915	0.107	-0.354
Total asset growth rate	0.950	-0.046	-0.046
Fixed asset investment expansion	0.913	0.110	-0.353
assets utilization	0.949	-0.025	-0.072
GDP growth	0.386	0.826	0.402
CPI	0.172	0.955	0.229

TABLE 6. Component score covariance matrix

Component Score Covariance Matrix			
Component	1	2	3
1	1.000	0.000	0.000
2	0.000	1.000	0.000
3	0.000	0.000	1.000

3.6. Calculate the Main Factor Scores Through Component Score Coefficient Matrix. The main factor scores can be calculated based on the main factors namings , linear expression between the main factors and the original indicator variables on table 7 component score coefficient matrix.

Linear expression between the main factors and the original indicator variables is:

F1 = - 0.154*debt ratio +0.123*equity ratio -0.159*capital cost rates +0.251*return on assets +0.147*OPE +0.147 *total asset growth rate +0.27*fixed asset investment expansion + 0.158*assets ultilization-0.085*GDP growth rate -0.40*CPI

F2 = 0.483*debt ratio+0.487*capital cost rates +0.121*equity ratio -0.153*return on assets -0.157*OPE +0.059*total asset growth rate-0.157*fixed asset investment expansion +0.039*assets ultilization+0.091* GDP growth rate+0.055*CPI

F3 = 0.18*debt ratio -0.052*equity ratio +0.16*capital cost rates -0.35*return on assets -0.027*OPE -0.09 *total asset growth rate -0.25*fixed asset investment expansion -0.06*assets ultilization+0.515*GDP growth rate +0.520*CPI

TABLE 7. Component score coefficient matrix

	component		
	1	2	3
Debt ratio	-0.154	0.483	0.018
Equity ratio	0.123	0.121	-0.052
Capital cost rates	-0.159	0.487	0.016
Return on assets	0.251	-0.153	-0.035
OPE	0.270	-0.157	-0.027
Total asset growth rate	0.147	0.059	-0.009
Fixed asset investment expansion	0.270	-0.157	-0.025
Assets utilization	0.158	0.039	-0.006
GDP growth	-0.085	0.091	0.515
CPI	-0.040	-0.055	0.520

The three main factors' scores of each quarter can be calculated if we use the linear expression to calculate specific targets for each quarter, as Table 8.

Using factor analysis the original structure of index can be structured treatment, this method not only can eliminate the total the target linear effects, but also reduce and simplify the observation dimension, meantime ensure the information of the original data, forecast accuracy can be improved through logistic regression analysis t again on this basis logistic regression analysis.

TABLE 8. Main factors' scores

quarter	F1	F2	F3	quarter	F1	F2	F3
2003.01	-0.780	-2.010	-0.813	2006.03	-0.219	1.029	-0.832
2003.02	-0.818	-1.736	-0.428	2006.04	0.4939	-0.017	-0.828
2003.03	-0.795	-1.733	-0.302	2007.01	-0.855	0.686	-0.004
2003.04	-0.788	-1.581	-0.207	2007.02	-0.515	1.200	-0.281
2004.01	-0.790	-1.154	1.110	2007.03	-0.113	1.085	-0.329
2004.02	-0.448	-1.168	1.207	2007.04	0.635	0.596	-0.318
2004.03	-0.527	-0.481	1.410	2008.01	-0.396	0.810	0.304
2004.04	-0.571	0.050	1.272	2008.02	0.557	0.804	0.867
2005.01	-0.851	0.778	1.190	2008.03	2.185	-0.097	1.534
2005.02	-0.416	0.805	0.806	2008.04	3.073	-0.764	1.323
2005.03	-0.115	0.822	0.511	2009.01	-0.070	-0.069	-0.934
2005.04	0.084	0.846	0.395	2009.02	0.489	0.155	-1.371
2006.01	-0.849	0.925	-0.902	2009.03	1.195	-0.302	-1.826
2006.02	-0.540	1.086	-0.792	2009.04	1.745	-0.562	-1.760

Source: SPSS automatically calculated based factor score coefficient matrix.

4. Construction of Security Early Warning Model Based on Logistic. We can set up security early warning model based on Logistic after the data collated and the main factor and its' scores obtained. We can set up the logistic regression model if we think the financing security factor F1, the investment security factor F2, the macroeconomic environment security factor F3 as the l variables of predictive model, logistic regression results in Table 9.We use Z value to represent the existence of the coal industry investment and financing security, Z = 0 shows that there is no security problems, Z = 1 shows that there is security problems. Define Z = coal industry investment and financing security VaR value / equity of the coal industry, through the calculation of the average Z of 11.4%. So Z is defined as follows: Z <11.4%, Z = 0, Z ≥ 11.4%, Z = 1. Using SPSS's logistic regression function to binary logistic regression analyze for the sample, we can obtain logistic regression model.

TABLE 9. Logistic regression results

	B	S.E	Wald	df	Sig.	Exp(B)
Step 1^a	-0.344 -2.708 3.319 2.563	0.166 1.332 1.767 1.223	4.260 4.132 3.530 4.392	1 1 1 1	0.039 0.042 0.060 0.036	0.709 0.367 0.236 0.928

Where: B:coefficient for the independent variables and constants, SE:standard error, Wald:chi-square value for the Wald, df:the degrees of freedom, sig:P value, p value < 0.1, reject the original hypothesis, so the three factors have significant impact on the coal industry investment and financing security problems. The F1, F2, F3 three factors as independent variables, all included in the regression equation, the use of logistic regression coefficients derived from the variable coefficient values obtained logistic regression model as follows:

$$P=\frac{\exp(2.563-0.344F1-2.708F2+3.319F3)}{1+\exp(2.563-0.344F1-2.708F2+3.319F3)}$$

5. Test for Security Early Warning Model Based on Logistic. In this logistic model, because the quarterly rate of security problems occurred is 0.39,that means 2quarters, 11 quarters that there is security problems in 11 quarters of 28quarters, so we choose 0.39 as the discriminant (or critical) point, $P > 0.39$is identified as a security problems issued quarter , the larger value, the greater risk, P value < 0.39 is identified as a security quarter , the smaller value,the less risk, if p = 0.39, it indicates that the coal industry is not enough to distinguish investment and financing uncertain security situation , it is a gray area.

TABLE 10. Fitting sample data table

Observed			Predicted		
			Z		Percentage Correct
			0.00	1.00	
Step 0	Z	0.00	13	4	76.5
		1.00	4	7	63.5
Overall Percentage					71.4

a. Constant is included in the model.
b.The cut value is 0.390

Estimates from the classification results of 28 this quarterly data, in 28 quarters, four quarters was be mistaken as a security problems issued quarter in the 17 non-security problems issued quarter, accuracy was 76.5%, four quarters was be mistaken as a non-security problems issued quarter in the 11 security problems issued quarter, error rate 63.5%, the overall predicted accuracy was 71.4%, so goodness of fit is better in this model.

6. Conclusion. Through empirical analysis we study the investment and finance risks sources in three aspects, including the financing situation of the coal industry, investment conditions and the macroeconomic environment. We picking up three main component factors as independent variables to construct Logistic Model to accurately predict investment and financial risks in the coal industry and accuracy is 71.4%, maintaining the original 10 indicators unchanged, extraction the three common factors who can maximize explaine variables to construct the Logistic model. Upon examination, the prediction accuracy of 71.4%. if we know quarterly data of the coal industry's financial indicators, GDP growth rate and CPI,we can obtained the coal industry safety eventual probability of investment and financing through the calculation the value of the financing security principal component, investments principal component and macroeconomic principal component, and we can think the situation of estimatesd probability occued risk > 0.39 as a security problems issued situation, otherwise there is no risk if the risk probability is less than 0.39, so this model can give the corresponding security status signal to warning role.

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SIMULATE THE EFFECTS OF RMB APPRECIATION IN AN OPEN-ECONOMY DSGE MODEL

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ABSTRACT. *The issue on RMB Yuan appreciation has aroused growing interest in Chinese macroeconomics. The People's Bank of China (PBoC) has promoted the reform to enhance the flexibility of the RMB exchange rate. Using an open-economy dynamic stochastic general equilibrium (DSGE) model, we simulate the likely behavior of the Chinese output, inflation, and interest rate by changing RMB appreciation shock of 1.7%, 3.8%, and 5.0%, separately. The simulation results indicate that RMB appreciation shock induces a reduction in nominal interest rate and its effect leads to an increase in the output and inflation. In particular, the China's inflation will increases by 1.5% if the RMB appreciates by 3.8%. The appreciation of the Chinese Yuan will have a powerful impact on the Chinese economy. Therefore, the PBoC should pay close attention to the pace of RMB appreciation when it promotes the reform of the RMB exchange rate regime.*
Keywords: RMB Appreciation Shock; Chinese Inflation; DSGE Model

1. Introduction. For virtually a decade, RMB Yuan has been under heavy pressures to appreciate. The exchange rate remained de facto pegged at 8.2773 to the dollar until 21 July 2005. At this point, the shift to a managed float of the RMB to a basket of currencies and the 2.1% revaluation of the RMB was announced by the People's Bank of China (PBoC). Entering 2010, the PBoC announced that it would proceed the reform of the RMB exchange rate regime to increase the flexibility of the RMB exchange rate (China Daily, 2010 June 20).

The issue of the RMB appreciation has attracted the attention of academics, at large. Zhang and Fung (2006), for example, find that appreciation of RMB Yuan has strong impacts on China's domestic economy in terms of trade composition, inflation, and real interest rates. They finally propose that China should minimize changes in its currency value in the short run. In addition, as shown in Hua (2007), the real appreciation of the RMB exerts a statistically significant negative effect on Chinese manufacturing employment.

As Japan provides an important role model for China, Danne and Schnabl (2008) study the role of the yen/dollar exchange rate for Japanese monetary policy after the shift of Japan from a fixed to a floating exchange rate regime. Their final economic policy conclusion for China is to keep the exchange rate pegged (to the dollar). In contrast, Xu (2008) get important lessons for mainland China from Taiwan's experience of currency appreciation. He proposes that moving quickly from a peg or heavily managed float to a pure floating rate is risk and turbulent, in the context of Chinese under-developed financial markets and institutions. Furthermore, Xu (2009) argues that real appreciation of the Chinese Yuan has a powerful effect in boosting job creation in the service sector.

How are the Chinese output, inflation, and interest rate likely to behave under more exchange rate flexibility of the Chinese Yuan? This paper attempts to answer this question. We adopt an open-economy dynamic stochastic general equilibrium (DSGE) model to study the impacts of the more flexible exchange rate regime of RMB on the Chinese economy. As argued by Zhang (2009), Scheibe and Vines (2005), and Chow (2002), the Chinese economy has become marketised to such a degree since 1978 that it is appropriate to model China's economy in a framework of the advanced economies. The model parameters are estimated applying the Bayesian approach, see Schorfheide (2000), Smets and Wouters (2003) for instance. Then a simulation exercise is used to assess the behavior of Chinese economy through different levels of the RMB appreciation shock. The average size of Yuan-Dollar exchange rate volatility was about 2% between 2005q1 to 2009q4, while the quarterly change in nominal Yuan-Euro exchange rate reached about 5 percentage points between 2000q1 to 2009q4 (See Fig. 1). Thus, the present study uses different scenarios by changing RMB appreciation shock of 1.7%, 3.8%, and 5.0% to analyze effects on the Chinese economy.

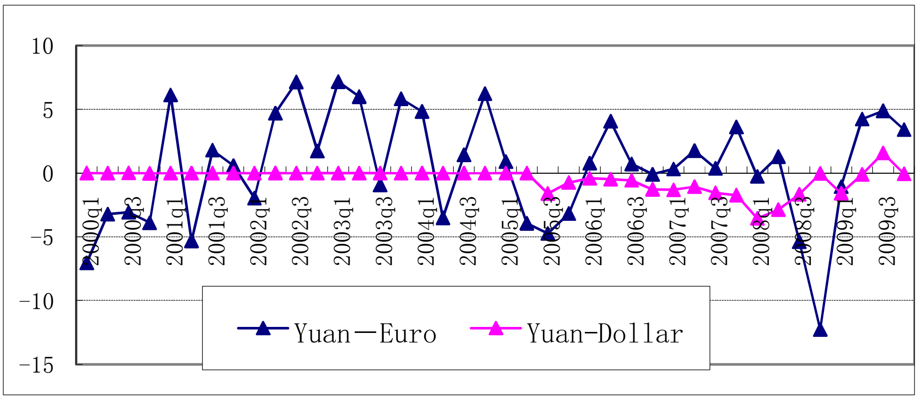

FIGURE1. Quarterly change in nominal exchange rate

The rest structure of this paper is organized as follows: section 2 presents the DSGE model and shows the consequential first order conditions engendered by households' and firms' optimization behaviors; Section 3 carries out econometric estimation; Section 4 undertakes the simulation exercises, and section 5 concludes the paper.

2. An Open Economy Model. The model used in this paper belongs to the framework of dynamic stochastic general equilibrium (DSGE) model, a simplified version of the model Galí and Monacelli (2005). Our model consists of three core equations: a forward-looking IS-equation, a Phillips Curve and a Taylor-type monetary policy rule, which determine the path of output, prices and nominal interest rate. The system is put in motion by five structural shocks: shock on the exchange rate, on the terms of trade, on the interest rate, on the world output, and on the world technology. All these shocks are normally distributed and uncorrelated with each other at all leads and lags.

An open economy IS-curve, derived from the household's optimization problem, can be written as follows:

$$y_t = E_t y_{t+1} - [\tau + \alpha(2-\alpha)(1-\tau)](R_t - E_t \pi_{t+1}) - \rho_z z_t$$
$$-\alpha[\tau + \alpha(2-\alpha)(1-\tau)]E_t \Delta s_{t+1} + \alpha(2-\alpha)\frac{(1-\tau)}{\tau} E_t \Delta y^*_{t+1} \quad (1)$$

where y_t is the output at time t, τ is the intertemporal substitution elasticity, $0 \le \alpha < 1$ is the import share. R_t is the nominal interest rate, π_t is the inflation rate, s_t are the terms of trade, y^*_t is exogenous world output, and z_t is the growth rate of an underlying non-stationary world technology process A_t.

The open economy Phillips Curve, obtained from optimal price setting of domestic firms, can be written:

$$\pi_t = \beta E_t \pi_{t+1} + \alpha\beta E_t \Delta s_{t+1} - \alpha \Delta s_t + \frac{\kappa}{\tau + \alpha(2-\alpha)(1-\tau)}(y_t - \overline{y_t}) \quad (2)$$

where $\overline{y_t} = -\alpha(2-\alpha)(1-\tau)/\tau y^*_t$ is potential output at time t, β is the discount factor, and $\kappa > 0$ is a constant that captures the level of price stickiness.

In order to study the Chinese exchange rate policy, we introduce the exchange rate e_t via the definition of the CPI and the purchasing power parity (PPP). Assuming that relative PPP holds, we have

$$\pi_t = \Delta e_t + (1-\alpha)\Delta s_t + \pi^*_t \quad (3)$$

where π^*_t is a world inflation shock, which captures deviations in purchasing power parity, with variance σ^2_π, and Δe_t is normal exchange rate depreciation. The behavior of the depreciation rate is given by the following equation:

$$\Delta e_t = \rho_e \Delta e_{t-1} + \varepsilon^e_t \quad (4)$$

where $0 < \rho_e < 1$ and ε^e_t is an exogenous shock on the nominal exchange rate depreciation, with variance σ^2_e.

The monetary policy is described by a general Taylor rule (2001), which proposes that normal interest rate can be set as function of output gap, inflation and normal exchange rate depreciation:

$$R_t = \rho_R R_{t-1} + (1-\rho_R)[\psi_1 \pi_1 + \psi_2 y_2 + \psi_3 \Delta e_t] + \varepsilon^R_t \quad (5)$$

where $0 \le \rho_R \le 1$ introduces some persistence to the nominal interest rate, $\psi_1, \psi_2, \psi_3 \ge 0$, and ε^R_t is an exogenous policy shock, with variance σ^2_R.

In addition, we fit $AR(1)$ processes to $A_t, \Delta s_t$ and y^*_t as follows:

$$A_t = \rho_z A_{t-1} + \varepsilon^z_t \quad (6)$$

$$\Delta s_t = \rho_s \Delta s_{t-1} + \varepsilon^s_t \quad (7)$$

$$y^*_t = \rho_{y^*} y^*_{t-1} + \varepsilon^{y^*}_t \quad (8)$$

where $\varepsilon^z_t, \varepsilon^s_t$ and $\varepsilon^{y^*}_t$ are exogenous shocks, with variances σ^2_z, σ^2_s and $\sigma^2_{y^*}$, respectively. The model is solved using the method described in the following section.

3. Econometric Estimation.

3.1. Data Considerations. We use seasonally adjusted quarterly data of the gross domestic product (GDP), inflation, nominal interest, nominal exchange rate and terms of trade, from the first quarter of 2000 to the fourth quarter of 2009, with 40 observations for each variable. The nominal exchange RMB/US$ rate, nominal interest, and the value of export and import were obtained from People's Bank of China. The data of gross domestic product and the Consumer Price Index were obtained from national statistics bureau of China.

Potential GDP was obtained by applying the Hodrick-Prescott (HP) filter to the GDP series. The inflation rate is the quarter percentage change in the Consumer Price Index (CPI) growth rate. Nominal interest rate is the weighted average interest rate in Chinese National Interbank Market. The terms of trade is defined as the relative value of exports in terms of imports.

3.2. Bayesian Estimation. In this paper, we fit our model using Bayesian techniques, which consists in placing a priori distribution $p(\theta)$ on the structural parameters θ ($\theta = [\psi_1, \psi_2, \psi_3, \alpha, \beta, \kappa, \tau, \rho_R, \rho_s, \rho_z, \rho_{y^*}, \rho_e, \sigma_R, \sigma_s, \sigma_z, \sigma_{y^*}, \sigma_e]$), the estimates of which are then updated using the data Y^T according to the Bayes rule:

$$p_D(\theta|Y^T) = \frac{L_D(\theta|Y^T)p(\theta)}{\int L_D(\theta|Y^T)p(\theta)d(\theta)}$$

where $p_D(\theta|Y^T)$ is the posterior distribution of parameters, $L_D(\psi,\theta|Y^T)$ is the likelihood conditional on the observed data Y^T, and $Y^T = \{Y_1, \ldots\ldots, Y_T\}$. $\int L_D(\theta|Y^T)p(\theta)d(\theta)$ is the marginal likelihood(marginal data density).

The solution to our linear model with rational expectations is transformed easily in the following state space form:

$$H_t = MH_{t-1} + \varepsilon_t$$
$$Y_t = \Pi H_t$$

where H_t is a vector of observed and unobserved variables, and ε_t is a vector of stochastic disturbances. The matrices M and Π comprise the underlying parameters of the model. Y_t is a vector of observed variables, which is composed of annualized interest rates , annualized inflation rates , output growth , depreciation rates , and terms of trade changes. The vector of observations is related to our model variables according to $Y_t = [4R_t, 4\pi_t, \Delta y_t + z_t, \Delta e_t, \Delta s_t]'$.

3.3. Prior Distributions. Table 1 presents the prior distributions of the parameters. The import share follows a Beta distribution with mean 0.1 and variance 0.05. The intertemporal substitution elasticity is adopted a Beta distribution with mean 0.5 and variance 0.25. The discount factor β is computed as $\exp[-r/400]$ (Lubik and Schorfheide, 2007), where r is the steady state real interest rate with mean 1.5 and variance 0.02. κ, a constant that captures the level of price stickiness, is Gamma distributed with mean 0.5 and variance 0.25. From the Taylor rule, ρ_R is set to obey a Bata distribution with mean 0.5 and variance 0.2, ψ_1 follows a Gamma distribution with mean 5 and variance 0.05, ψ_2 follows a Gamma distribution with mean 2 and variance 0.05, and ψ_3 follows a Gamma distribution with mean 0.5 and variance 0.05.

We fit an AR (1) process to the terms of trade, and nominal exchange rate depreciation. ρ_s is centered at 0.7 and σ_s at 5. The points estimates of ρ_e and σ_e are 0.45 and 4, respectively. Following Lubik and Schorfheide (2007), we chose the prior means for ρ_{y^*} of 0.9 , σ_{y^*} of 1.5 , and ρ_z of 0.2.

3.4. Posterior Distributions. All our computations are performed using the DYNARE toolbox for Matlab (Juillard, 2005). We estimate the posterior distributions of the parameters using the Metropolis-Hastings algorithm. Using the Metropolis-Hastings algorithm with 3,000 iterations, we find that the Monte Carlo Markov Chains algorithm converges.

Table 1 contains the mean, and the 90% confidence interval of the estimated coefficients. We find that the PBoC follows an anti-inflationary policy ($\psi_1 = 5.002$) and demonstrates a strong concern for output ($\psi_2 = 1.997$).The estimated coefficient $\rho_R = 0.603$ indicates high persistence of nominal interest rates and therefore a smooth interest rate path. The value of 0.445 obtained for ψ_3 indicates that the PBC pays close attention to exchange rate movement to define the interest rate path.

TABLE 1. Prior and posterior distributions for the parameters

	Prior distribution		Posterior distribution	
Name	Density	Mean(SD)	Mean	Confidence interval (90%)
ψ_1	Gamma	5.000(0.050)	4.997	[4.913,5.071]
ψ_2	Gamma	2.000(0.050)	2.004	[1.943,2.084]
ψ_3	Gamma	0.500(0.050)	0.483	[0.404,0.549]
α	Beta	0.100(0.050)	0.050	[0.023,0.074]
r	Gamma	1.500(0.020)	1.506	[1.475,1.534]
κ	Gamma	0.500(0.25)	0.705	[0.313,1.047]
τ	Beta	0.500(0.25)	0.133	[0.041,0.218]
ρ_R	Beta	0.500(0.200)	0.550	[0.356,0.769]
ρ_s	Beta	0.700(0.020)	0.693	[0.662,0.720]
ρ_z	Beta	0.200(0.050)	0.282	[0.199,0.356]
ρ_{y^*}	Beta	0.900(0.050)	0.994	[0.990,0.997]
ρ_e	Beta	0.450(0.020)	0.445	[0.415,0.475]
σ_R	InvGamma	2.000(4.000)	2.244	[1.489,2.897]
σ_s	InvGamma	5.000(4.000)	5.137	[4.104,6.159]
σ_z	InvGamma	0.500(4.000)	1.102	[0.510,1.631]
σ_{y^*}	InvGamma	1.500(4.000)	5.014	[1.298,8.301]
σ_e	InvGamma	4.000(4.000)	3.079	[2.519,3.721]

4. Simulation Evidence. In this part, we simulate the effects of the negative shock on nominal exchange rate depreciation, called the RMB appreciation shock. These shocks are 1.7%, 3.8%, and 5% in size, occur in period 0, are unanticipated, and have zero persistence. Fig.1 depicts the impulse response of endogenous variables to these shocks for ten years. The horizontal axis represents time on a quarterly scale, and the vertical axis represents percentage deviations from equilibrium.

Figure 2 displays the impulse response functions of the negative shocks on nominal exchange rate depreciation (ε_t^e). These shocks produce decreases in the normal exchange rate depreciation, which lead to the reductions in the normal interest rate. The reductions in the interest rate lead to expansions in the output and make the current inflation edge up. Most of the shocks absorption occurs between the first and second years, as shown in Fig. 2. A 3.8% level of RMB appreciation produces a decrease in the nominal interest rate of 0.17% in the first period, and its effect on output makes the current output increase by 0.96%. The increasing output pushes the inflation up 1.5% in the first quarter.

Table 2 shows the impulse response of the inflation to the different levels (1.7%, 3.8%, and 5.0%) of RMB appreciation shocks. A 1.7% of the RMB appreciation shock pushes inflation up to 1% in the first quarter. As the RMB appreciation shock reaches 5%, the inflation increases by 1.72% in the first period. Two years later, the impacts of these shocks on the Chinese inflation is totally absorbed, as shown in Table 2.

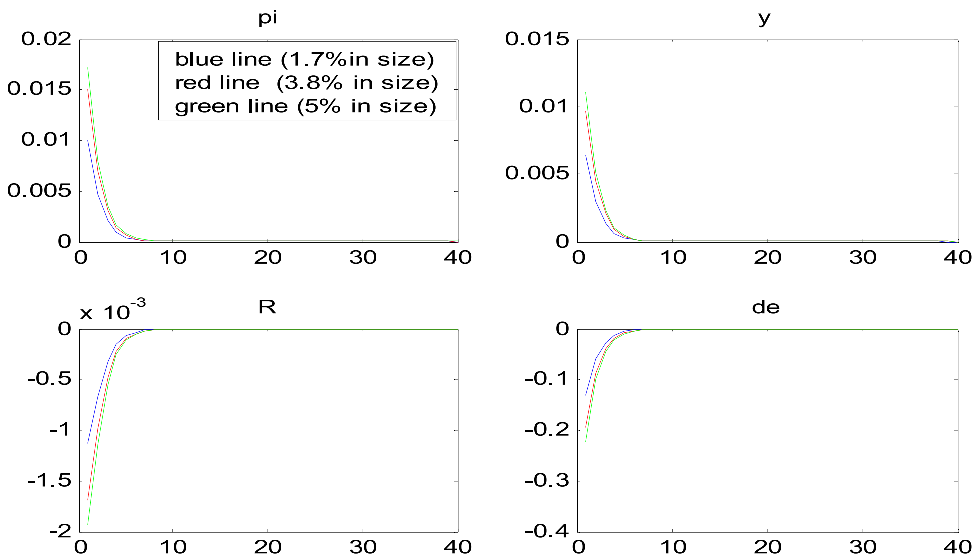

FIGURE 2. Impulse response functions of negative shocks on ε_t^e

TABLE 2. Impulse response of π in each period to shocks on ε_t^e

period	Size of Shocks on ε_t^e (%)		
	1.70	3.80	5.00
1	1.00	1.50	1.72
2	0.46	0.69	0.79
3	0.21	0.31	0.36
4	0.09	0.14	0.16
5	0.04	0.06	0.07
6	0.02	0.03	0.03
7	0.01	0.01	0.01
8	0.00	0.01	0.01
9	0.00	0.00	0.00

5. Conclusions. For virtually a decade, the central bank of China has faced a further reform of the RMB exchange rate regime to enhance the flexibility of the RMB exchange rate. In this context, we assess the effects of the RMB appreciation shocks on the China's economy, using the Bayesian approach to estimate an open-economy DSGE model. We design different scenarios by changing RMB appreciation shock of 1.7%, 3.8%, and 5.0% to analyze effects on the Chinese economy.

The simulation results indicate that the appreciation shock of RMB induces a reduction in nominal interest rate and its effect leads to an increase in the output and inflation. The China's inflation increases by 1.5%, after a RMB appreciation shock by 3.8%. The appreciation of the Chinese Yuan will have a powerful impact on the Chinese inflation. Therefore, the PBoC should pay close attention to the appreciation level of Chinese currency RMB when it promotes the reform of the RMB exchange rate regime to increase the flexibility of the RMB exchange rate.

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RESEARCH ON DECOMPOSITION OF INCOME INEQUALITY BASED ON INCOME DISTRIBUTION IN CHINA

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ABSTRACT. *This paper develops methods for decomposing changes in the income distribution using decompositions of the income density function. The changes of income density are broken down using elementary transformations of income. These density decompositions are analogous to the widely-used decomposition of inequality indices except that they summarize multiple features of the income distribution (using graphs), rather than focusing on a specific feature such as dispersion and are not dependent on the choice of a specific summary index. Nonetheless, since inequality indices can be expressed as PDF functionals, our density based methods can also be applied to provide the numerical decompositions.*
Keywords: Density Functions; Income Distribution; Inequality; Density Decomposition

1. Introduction. Decomposition of income inequality is a hot topic. More and more scholars from a different perspective study this problem. Most previous analysis about decomposition of income inequality has focused on a specific feature of the distribution-inequality, poverty, or mean income - rather than looking at changes in the distribution as a whole. They may not capture other aspects such as polarization. Moreover the estimated importance of the different factors in a decomposition may be sensitive to the choice of index used. It is therefore of interest to explore an approach to decomposition that summarizes multiple features of the income distribution, and yet is amenable to decomposition in the same way that inequality indices are. In this paper, we propose a decomposition method based on income probability density functions (PDFs) that has these capabilities.

We show in this paper that a PDF can be decomposed by population subgroup in a manner analogous to the decomposition of inequality indices, with the crucial difference that our decomposition is applied to non-parametrically estimated income PDFs (as in Figure 1), rather than to scalar indices. The method takes account of (changes in) the complete distribution of income within each subgroup, rather than only the mean and spread. We propose a way to characterize within-group income changes, based on 'elementary income transformations' that characterize changes in location, changes in spread, and changes in higher moments of the subgroup distributions. Although our methods focus on PDFs, and results are summarized graphically, they provide a unified framework that may also be used to derive decompositions of changes in scalar inequality indices, since these indices are functional of the PDF and so may be calculated from them. And, although our application focuses on trends over time, the methods themselves are more widely applicable, to differences in income distributions across countries, for example.

2. Income Distribution of Nonparametric Fitting. Given a set of data, $X_1, X_1, \cdots X_n$, it is often the case that interesting features of the sample can be quickly acquired through plotting a kernel density estimator, defined as

$$\hat{f}(x) = \frac{1}{nh} \sum_{i=1}^{n} K\left(\frac{x - X_i}{h}\right) \tag{1}$$

where $K(\cdot)$ is a ''kernel function'', often taken to be a symmetrical probability density function, and h is the ''bandwidth'' or smoothing parameter. As is well known, the crucial parameter in kernel density estimation is the choice of the bandwidth, which controls the trade-off between bias and variance of the estimator. A large bandwidth will provide a smooth and not very variable estimate, while a small bandwidth will produce an unnecessarily variable plot. Kernel density estimation is essentially an exercise in ''smoothing'' the observations of a sample to get an idea of the underlying density of the observations, $f(x)$, and the bandwidth controls the amount of smoothing eventually imposed on the data by the estimation procedure.

Hence consider now that the observations carry a weight attached to them, $\omega_1, \omega_1, \cdots \omega_n$, which are normalized so they add up to 1, $\sum_{i=1}^{n} \omega_i = 1$. The obvious generalization of the kernel density estimator is to replace the simple sum in (1) by a weighted sum (DiNardo et al., 1996; Deaton,1997), so the weighted estimator becomes

$$\hat{f}(x) = \frac{1}{h} \sum_{i=1}^{n} \omega_i K\left(\frac{x - X_i}{h}\right) \tag{2}$$

reflecting the fact that not every observation contains the same information about the underlying density. In this way the weights alter the height of the individual bumps, $\frac{1}{h}\omega_i K\left(\frac{x - X_i}{h}\right)$, from which the estimate, $\tilde{f}(x)$, is constructed by adding them up. Note that provided h and the kernel are the same in (1) and in (2) this is the only difference between the two estimators.

3. Decomposing Income Density Function Changes. Accounts based on estimates of the 'changing density' components tell only part of the story about income distribution change. It is also useful to be able to break the change density component down further and to account for the changes in PDFs. The key features of each PDF that we focus on are its location and its spread, plus other features related to higher moments. We characterize changes in PDFs as arising in three different ways, which we label three 'S's of distributional change:

a sliding: a ceteris paribus shift of the PDF along the income line;

a stretching: a ceteris paribus increase in spread around a constant mean;

a squashing: a ceteris paribus disproportionate increase in density mass on one side of the mode.

Our proposed decomposition approach is the decomposition of changes in a PDF into components summarizing changes in income location, spread, and other distributional features. Thus the decomposition of the change in the aggregate density has three components:

$$\Delta f(x) = C_{D1}(x) + C_{D2}(x) + C_{D3}(x) \tag{3}$$

where $C_{D1}(x), C_{D2}(x) and C_{D3}(x)$, measure the impacts of sliding, stretching, and squashing, respectively.

To estimate $C_{D1}(x), C_{D2}(x) and C_{D3}(x)$, we use an approach based upon elementary transformations of densities. Suppose that there is an income transformation function that describes the relationship between base and final period income for each individual within a given group. That is, we have $x_1 = g(x_0)$. This implies a relationship between income PDF in the two periods:

$$f_1(x) = \left| \frac{d(g^{-1}(x))}{dx} \right| f_0(g^{-1}(x)) \tag{4}$$

By choosing a particular $g(x)$, we can construct counterfactual PDFs that reflect various characterizations of income changes. For example, controlling for the shifting and stretching of PDFs is straightforward. We assume that, the relationship between income in year 1 and income in year 0 is linear:

$$x_1 = \alpha + \beta x_0 \tag{5}$$

The resulting PDF is therefore

$$\zeta(x) = \left| \frac{1}{\beta} \right| f_0\left(\frac{x - \alpha}{\beta} \right) \tag{6}$$

We use $\zeta(x)$ to refer to counterfactual constructs based on linear income transformation functions; $f_0(x)$ refers to actual base or final period density functions.

3.1. Changes in Income Distribution Locations. Consider an income transformation consisting of an equal addition to all incomes: $\alpha = a, \beta = 1$. The density function implied by Equation (7) is the initial PDF shifted along the income line. Mean income is increased by a but the variance is left unchanged. Hence to construct a counterfactual PDF that incorporates the change in mean, we simply apply this income transformation and calibrate a so that the mean income in the counterfactual distribution, $\zeta_1(x)$, is equal to the mean income in the observed final distribution, Ef_1, i.e.

$$a = E(f_1) - E(f_0) \tag{7}$$

Denote the counterfactual PDF obtained after such a transformation $\zeta_1(x; \mu_1, \sigma_0)$, where μ_1 and σ_0 reflect the fact that mean income is at its final period value and the variance is at its base period value.

3.2. Changes in the Shape of Income Distribution. Now consider a second income transformation incorporating a increase in dispersion which stretches the PDF around a constant mean. Each income in the second period is a fraction s of initial income and a fraction $(1-s)$ of base-period subgroup mean income:

$$x_1 = sx_0 + (1-s)E(f_0) \tag{8}$$

The parameters of the linear transformation in this case are $\alpha = (1-s)E(f_0)$ and $\beta = s$. Mean income remains constant but the variance increases by a factor s^2. Hence we can construct a counterfactual PDF that incorporates a *ceteris paribus* increase in income dispersion by calibrating the transformation parameters so that $Var(\zeta_1) = Var(f_1)$ with

$$s = \sqrt{\frac{Var(f_1)}{Var(f_0)}} \tag{9}$$

Denote the counterfactual PDF obtained after such a transformation $\zeta_1(x; \mu_0, \sigma_1)$, where μ_0 and σ_1 reflect the fact that mean income is at its base period value and the variance is at its final period value.

3.3. Changes in Both the Location and the Shape of Income Distribution. The two preceding transformations can be combined to construct a counter-factual PDF that allows for changes in means and in variances with the following transformation parameters

$$\alpha = E(f_1) - sE(f_0), \qquad \beta = s \tag{10}$$

These parameters imply a counterfactual density, $\zeta_1(x; \mu_1, \sigma_1)$, where μ_1 and σ_1 reflect the fact that mean and the variance both are at its final period value.

We combine the three counterfactual constructs just described to compute the elements of the decomposition set out in Equation (3).

4. Empirical Results.

4.1. Data. We illustrate the methods with analysis of the changes in the China income distribution between 2000 and 2005 using data on household income from the 'China statistical Yearbook'. The income concept which we are referring to is the household disposable income which is defined as the amount of the available current resources for financing the consumption expenditure. The sample in 2000 is 249, and being 280 in 2005.

4.2. Income Distribution Changes between 2000 and 2005. The first step we used a kernel density estimator to estimate the income density functions for urban residents as a whole. The advantage of this estimator is that it does not over-smooth the distribution in zones of high income concentration, while keeping the variability of the estimates low where data are scarce, for example in the highest income ranges.

The importance of considering multiple features of the income distribution is illustrated by the China experience. Consider Figure 1 which plots estimates of the PDFs for the China income distribution in 2000 and 2005. Income trends were complex in nature. The peak of the income density changed from being single-peak to a near-bimodalmore complex shape. There was a large shift in the concentration of incomes away from the 2000 peak and down to the right, combined with a small increase of concentration at the very lowest incomes. Peak split shows that urban residents in lower-income person have a growing income gap. It is evident that the income PDFs both in 2000 and 2005 are in the left tail of the distribution, in fact more of the residents are still concentrated in low-income levels. To characterize these changes as an increase in inequality (as an inequality decomposition analysis might) would omit much of the multi-faceted nature of the changes.

4.3. Space Decomposition of the PDF. Regional economic development in China is uneven, so that the impact of regional income distribution on the overall income distribution would not be bound to the same. Therefore, it is necessary for all regions to study the changes in income distribution, and on this basis to assess their impact on the overall income distribution. In order to illustrate these concepts, prefectural-level cities were divided into the eastern, central and western regions according to their respective districts. So the income PDFs of three regions could be obtained, at the same time, the national income PDF together with the per capita GDP in various regions as the weight.

Figure 2 shows that the distribution of overall national income for 2000 were essentially governed by the location of the central and western regions affected, but the shape is more determined by the eastern region. Compared with 2000， the central and western region had decided not only the location of the overall income distribution in 2005, but also a certain extent its shape。Affected by the characteristics，the main peak in 2005 began to split。This means that the degree of income inequality in different income groups has been strengthened。But the effect of changes in regions is hard to identify in such a figure, we calculate the relevant statistical indicators of income distribution in Table 1 and inequality indicators in Table 2.

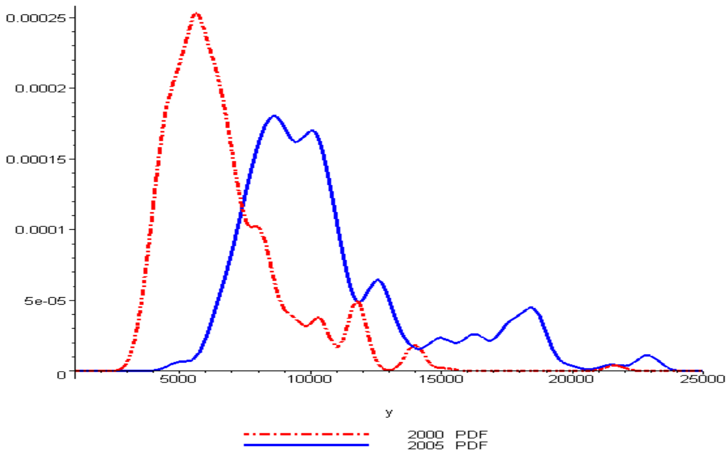

FIGURE 1. Income PDFs for 2000 and 2005

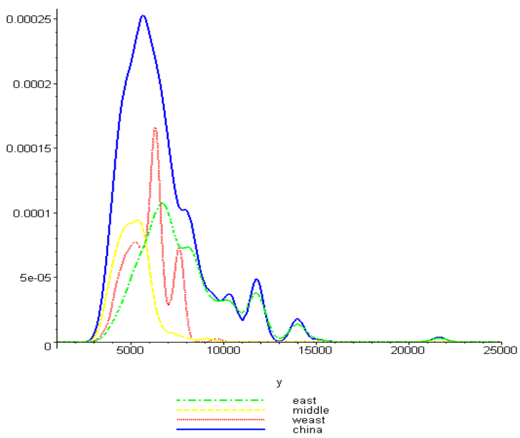

FIGURE 2. Income PDFs for 2000

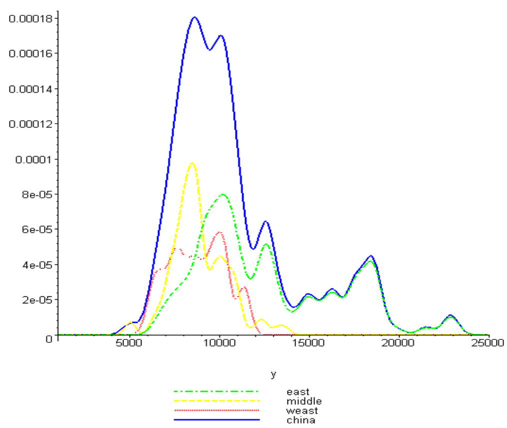

FIGURE 3. Income PDFs for 2005

TABLE 1. The statistical indicators for 2000 and 2005

	Mean		P10			P50			P90		
	2000	2005	2000	2005	Ratio	2000	2005	Ratio	2000	2005	Ratio
Nationwide	6678	10796	4330	7341	69.54	6114	9815	60.53	9993	17095	71.07
Eastern	7958	12655	5180	8365	61.49	7344	11474	56.24	11665	18424	57.94
Central	5519	8859	3862	7150	85.14	4933	8620	74.74	5874	10837	84.49
Western	5947	8745	4438	6584	48.36	6055	8764	44.74	7522	10848	44.22

Notes：P10 means low-income group; P50 means medium-income group; P90 means high-income group. All statistics estimated by numerical integration of the relevant density function estimates.

TABLE 2. The Inequity Indicators for 2000 and 2005

	Gini		P90/P10		P90/P50		P50/P10	
	2000	2005	2000	2005	2000	2005	2000	2005
Nationwide	0.31 (100)	0.37 (100)	2.31 (100)	2.33 (100)	1.63 (100)	1.74 (100)	1.41 (100)	1.34 (100)
Eastern	0.32 (37.21)	0.38 (41.30)	2.25 (46.75)	2.70 (46.27)	1.59 (46.82)	1.61 (45.34)	1.42 (48.34)	1.37 (47.92)
Central	0.28 (32.56)	0.33 (35.87)	1.52 (13.82)	1.51 (17.61)	1.19 (15.33)	1.26 (19.55)	1.28 (19.06)	1.21 (26.52)
Western	0.26 (30.23)	0.21 (22.83)	1.69 (22.68)	1.65 (17.00)	1.26 (23.58)	1.24 (17.10)	1.36 (29.90)	1.33 (20.83)

Notes：①P10 means low-income group; P50 means medium-income group; P90 means high-income group. All statistics estimated by numerical integration of the relevant density function estimates. ②Numbers in brackets show the marginal contributions expressed as a percentage of the total income inequality(%).

Table 2 displays the changes in the bottom decile (p10), the median (p50), the mean and the top decile (p90) of the income distribution. The average income of eastern region had significantly higher than that of the national level in 2000 and 2005， and then central and western regions were below the national level. In 2000, the average income of the central areas was lowest, which was only 5519 less than the average national level 17.36%， however in 2005 the western region, the average income level for 8745 less than the average national level 19.01%. As far as the low， middle and high income groups was concerned, the rate of increase was the quickest in central region, followed by eastern region, and was the slowest in western region.

Figure 3 shows the changes of income inequality for a more detailed explanation of the country and the east, central and western regions. Compared with 2000, in 2005 the national and regional income inequality levels have decreased. The inequality between high and low income group has a little increased, and similarly for the inequality between high and medium income group. However, the inequality between medium and low income group has a significantly reduced.

4.4. Decomposition of the Change in the PDF. In the previous studies, it is also difficult to disentangle the role of differential increases in mean income and the role of the general increase in spread. The pictorial representations of Figures 3 and 4 and the summary indices presented in Table 2 and 3 suggest important candidate explanations for the distributional change but, at the same time, questions remain about which was the most important of them. Our density function decomposition methodology provides a means of isolating the contributions of the various factors and quantifying their impact. Results from the decomposition exercise are presented in Figure 5 to Figure 8. A multiplicative model provided a better fit of the changes than did an absolute model (apparent from a visual inspection of plots not shown). We assessed the effect of the three 'S's of change in Figure 6 to Figure 8, and allowed first for the change in means, then in the change in spread.

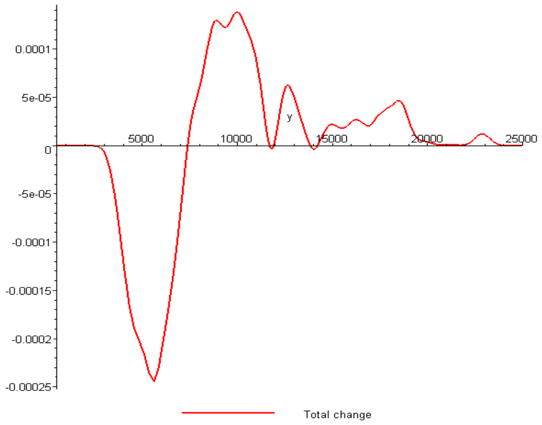

FIGURE 4. PDF change 2000-2005

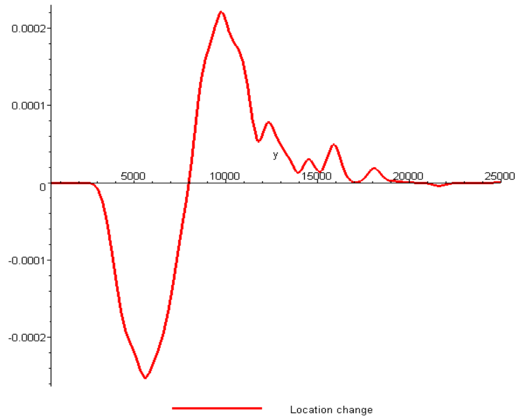

FIGURE 5. Location change 2000-2005

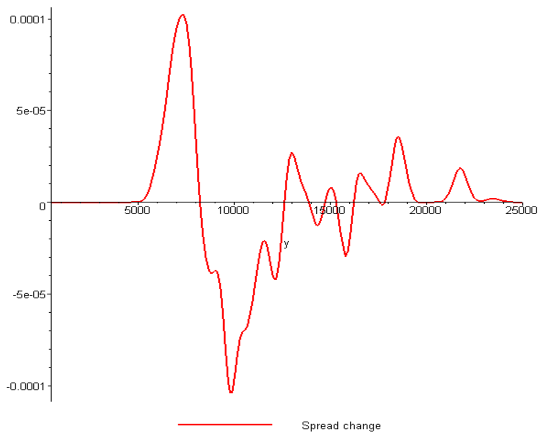

FIGURE 6. Spread change 2000-2005

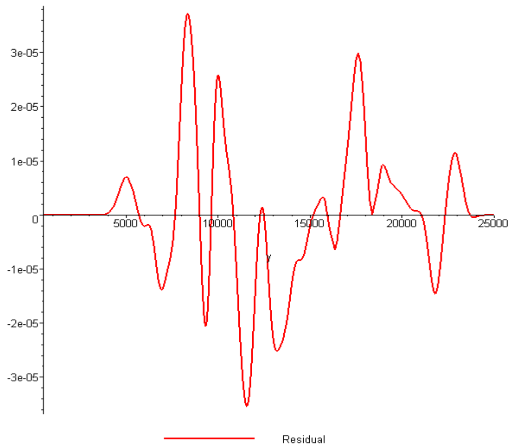

FIGURE 7. Residual 2000-2005

Figure 4 shows the difference between the 2000 and 2005 PDFs. The mass at very low incomes increased slightly, but there was a decrease in the density between 4000 and 7000. This was accompanied by a substantial increase in density over the range 7000 to 12000. The three components of the decomposition of the change are presented in Figure 5 to Figure 7. The further away from zero the line is at any income level, the more of the change in the density that is accounted for that component (the contributions may be in the same direction or the opposite direction as the aggregate change); if a component had no impact, the relevant graph would be a horizontal line at zero.

Changes in PDF location stand out as having made the largest contribution to changes in the aggregate PDF. The increase in mean income shifted density mass to the right, with a steep fall concentrated at about 5000 and increase at all income greater than 8000. The next most important components were the contributions from changes in spread, which accounted for the increase in mass at very low incomes. At most income levels (incomes below 8000), they tended to offset the effect of higher mean incomes but, overall, their effects were dominated by it. The residual component is the least important. Its contribution was fluctuated violently range from low income to high income.

In sum, the change in PDF between 2000 and 2005-the decrease in density mass in the middle-income range and the increase at higher income-is mostly accounted for by changes in the location of the PDFs (a sliding effect). The increase in mass at very low incomes is also identified well.

4.5. Decomposition of Changes in Summary Indices. We have emphasized the relevance of looking at the income distribution as a whole but, of course, there is also interest in particular features such as inequality. To draw conclusions about more specific aspects of distributional change, we can derive counterfactual indices of inequality, and other summary statistics, from the counterfactual distributions since the statistics are functions of the PDFs.

TABLE 3. Estimates of marginal contribution to changes in summary statistics

	P10	P50	P90	Gini	P90/P10	P90/P50	P50/P10
Total change	3011 (100)	3701 (100)	7102 (100)	0.06	0.02	0.11	-0.08
Location change	4117 (136.73)	4116 (111.21)	4118 (57.98)	-0.32	-0.64	-0.26	-0.20
Shape change	-1136 (-37.73)	-291 (-7.86)	1722 (24.25)	0.27	0.50	0.21	0.15
Residual	30 (1.00)	-124 (-3.35)	1262 (17.77)	0.11	0.16	0.15	-0.02

Notes：①P10 means low-income group; P50 means medium-income group; P90 means high-income group. All statistics estimated by numerical integration of the relevant density function estimates. ②Numbers in brackets show the percentage change and marginal contributions expressed as a percentage of the total change(%).

Table 3 reports changes in selected quantiles, three relative inequality indices, together with the estimated contributions to the change of the four explanatory components. The estimates for the quantiles are consistent with the results obtained from inspection of Figure 5 to Figure 8. All quantiles increased, reflecting the sliding effect, but this was offset by the impact of changes in spread (at the lower quantiles). At the tenth percentile the offsetting effect was large so that the actual increase was only 3011(the effect of residual component was negligible). At the fiftieth percentile the effect of changes in location dominated，but the impact of changes in spread was small (the residual component was offsetting too). However，at the ninetieth percentile the spread effect contributed the changes to increase as the location effect did.

The effects of changes in spread were more important for inequality. It was mostly the increase in spread that accounted for the increase in each relative inequality index. Changes in location, which reflect changes in income for these indices, played a secondary role. One exception is the P50/P10 ratio, for which changes were mainly driven by location and residual components. Unsurprisingly, changes in the Gini were mainly driven by the location component.

5. Concluding Remarks. This paper has developed a PDF decomposition methodology to account for income distribution trends, analogous to that based on decompositions of inequality indices. We have shown that a change in a density may be decomposed into terms accounting for the effects of changes in subgroup population shares and in subgroup densities. The second term may itself be decomposed into three terms representing the impacts of the three 'S's of distributional change: sliding (changes in location), stretching (changes in spread), and squashing (changes in higher moments). Although we focused our discussion and empirical application on changes over time, the methodology has wider application, for example to analysis of differences in income distributions between countries.

Our application of the PDF decomposition methodology to China income distribution trends between 2000 and 2005 unraveled what was, at first glance, a complex change. Two forces acted in opposite directions. On the one hand, increases in income levels shifted density mass towards higher income levels, and these were also responsible for some flattening of the PDF since the largest gains were obtained by the most well-off group of people. On the other hand, there was an increase in the proportion of the population that had relatively low average income, accompanied by an increase in income spread. Although these were offsetting factors, their effects were much smaller than the effects of changes in average incomes.

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ROLE OF NEW ACCOUNTING STANDARD FOR ENTERPRISES IN RISK AVERSION

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ABSTRACT. *New Accounting Standard reduces the cost of the owner in supervision: It is mainly based on "fair" as the core, emphasizing the price of corporate assets and operation proceeds, demonstrated the operation results of enterprises in the market, and reduced the risk of information asymmetry. Though the New Accounting Standard reducts the owners' commission–agency costs, it increases other risks of the enterprises, thus the enterprises' overall risk became more uncertain. Through the discussion in this paper, we should further strengthen the management of enterprises.*
Keywords: Accounting Standards; Interests Protection; Risk Management

1. Introduction. Promulgating the New Accounting Standard rises everyone's concerns, as fling a stone at the water. There were 39 items of Accounting Standards and 48 items of Certified Public Accountants Auditing Standards revised substantially in the New Accounting Standard Guidelines, and were implemented after January 1st, 2007. Incising the "application of fair value," the "First-In First-Out inventory measures"(FIFO) and "the debt restructuring method," transposing "the items inside or outside the accounting table" in the Accounting Standards, and nailing down "the scope of the corporate mergering and their accounting methods ", ruling "the corporation disclosing the accounting policies base " at the same time, is a feat in the China's real conditions.

2. The Stakeholders Would Like to Access More benefits in the New Accounting Standard. The aim of the national regulatory agencies is to strengthen the monitoring to the enterprise managers and reduce credit risk. Comparing the Old and the New Accounting Standard, we found that the core of the national regulatory agencies is how to attain more realistic accounting information, to emphasize that the validity of accounting data and reduce the users' accounting information cost.

The managers of enterprises want to have more powers. The managers, the management of enterprises, they are entrusted to manage the companies, the more powers they can control the more value they can manifest. So the managers of enterprises were anxious to know how to exert their powers after the New Accounting Standard goes into effect. That is to say, managers want to know which of the managers' powers will be limited, which powers they will have.

What shareholders care about is implementation of the New Accounting Standard, namely, if their interests are protected more effectively. Generally, investors take a fancy to the investment growth effectively and avoid the risk. Now none but the government and its agencies governments can have the ability to manage the enterprises by imposing into the enterprise internal. Small and medium-sized shareholders can only touch the dividends and they can hardly infect the survival and development of the enterprises. While credit risk case occurs frequently in recent years solicit their afraid, investors appeal to safeguard interests and strengthen supervision, and revising the Accounting Standards is national regulatory agencies' response to the appeal.

The New Accounting Standard focus on credit risk control, and little concern about risk-to-business operations and the links between credit risk control and operational risk control. The risk of market operations and corporate credit of enterprises is increasing during the implementing process of the Accounting Standards, for the external control of enterprise risk management plays an important role in a lot of constraints. And the risk become bigger and bigger as the kinds of risks interact, influence and checks and balances mutually in the system. Highlighting the credit risk control in the New Accounting Standard and losing sight of the other risk's impact makes the enterprise overall risk would be complex.

3. To Reduce Information Asymmetry and to Optimize the Credit Risk Management. Taking a panoramic view of the New Accounting Standard, we can see that the entire amendment is based on "fair" as the core, emphasizing the market price of corporate assets and the proceeds, demonstrate the operation results of enterprises in the market, which makes the results of business operations more true, the accounting information provided more credible, so the risk of information asymmetry reduced greatly.

In general, the New Accounting Standard reduced regulatory costs of the owner.

(1) To introduce to the concept of "fair value", the financial instruments, real estate investment, mergers under the non-common control, debt restructuring and non-monetary transactions, the confirming amount changes significantly, this stands out the increase of project value.
(2) To adopt "FIFO" inventory measures, prevents of adjusting the profits arbitrarily.
(3) To account the items which outside the balance-sheet previously increases the corporate financial reports user's risk identification ability.
(4) To change the debt restructuring method impacts the profit markedly, increasing owner's uptake to the risk of corporate operations.
(5) To unify the scope of the merger and the accounting treatment, states business operations more clear.
(6) To disclose the base of accounting policies can show business management intention clearly.

Specifically, to implement the New Accounting Standard reduces the probability of corporate management hiding profits.

Firstly, comparing with the recorded book value, the "fair value" of assets and liabilities can embody the present value of cash flow and future market value maximum, the capital value that investors put into the enterprise is reflected clearly.

Secondly, comparing with the "last-in first-out" inventory measures, adopting "FIFO" inventory measures can prevent the enterprises managers from taking advantage of rising prices of raw materials to reduce corporate profits, greatly reducing the space to hide profits.

Thirdly, disclosing some affair being not public in balance-sheet items formerly, such as futures, options, and so on, which can remind investors of enterprises risk and control the investment risk.

Fourthly, putting the debt restructuring return into the profit and accounting with the fair value price can prevent the enterprise management from eroding debt restructuring return.

Fifthly, instead "control" of "equity ratio", statements of parent company including all the subsidiaries controlled makes enterprise operating results more truly.

Sixthly, disclosing the basis for the accounting policies, such as the depreciation period of fixed assets, the amortization duration of intangible assets, gives investors more specific information related to accounting.

4. Information Exposure Increases the Risk of The Enterprise Operation in Market. As mentioned above, the New Accounting Standard aimed at strengthening corporate governance, seeking to reduce credit risk, which can undoubtedly play a significant role in the reduction of the owner of principal - agent costs. Then, can implementing the New Accounting Standard reduce the enterprise risk in the enterprise-wide risk management model?

First of all, the enterprise market risk increases. The New Accounting Standard counts the value of the assets with "fair value", in order to prevent the enterprises from underestimating the assets and profitability of investment. Though the New Accounting Standard allows the enterprise increase the value of the assets when book value less than "fair value", the enterprise market risk may increase, for the requirement "asset loss can not be recognized back in succedent accounting period” would causes the loss not be reflected in time.

Secondly, enterprise potential risk increases. Borrowing costs and development costs capitalized lowers the costs of investment period, the current margin can be reflected accurately, the enterprises’ independent development capacity raises; but on the other hand, the ruling makes it possible that the enterprises may transfer the current losses and fabricate the financial report. "FIFO" inventory measures dissevers the correlation of the market-oriented enterprises and the market. All of these increases the enterprises’ potential long-term risk.

Third, credit risk increases. Putting the income of debt restructuring into the turnover and kain debt repaying by fair prices can avoided managers of dealing with the private enterprise assets cheaply and slattern the corporate debt restructuring proceeds, corporate debt restructuring effectiveness can be displayed over financial crisis and debt crisis, so owner’s assets are safe. On the other hand, this makes it possible that some bad business credit debt enterprise evasion credit, some creditor enterprise managers conceal and erode enterprise profits with other enterprises by creating the illusion, the credit risk increases.

Fourth, the risk of enterprise impacted by speculative capital increases. Harmonization of accounting standards unify the annual performance report at home and abroad lowers the transaction costs, so more stakeholders can fully understand the financial profitability, the current value of enterprises' assets, and be convenient for enterprises seeking for strategic cooperation. But the provisions of the New Accounting Standard approaching international ones increases the possible to be the impacted by international speculative capital. China's enterprises security is threatened.

5. Conclusion. We can see from the analysis, the New Accounting Standard meets the needs of the corporate governance development in recent years, improves the corporate governance efforts, so these measures must be formed a good impact to reduce credit risk in our country. But we can also see that the New Accounting Standard is a "double-edged sword," it reduces the owner's principal - agent costs, also increases other risks of the enterprise, so that enterprises overall risk becomes indeterminacy. Even so, regulation of business is a great difficulty matter for us, we could not take a new deal by implementing a policy once and for all there.

Therefore, I believe that we should try our best to strengthen the corporate governance. Specifically, we should focus on the following points:

First, we should strengthen financial supervision.Amending the organization rules to enhance internal financial management behavior enable enterprises disclose the difference of enterprise assets value, and its impact on the profit and loss in financial reporting in time.

Second, we should strengthen debt management. Amending the financial management regulations, regular checking accounts together with creditors to strengthen the internal management of transactions, keeping in touch with debt companies and banks to strengthen supervision of the enterprises debt and obtain more real situation of debt.

Third, we should strengthen the monitoring to the ownership structure. We should monitor the changes in shares outstanding specially and take effective measures to prevent the hostile takeover when massive changing in outstanding shares emerges.

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GREY SYSTEM THEORY APPLICATION ON EXCHANGE RATE PREDICTION IN POST-CRISIS ERA

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ABSTRACT. *International financial crisis has brought great influence in economy to every country in the world. After the financial crisis, the factors from many aspect aggregates the uncertainty of Chinese exchange rate. To explore the future changes tendencies of exchange rate exactly, GM (1, 1) model is proposed to predict Chinese exchange rate in short time. Weakening Operator method is applied to improve the prediction accuracy. The results showed that the Grey System model is applicable to predict the change trend of exchange rate with insufficient data and the prediction accuracy is high. Based on the simulation results, the robustness of model is supported. The results also showed exchange rate of RMB to USD is to appreciate.*
Keywords: Grey System Theory; GM (1, 1); Exchange Rate Prediction; Post-Crisis Era

1. Introduction. Since 2008, financial crisis has been spread to total world from USA. The global financial crisis has brought great impact to every country in the world. The Federal Reserve Bank dropt its interest rate sharply and it made the interest rate different between China and the USA increase, which aggravate China's pressure to hold the US foreign exchange. Meanwhile, to reduce the influence of international financial crisis and relieve the internal employment pressure, Europe and the United States exert pressure to make RMB to appreciate. Chinese government carried out corresponding measures, People's Band of China began to adjust the interest rate from 7.20% on Sep 16th in 2008 down to 5.31% on Dec 23rd in 2009. Meanwhile, Chinese government carried out many measures to adjust industry structure, increase internal demand, transfer and absorb the surplus product ability of certain industries. Aiming at the sensitive question of RMB appreciation, Chinese government deepens the exchange rate reform further and People's Bank of China announced to increase the exchange rate elasticity. Under the situation, the historical exchange rate data lacks sufficient support the changes of future exchange rate and the insufficient data can't support the general econometric and statistic models. Furthermore, to recover their own economy, every country in the world carries out all kinds of policies frequently, which increases the uncertainty of exchange rate. The GM (1, 1) model based on grey system theory was proposed by Professor Deng in 1982 and could overcome the weak point that discrete recurrence model couldn't predict the system in long-term periods. Therefore, Grey System model GM (1, 1) is proposed out to predicted future exchange rate of China in short term.

2. Literature Review. Grey system prediction model GM (1, 1) has been widely used in many areas. Related papers were referred to the areas of securities market prediction, mechanical workout prediction and the improvement of grey prediction methodology. In Cai's study, the grey prediction is applied to the prediction of stock trends and is found highly effective on the short-term basis (Cai, 2000). Wang (2002) constructed a data mart to reduce the size of stock data and combined fuzzification techniques with the grey theory to develop a fuzzy grey prediction to predict the possible answer immediately (Wang, 2002). Meanwhile, more literatures focused on the application areas of mechanical workout prediction and the wear prediction of engine. To predict the extent of turning force uncertainty quantitatively, Wang, Peng et al. proposed a fuzzy-grey prediction procedure based on the symmetric fuzzy number, linear planning theory and grey set theory (Wang, Peng et al., 2002). And there was also another study on the control and prediction of cutting force (Lian, et al., 2005). Some scholars applied a gray prediction scheme to eliminate the "chattering" disadvantage of the traditional variable structure control (Chou, 2003). Chang, Zhang et al. (2003) calculated the relationship between wear and blow-by gas and the influence of blow-by gas on the Diesel engine performance (Zhang et al., 2003). Furthermore, the unequal interval revised grey model (UIRGM) (1, 1) is presented in Zhang, Li et al research, and they built the model to fit and predict element concentration as determined by oil spectrometric analysis. The results proved that UIRGM (1, 1) determined the exact turning point, and the fitting and prediction results were acceptable (Zhang, Li et al., 2003). In methodology improvement, many scholars made many significant progresses. Under the proposed methodology, the simulation results were shown to be superior to those systems which exploit complicated control variables and rules (Yo-Ping and Chi-Chang, 1996). Tien (2009) proposed a new prediction model called the deterministic grey dynamic model with convolution integral (DGDMC (1, n)) (Tien, 2009).

Based on the works above, it indicates that there are little applications of Grey System model in economic areas. Generally, the exchange rate fluctuates frequently and there is little information and the freedom of observations is limited, so the traditional regression models can't be applicable to do exchange rate prediction. Therefore, GM (1, 1) model is employed to predict the changes of exchange rate. And Weakening operator method is also applied to improve the prediction accuracy.

3. Methodology and Data.

3.1. Weakening Operator. In this article, Weakening Operator method is applied to improve the prediction accuracy. Therefore, the 1st lag Weakening Operator was drawn in the research to smooth the original data series. And then assume the original sequence is as follows:

$$X^{(0)} = (x^{(0)}(1), x^{(0)}(2), \cdots, x^{(0)}(n)) \tag{1}$$

Then the sequence treated by Weakening Operator can be given as follows:

$$X^{(0)}D = (x^{(0)}(1)d, x^{(0)}(2)d, \cdots, x^{(0)}(n)d) \tag{2}$$

Where $X^{(0)}(k)d$ in equation (2) equals to $\frac{1}{4-k+1}(x^{(0)}(k) + x^{(0)}(k+1) \quad + \cdots + x^{(0)}(n))$ and $k = 1, 2, \cdots, n$. When the sequence of X is monotonic increasing sequence, monotonic decreasing sequence or vibration sequence, D stands for the weakening operator.

3.2. Model GM (1, 1). Grey system prediction model is employed to predict the fluctuation of exchange rate. Grey prediction discovered and got hold of the system development discipline and quantitatively forecasted system future situation scientifically by handling original data with certain methods and building grey prediction model. GM (1, 1) model is usually used to forecast fluctuation sequence. Based on the qualitative analysis, define appropriate sequence operator, use the sequences dealt with certain operators to build GM (1, 1) model. After accuracy test, it could be utilized to predict further. GM (1, 1) model can be built as four following steps.

(1) Making totting-up sequences. Let $X^{(0)}$ be non-negative sequence and it can be composed as follows:

$$X^{(0)} = \left(x^{(0)}(1), x^{(0)}(2), \cdots, x^{(0)}(n)\right) \tag{3}$$

Then $x^{(0)}(k) \geq 0$ and $k = 1, 2, \cdots, n;$ $X^{(1)}$ is the 1-AGO sequence of $X^{(0)}$ which can be expressed as equation (4).

$$X^{(1)} = \left(x^{(1)}(1), x^{(1)}(2), \cdots, x^{(1)}(n)\right) \tag{4}$$

In the equation (4), $x^{(1)}(k)$ equals to $\sum_{i=1}^{k} x^{(0)}(i)$, $k = 1, 2, \cdots, n$. $Z^{(1)}$ is the proximate mean sequence of $X^{(1)}$ and it is given as follows:

$$Z^{(1)} = \left(z^{(1)}(2), z^{(1)}(3), \cdots, z^{(1)}(n)\right) \tag{5}$$

And in equation (5), $z^{(1)}(k) = 0.5\left(x^{(1)}(k) + x^{(1)}(k-1)\right)$ and $k = 2, 3, \cdots, n$. Furthermore, the following equation is called GM (1, 1) model.

$$x^{(0)}(k) + az^{(1)}(k) = b \tag{6}$$

(2) Solving matrix Y and B, and the parameters sequence. In GM (1, 1) model, the matrix Y and B can be given as follows:

$$\text{Y}=\begin{pmatrix} x^{(0)}(2) \\ x^{(0)}(3) \\ \vdots \\ x^{(0)}(n) \end{pmatrix} \text{ and } B = \begin{pmatrix} -z^{(1)}(2) & 1 \\ -z^{(1)}(3) & 1 \\ \vdots & \vdots \\ -z^{(1)}(n) & 1 \end{pmatrix} \tag{7}$$

Then the OLS parameters sequence of GM (1, 1) model can be solved based on the equation (8).

$$\hat{a} = \left(B^T B\right)^{-1} B^T Y = \begin{pmatrix} a \\ b \end{pmatrix} \tag{8}$$

(3) Solving whitenization equation. Whitenization equation in GM (1, 1) model is given as follows:

$$\frac{dx^{(1)}}{dt}+ax^{(1)}=b \tag{9}$$

And the time response sequence of GM (1, 1) in $x^{(0)}(k)+az^{(1)}(k)=b$ is as follows:

$$\hat{x}^{(1)}(k+1)=(x^{(0)}(1)-\frac{b}{a})e^{-ak}+\frac{b}{a} \tag{10}$$

(4) Model error test. The errors of the model can be given as following sequence:

$$\varepsilon^{(0)}=x^{(0)}(1)-x^{(1)}(1),x^{(0)}(2)-x^{(1)}(2),\cdots,x^{(0)}(n)-x^{(1)}(n) \tag{11}$$

The simulation relative error K point is as $\bar{\Delta}=\frac{1}{n}\sum_{k=1}^{n}\Delta_k$, The mean of simulation relative error is $\bar{\Delta}=\frac{1}{n}\sum_{k=1}^{n}\Delta_k$, and the average of accuracy is $1-\bar{\Delta}$.

3.3. Data. The sampling data in the application research is chosen from the exchange data from July 2009 to June 2010 and the sequence is made up by monthly data. The data are from People's Bank of China and the exchange rate of RMB to USD is the middle price at the end of every month. Under the global crisis, the data sequence is in decreasing trend, so the characteristic of the sampling data are applicable to the GM (1, 1) model.

4. Empirical Analysis.

4.1. Data Simulation and Model Test. Based on the original data sequence, the new data sequence of exchange rata of RMB to USD is computed by Weakening Operator method (table 1). Then the original data sequence and the converted data sequence are utilized to predict the further changes of Chinese exchange rate by GM (1, 1) model. Therefore, the basic data in the model is $x_1^{(0)}(k)$ and $k=1,2,\cdots,12$. Furthermore, the procedure of grey system software called "main" is utilized to predict the exchange rate changes.

According to Table 2, the stimulation results, the residual errors and the relative errors are given out. The relative errors of the first 10 stimulation value are very small, which are all below 0.1%. And only the relative error of 11th stimulation result is 0.21%, which can be explained by the big exchange rate changes in June 2010. Then the average relative error is 0.06223%, so the prediction accuracy attains to 99.94%. Combining the accuracy of grey prediction model with the reference level table of accuracy test, the prediction accuracy of weakening operator conversion sequence was the 1st level (Table 3).

Combining the research made by Professor Liu and Deng (2000) with our work, α equals to 0.000348. Therefore, the model GM (1, 1) could do medium-term or long-term prediction. And our destination is to explore the medium-term change tendencies of Chinese exchange rate, so the future 6 months exchange rates are to be predicted.

TABLE 1. The original and the converted exchange rate data of RMB to USD

Month	Original data	Weakening Operator data
Jul-2009	6.8323	6.8251
Aug-2009	6.8312	6.8245
Sep-2009	6.8290	6.8238
Oct-2009	6.8281	6.8232
Nov-2009	6.8272	6.8226
Dec-2009	6.8282	6.8219
Jan-2010	6.8270	6.8209
Feb-2010	6.8269	6.8197
Mar-2010	6.8263	6.8179
Apr-2010	6.8263	6.8151
May-2010	6.8280	6.8095
Jun-2010	6.7909	6.7909

Data source: The data is from People's Bank of China and the Weakening Operator data sequence is computed based on its definition in equation (2).

TABLE 2. The stimulation result, residual error and relative error

Month	Stimulation Result	Residual Error	Relative Error
Aug-2009	6.8291	0.0046	0.07%
Sep-2009	6.8268	0.0030	0.04%
Oct-2009	6.8244	0.0012	0.02%
Nov-2009	6.8220	-0.0006	-0.01%
Dec-2009	6.8196	-0.0023	-0.03%
Jan-2010	6.8173	-0.0036	-0.05%
Feb-2010	6.8149	-0.0048	-0.07%
Mar-2010	6.8125	-0.0054	-0.08%
Apr-2010	6.8102	-0.0049	-0.07%
May-2010	6.8078	-0.0017	-0.03%
Jun-2010	6.8054	0.0145	0.21%

Data source: The data in table 2 is arrange from the predict result of Grey System model.

TABLE 3. The reference level table of accuracy test

Accuracy Level	Relative Error	Degree of Correlation	Unbiased Variance Ratio	Small Error Probability
1st level	0.01	0.90	0.35	0.95
2nd level	0.05	0.80	0.50	0.80
3rd level	0.10	0.70	0.65	0.70
4th level	0.20	0.60	0.80	0.60

Notes: The data is from Liu, Dang and Fang (2004). Grey system theory and its application, pp.164.

TABLE 4. The predicted results by grey system model GM (1, 1)

Month	Jul-2010	Aug-2010	Sep-2010	Oct-2010	Nov-2010	Dec-2010
Predicted Result	6.8031	6.8007	6.7983	6.7960	6.7936	6.7912

4.2. Exchange Rate Prediction. Grey system software is utilized to analyze the changes of exchange rate with the data in table 1. Firstly, the time response function is computed by

$$x\,(k+1)=-19628.602952\exp(-0.000348*k)+19635.428052 \quad (12)$$

Then the prediction results show that the exchange rate appears to be decreasing trend. Up to Dec 2010, the prediction results are to be respectively as these in table 4.

5. Conclusion. Based on the prediction process and the results, the GM (1, 1) model is applicable to predict the changes of exchange rate which is of fluctuation characteristic and it has more advantages that general econometric and statistic models. Firstly, from the stimulation errors, the relative errors are very small. In the research, it is smaller than 1%. Secondly, from angel of the model accuracy, the prediction accuracy is high and it attains to 99.94%, which makes the accuracy of the GM (1, 1) model get to 1^{st} level. Therefore, employ GM (1, 1) model to explore the change tendencies of exchange rate can assure the prediction accuracy. Thirdly, the change trend of exchange rate is in line with the original situation. Finally, the exchange rate is going to go down in the prediction results, which meets the situations nowadays. Therefore, RMB is going to appreciate and it can give instructions to investors and the government in its macro economy policies making.

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EFFICIENCY AND SATISFACTION EVALUATION FOR PUBLIC CHIANG MAI HEALTH CARE SYSTEM

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ABSTRACT. *This study focuses on patients' satisfaction with primary health care services and the public health system for communities at Chiang Mai province. To accomplish the objective, we use the ordered probit model to estimate patients' satisfaction with community based services. We find that the higher in marital status such as education, career and spending of health care services, the higher degree of satisfaction in health care services. While, the increase in frequency of treatment of patient demonstrate low degree of the satisfaction of health care. Moreover, patients who live in rural areas exhibit the higher degree of satisfaction on health care than patients who live in city. Finally, cost of treatment should be examined in future studies within community based health services.*

Keywords: Ordered Probit Model; Chiang Mai Health Care; Satisfication

1. Introduction. In 2001, the Government of Thailand launched the universal health care coverage (UC) scheme, which is also known as the "30 baht health care scheme" with the aim of ensuring equitable health care access. The insured patients are all of the people who were not in any health scheme and whose names are in the house registrations in those provinces. These people would receive the universal health card or the gold card. This card must show consistency with the individual's identification card every time they access the health services, which are the government health services or the private sector health services registered with this project. The accessing health service has to follow the referral system from the primary health center or the nearby hospital, which are registered under the project. For emergencies and accidents, the insured can access any government health services. To access needy health services under universal coverage policy, the insured patients will receive the same quality health services as offered by other health schemes. This study focuses on patient satisfaction as a measure of value in the provision of community based health care services under 30 baht health care scheme. Does the public health scheme be successful in making treatment widespread? Patient satisfaction with health care is dependent on the interaction of patient and the health care system (Swan, 1992; Riley, 1994). Researchers who empirically examined consumer satisfaction with health care suggested that satisfaction is influenced by aspects of care that are specific to the health care experience (Abramowitz et al., 1987; Cleary and McNeil, 1988; Russell, 1990; Strasser et al., 1993; Ware and Synder, 1975; Woodside et al., 1980), and that consumer are able to form summary measures of their satisfaction based on their satisfaction with components of care (Aharony and Strasser, 1993; Kolodinsky, 1997; Luft, 1981; Strasses et al., 1993). Some researchers focused specifically on the process of health care delivery (distinct from the physical outcome) as being a major influence on consumer perceptions of satisfaction with medical services (Buller and Buller, 1987; Street and Wiemann, 1987; Woolley et al., 1978). Swan (1992) suggested that the formation of patient satisfaction perceptions is based on a reciprocal process that is influenced by both the consumer and provider of medical services. This is an extension of the expectation/disconfirmation model (Cardozo, 1965; Oliver, 1989), and is complementary to the work of Woodruff et al. (1983) who assert that consumers develop a set of experience based norms on which they judge whether expectations are disconfirmed. It is Swan's (1992) proposition that "patient expectations and standards for performance are negotiated as health care providers attempt to change unrealistic patient expectations/performance standards".

2. Research Objective. The objective of the study is to evaluate patients' satisfaction with primary health care services or public health scheme for communities at Chiang Mai province.

3. Scope of This Research. The scope of this research focuses on patients for those living in rural areas have the lowest and the highest levels of satisfaction with care and ease of using health care services among parents in hospitals in Chiang Mai. Patient satisfaction surveys were conducted for purposes to improve the quality of public health care services during period of 2009-2010.

4. The Research Framework and Methodology.

4.1. The Health Care Satisfaction Model (Kolodinsky and Shirey, 1999). The Health Care System Satisfaction Model (HCSS) is function of Demographic Factors (DF), Economic Factors (EF) and Satisfaction-Continuous(SC), (see equation (1))

$$HCSS = HCSS\ (DF, EF, SC) \qquad (1)$$

Thus, the set of explanatory variables used in their basic model includes the Demographic Factors (DF are Sex, Age, Marital status, Education and Residence. The Economic Factors (EF) represents Career, Income and spending of public health care system. And the Satisfaction-Continuous (SC) represents the frequency of treatment.

4.2. Modified Ordered Probit Model to HCSS Model. The Health Care System Satisfaction Model (HCSS) be able to define that Y is the outcome of Health Care System Satisfaction. And the first outcome (Y = 0 or Y=1) it is meaning that "strong disagree in health care system satisfaction" and the last outcome (Y=J) it is also meaning that "strong agree in health care system satisfaction". In addition, X is independent variables in model such as the demographic factors (DF), the economic factors (EF) and the satisfaction - continuous (SC) (see more detail in below formula).

$$Y_{it}^{*} = x_{it}^{/}\beta + \varepsilon_{it}$$

$$Y_{it} = 0 \ \ if \ \ y_{it}^{*} \le 0; \ \ prob[y_{it} = 0] = \Phi[-x_{it}^{/}\beta]$$

$$Y_{it} = 1 \ \ if \ \ 0 < y_{it}^{*} \le \mu_1; \ \ prob[y_{it} = 1] = \Phi[\mu_1 - x_{it}^{/}\beta] - \Phi[-x_{it}^{/}\beta]$$

$$Y_{it} = 2 \ \ if \ \ \mu_1 < y_{it}^{*} \le \mu_2; \ \ prob[y_{it} = 2] = \Phi[\mu_2 - x_{it}^{/}\beta] - \Phi[\mu_1 - x_{it}^{/}\beta]$$

$$\cdots\cdots\cdots\cdots$$

$$Y_{it} = J \ \ if \ \ y_{it}^{*} > \mu_{J-1}; \ \ prob[y_{it} = J] = 1 - \Phi[\mu_{J-1} - x_{it}^{/}\beta]$$

5. Results of Research.

5.1. The Results of Research in the Health Care Services Satisfaction. Table 1 reports the results of the ordered probit estimation of the health care services satisfaction. Patient respondents are provided interpretation services based on their implied preference. And some explanatory variables are significantly different from zero or a statistically significant relationship between 5% and 1% significance level. The signs of the estimated coefficients are only directly informative for the probabilities associated with the first (strongly disagree in the health care services satisfaction), the last choice outcome (strongly agree in the health care services satisfaction) and the cumulative probabilities. The results show that the marital status of patient, the education of patient, the career of patient respondents and the spending of health care services of patient respondents have a positive impact on the probability of health care services satisfaction. There is evidence that, the probability of health care services satisfaction is higher for those explanatory variables. Otherwise, the frequency of treatment of patient respondents has negative impact to health care services satisfaction and implies that the probability of health care services satisfaction would be decreased after the patient respondents receive more frequent hospitalizations.

In ordered probit estimation the explanatory variables are tested to determine which might be able to derive more information from the estimated coefficients. Table 2 presents the derivatives of the five probabilities for a selection of important explanatory variables. These derivatives are calculated at the sample means of the independent variables. There is evidence that a marginal increase in marital status, education, career and spending of health care services increases the probabilities of satisfaction with care and ease of using health care services among patient respondents. Otherwise, it is also clear that marginal increase in frequency of treatment of patient respondents decrease in the probabilities of health care services satisfaction.

TABLE 1. Ordered probit estimation result of health care services satisfaction

Variables	Coefficient	Std. Error	z	P>|z|
Sex	0.0193875	0.1011217	0.19	0.848
Age	-0.0318234	0.0377932	-0.84	0.400
Marital status	0.1659114***	0.0828839	2.00	0.045
Education	0.0938357**	0.0499373	1.88	0.060
Residence	0.0008671	0.1042445	0.01	0.993
Career	0.0694304***	0.0211078	3.29	0.001
Income	0.0013449	0.0442223	0.03	0.976
frequency of treatment	- 0.1206866***	0.0523677	-2.30	0.021
Spending of Health care services	0.0757689**	0.0424923	1.78	0.075
µ1	-2.48337	.4872903		
µ2	-1.178380	0.372488		
µ3	-0.750961	0.367072		
µ4	0.3576086	0.3652645		
Number of obs	595			
LR chi2(9)	34.26			
Prob > chi2	0.0001			
Log likelihood	-541.37235			

From: Computed
* denotes statistical significance at the 10 percent level,
** denotes statistical significance at the 5 percent level and
*** denotes statistical significance at the 1 percent level

TABLE 2. Marginal effects after ordered probit estimation of health care services satisfaction

Variables	$\frac{\partial \Pr(Y_i=0)}{\partial x_i^j}$	$\frac{\partial \Pr(Y_i=1)}{\partial x_i^j}$	$\frac{\partial \Pr(Y_i=2)}{\partial x_i^j}$	$\frac{\partial \Pr(Y_i=3)}{\partial x_i^j}$	$\frac{\partial \Pr(Y_i=4)}{\partial x_i^j}$
Marital status	-0.0004741 (-0.86)	-0.0117519** (-1.91)	-0.0122521** (-1.91)	-0.038762*** (-1.97)	0.06324** (2.00)
Education	-0.0002681 (-0.86)	-0.006646** (-1.81)	-0.0069295** (-1.78)	-0.0219229** (-1.86)	0.0357671** (1.88)
Career	-0.0001984 (-0.92)	-0.004917*** (-2.90)	-.0051272*** (-2.87)	-0.0162211*** (-3.18)	0.0264646*** (3.29)
The frequency of treatment	0.0003448 (0.90)	0.0085485*** (2.18)	0.0089123*** (2.13)	0.0281961*** (2.26)	-0.0460018*** (-2.30)
Spending of Health care services	-0.0002165 (-0.85)	-0.005366** (-1.72)	-0.0055953*** (-1.71)	-0.017702*** (-1.76)	0.0288807** (1.78)

From: Computed
** denotes statistical significance at the 5 percent level and
*** denotes statistical significance at the 1 percent level

Table 3 shows that the predicted outcome corresponds with the observed three for 9 (or 5.114% is correctly to predict). The majority of patient respondents in the sample seem to be a fairly good result: a rule which assigns all patients to the outcome with the highest number of observations (outcome 4), would correctly to predict is 98.09% of the outcomes. However, this model is able correctly to predict is 62.01% and also this model is not able correctly to predict is 37.98%.

TABLE 3. Prediction result of ordered probit estimation based on estimated equation of health care services satisfaction

Dep. Value	Obs.	Correct	Incorrect	% Correct	% Incorrect
0	1	0	1	0.000	100.000
1	23	0	23	0.000	100.000
2	28	0	28	0.000	100.000
3	176	9	167	5.114	94.886
4	367	360	7	98.093	1.907
Total	595	369	226	62.017	37.983

From: Computed

TABLE 4. Ordered probit estimation result of health care products satisfaction

Variables	Coefficient	Std. Error	z	P>|z|
Sex	-0.038717	0.094334	-0.410421	0.6815
Age	-0.052492	0.034530	-1.520183	0.1285
Marital status	0.120547*	0.074556	1.616865	0.1059
Education	0.132331**	0.046939	2.819227	0.0048
Residence	0.168888**	0.095943	1.760298	0.0784
Career	0.018381	0.019522	0.941572	0.3464
Income	-0.061621	0.041213	-1.495189	0.1349
The frequency of Treatment	0.101203***	0.048346	2.093292	0.0363
Spending of Health care services	0.026315	0.038475	0.683938	0.4940
$\mu 1$	-1.968642	0.414077		
$\mu 2$	-1.326374	0.356685		
$\mu 3$	-0.182235	0.338707		
$\mu 4$	1.087800	0.340289		
Number of obs	595			
LR chi2(9)	23.40			
Prob > chi2	0.0054			
Log likelihood	-639.72288			

*, **, *** denotes statistical significance at the 10,5 AND1 percent level,

5.2. The Results of Research in the Health Care Products Satisfaction. Table 4 reports the results of the ordered probit estimation of the health care products satisfaction. And some explanatory variables are significantly estimated at 10% and 1% significance level. The signs of the estimated coefficients are only directly informative for the probabilities associated with the first (strongly disagree in the health care products satisfaction), the last choice outcome (strongly agree in the health care products satisfaction) and the cumulative probabilities. From this table show that the Marital status, education of patient, the residence of patient and the frequency of treatment of patient have a positive probability impact to health care products satisfaction. It is clear that, the probability of health care products satisfaction is higher for those explanatory variables.

TABLE 5. Marginal effects after ordered probit estimation of health care products satisfaction

Variables	$\frac{\partial \Pr(Y_i = 0)}{\partial x_i^j}$	$\frac{\partial \Pr(Y_i = 1)}{\partial x_i^j}$	$\frac{\partial \Pr(Y_i = 2)}{\partial x_i^j}$	$\frac{\partial \Pr(Y_i = 3)}{\partial x_i^j}$	$\frac{\partial \Pr(Y_i = 4)}{\partial x_i^j}$
Marital status	-0.0010315 (-1.11)	-0.0039471 (-1.46)	-0.0246095 * (-1.61)	-0.0165971 (-1.57)	0.0461852* (1.62)
Education	-0.0011323 (-1.36)	-0.0043329*** (-2.19)	-0.027015 *** (-2.75)	-0.0182194*** (-2.62)	0.0506997*** (2.82)
Residence	-0.0014451 (-1.14)	-0.0055299 (-1.55)	-0.0344781** (-1.75)	-0.0232526** (-1.70)	0.0647058** (1.76)
Frequency of Treatment	-0.000866 (-1.20)	-0.0033137** (-1.76)	-0.0206605 *** (-2.09)	-0.0139338*** (-2.00)	0.038774*** (2.09)

*, **, *** denotes statistical significance at the 10,5 AND1 percent level,

TABLE 6. Prediction result of ordered probit estimation based on estimated equation of health care products satisfaction

Dep. Value	Obs.	Correct	Incorrect	% Correct	% Incorrect
0	2	0	2	0.000	100.000
1	9	0	9	0.000	100.000
2	89	0	89	0.000	100.000
3	263	192	71	73.004	26.996
4	232	116	116	50.000	50.000
Total	595	308	287	51.765	48.235

Table 5 also presents the derivatives of the five probabilities for a selection of important explanatory variables. These derivatives are calculated at the sample means of the independent variables. There is evidence that a marginal increase in marital status, education, residence of patient and frequency of treatment increases the probabilities of satisfaction in health care products satisfaction.

Table 6 shows that the predicted outcome corresponds with the observed three for 192 (or 73% is correctly to predict) of patient respondents in the sample seem to be a fairly good result: a rule which assigns all respondents to the outcome with the highest number of observations (outcome 4), would be correctly to predict is 50 % of the outcomes. However, this model is able correctly to predict is 51.76% and also this model is not able correctly to predict is 48.23%.

6. The Conclusions of Research. To accomplish the objective of this study, the statistical analysis technique was used. The ordered probit model attempts to investigate the public health scheme be successful in making treatment widespread. Data used to accomplish the objective of this study were obtained from 595 patient respondents as the members of the public health care system in Chiang Mai. Finally, the ordered probit analysis provided a very useful tool in evaluating patients' satisfaction with primary both health care services and health care products. Patients' satisfaction with primary both health care services and health care products will be in testified. The ordered probit model can help a particular community determine if it has improved its community based health system. The analysis suggests that patient respondents in several communities in Chiang Mai province have benefited from the expansion of community based health system. The results do provide the basis for to estimate patients' satisfaction with community based both health care services and health care products. However, the results do suggest that community based public health system should continue to expand in Chiang Mai province.

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ENVIRONMENTAL CONSTRAINTS AND INDUSTRIAL TOTAL FACTOR PRODUCTIVITY GROWTH

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ABSTRACT. *This paper aims to study the effect of the "bad output" environmental pollution on industrial total factor productivity growth by the Malmquist-Luenberger index. Empirical study finds that ignoring environmental factors will underestimate the technical efficiency level and technical efficiency index, but it will overestimate the technological progress index and total factor productivity index, and discovers that total factor productivity index of most industrial sectors is falling after considering environmental factors.*
Keywords: Total Factor Productivity; Environmental Constraints; Malmquist-Luenberger Index

1. Introduction. We know that industrial sector is a pillar industry for China’s economic development. The average proportion of industrial GDP for the past few years has come to more than 40% .However, the quality of growth of China's industry has been challenged since the reform and opening up. The extensive growth mode which depends on “high investment, high cost and low efficiency” is paid for a huge cost of resources and environment. Ecological environment destruction and pollution have seriously restricted the economic and social sustainable development. The economic impact on china from international financial crisis since 2008 is fundamentally due to unreasonable pattern of economic development. And the 2009 World Climate Conference in Copenhagen warns us once again, that it is very urgent to translate the extensive growth mode to the intensive growth mode.

The new classical theory of economic growth thinks that productivity growth is the only source of sustainable economic growth. Total factor productivity growth of industry has accumulated a lot of research literature, and this kind of literature can mainly be summarized as two respects: one of them is studying total factor productivity growth from the perspective of the province, such as Wang (2006); Liu and Li (2009); Tu (2007). The other one is studying total factor productivity growth from the perspective of industrial segmentation, such as Gan and Zheng (2009), Li and Li (2008), Zhu and Li (2005), Tu and Xiao (2005), Li et al. (2008).

The literature above mainly used the method of DEA and SFA to have an empirical analysis for industrial total factor productivity in China, and come to a lot of significant conclusions. But these studies only considered the "good" output and ignored the "bad" output in the process of environmental pollution. In fact, industry is the major source of environmental pollution in our country. Ecological environment destruction and pollution have seriously restricted the economic and social sustainable development. Given environmental pollution could cause the consequences, "bad output" should be considered when we will study total factor productivity of industrial department.

In this paper, we will consider the environmental pollution as the “bad” output when studying total factor productivity of subdivision industry, measuring the industrial total factor productivity growth with Malmquist-Luenberger index, analyzing the effect of the environmental constraints on total factor productivity. This study has very important and practical significance to evaluate and analyze the industrial total factor productivity growth in china, and try to discover the necessity for government regulation on the environment by comparing the case considering “bad output” to the other case ignoring that.

2. Introduction to Method and Model. Chung et al. (1997) proposed ML index basing on Directional Distance Function when he assessed the productivity of pulp mill in Swedish. This index considers both good outputs and bad outputs .Examples include farms that generate pesticide runoffs into rivers and streams, and electric utility plants that produce sulfur dioxide (SO2).Now the ML index has been usually employed by the researchers (Chung et al., 1997; Fare et al., 2001; Lindmark et al., 2003; Jeon and Sickles, 2004; Lindenberge (2004); Domazlicky and Weber, 2004; Yoruk and Zaim, 2005; Kumar, 2006; Ke, 2008; Wang, 2008; Yang, 2009; Wu, 2009). In this section, we model that aspect of the technology according to the industrial sectors in China.

To be formal, let us denote the good outputs by $y=(y_1,\cdots,y_M)\in R_M^+$,the bad or undesirable outputs as $b=(b_1,\cdots,b_I)\in R_I^+$ and inputs by $x=(x_1,\cdots,x_N)\in R_N^+$.We can then describe the technology via its output sets:

$$P(x)=\{(y,b):x \quad can \quad produce(y,b)\}, x\in R_N^+$$

We model the idea that it is costly to reduce the bad outputs by imposing the assumption that good and bad outputs are together weakly disposable , that is,

$$(y,b)\in P(x) \text{ and } 0\le\theta\le 1 \text{,imply } (\theta y,\theta b)\in P(x) \tag{1}$$

This condition allows for the reduction of the bad outputs when accompanied by a simultaneous reduction in the good outputs ,that is ,abatement uses resources that otherwise could have been used to expand production of the good output. This allows us to avoid the production of explicitly modeling abatement activities that requires imposing separability between good and bad output production.

In addition to weak disposability ,we assume that good outputs may be reduced without the reduction of the bad outputs .This involves assuming that the good outputs are freely disposable, that is ,

$$(y,b)\in P(x) and y'\le y \text{ imply} (y',b)\in P(x) \tag{2}$$

Equations (1) and (2) model the asymmetry between the good (freely disposable) and bad (not freely disposable) outputs. Finally, we model the idea that no good outputs can be produced unless some of the bad outputs are also produced. This idea is termed null-jointness and it is defined as

$$\text{If } (y,b) \in P(x) \text{ and } b = 0 \text{, then } y = 0 \tag{3}$$

Equation (3) means that no bad outputs are produced (b=0) only if none of the good output is produced (y=0), that is, if some good outputs are produced then some bad outputs must also be produced.

When the above conditions are satisfied, we assume that for each period $t = 1, \cdots, T$, there are $k = 1 \cdots K$ observations of inputs and outputs, $(x^{k,t}, y^{k,t}, b^{k,t})$, the z_k^t are the weights assigned to each observation when constructing the production set. Using this data, we can construct output sets that satisfy equation(1)-(3), namely

$$P^t(x^t) = \{(y^t, b^t) : \sum_{k=1}^{K} z_k^t y_{km}^t \geq y_{km}^t, m = 1, \cdots, M; \sum_{k=1}^{K} z_k^t b_{ki}^t = b_{ki}^t, i = 1, \cdots, I; \tag{4}$$
$$\sum_{k=1}^{K} z_k^t x_{kn}^t \leq x_{kn}^t, n = 1, \cdots, N; z_k^t \geq 0, k = 1, \cdots, K\}$$

By imposing the conditions

$$\sum_{k=1}^{K} b_{ki}^t > 0 \quad \text{i=1,...,I} \tag{5}$$

$$\sum_{i=1}^{I} b_{ki}^t > 0 \quad \text{k=1,…,K} \tag{6}$$

The good and bad outputs are null-joint .Condition (5) states that every bad output is produced by some segment k, and (6) states that every segment k produces at least one bad output.

Directional distance functions are our vehicles in defining and measuring productivity. The directional output distance function credits reduction of bad and expansion of goods. In contrast, Shephard's(1970) output distance function seeks to increase good and bad outputs simultaneously.

Let $g = (g_y, g_b)$ be a direction vector, then the directional distance function is given by

$$\vec{D}_o(x, y, b; g_y; -g_b) = \sup\{\beta : (y + \beta g_y, b - \beta g_b) + \beta g \in P(x)\} \tag{7}$$

In this case, the good and bad outputs are treated asymmetrically. β is the maximum feasible expansion of the desirable outputs and contraction of the undesirable outputs when the expansion and contraction are identical proportions for a given level of inputs.

We illustrate the two distance functions in Figure 1.Shephard's distance function radially scales the original vector from point A(y , b), proportionally, that is,($y/\theta, b/\theta$) to point C. The more general directional distance function takes the same output vector from A to B, that is, in the direction of $g = (g_y, -g_b)$. At the point B on the output set P(x), the output vector is $\left(y^t + \beta^* g_y, b^t - \beta^* g_b\right)$ where $\beta^* = \vec{D}_0^t(x^t, y^t; g_y, -g_b)$, that is , $\beta^* g_b$ has been added to the good output y^t and $\beta^* g_b$ has been subtracted from the bad output b^t.

For feasible output vectors, the directional distance function $\vec{D}_0^t(x^t, y^t, b^t) \geq 0$ and it equal zero if and only if the observation vector (y, b) is on the production possibilities frontier. At the same time environment technology efficiency (ETE) is 1.

$$ETE = \frac{1}{1+\vec{D}_o^t(x^{t,k'}, y^{t,k'}, b^{t,k'}; y^{t,k'}, -b^{t,k'})} \tag{8}$$

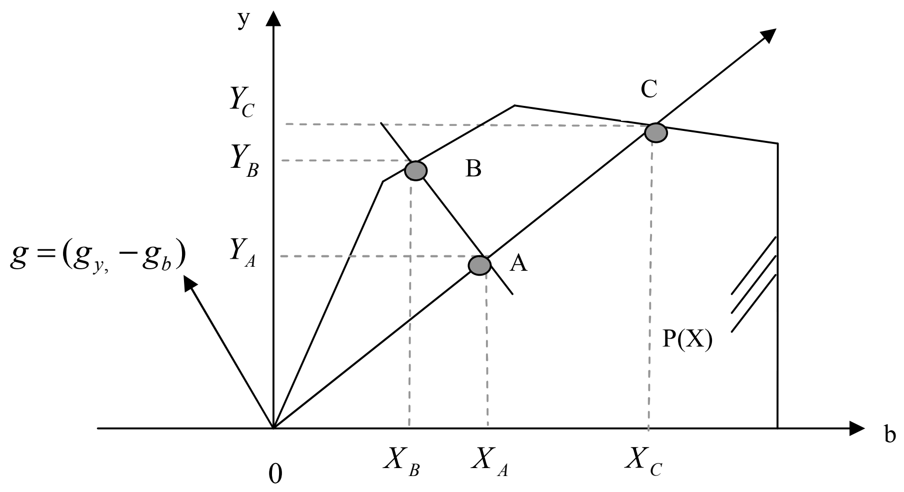

FIGURE 1. Shephard's distance function and the directional distance function

Using directional distance functions, we define the Malmquist-Luenberger(ML) Index as the geometric means of the technology of period t and t+1 as the reference technology . Following Chung et al. (1997), ML index can be decomposed into a technical change (TECH) and a change in efficiency component (EFFCH).

TECH measures the geometric mean of the shift in the production possibilities frontier. If a TECH index equals unity, this indicates that there was no shift in the production possibilities frontier. Shifts of the production possibilities frontier in the direction of "more goods and fewer bads" results in the value of the TECH index exceeding unity. A TECH index value of less than unity indicates a shift of the production possibilities frontier in the direction of "fewer goods and more bads".

EFFCH measures the change in output efficiency between the two periods. If EFFCH equals unity, it indicates that a producer is the same distance from the frontier in period t+1 as it was in period t. If EFFCH exceeds unity, it indicates that a producer is closer to the frontier in period t+1 than it was in period t. If EFFCH is less than unity, it indicates that a producer is further from the frontier in period t+1 than it was in period t.

$$\begin{aligned} ML_t^{t+1} &= \left\{ \frac{[1+\vec{D}_o^t(x^t, y^t, b^t; g^t)]}{[1+\vec{D}_o^t(x^{t+1}, y^{t+1}, b^{t+1}; g^{t+1}]} \times \frac{[1+\vec{D}_o^{t+1}(x^t, y^t, b^t; g^t)]}{[1+\vec{D}_o^{t+1}(x^{t+1}, y^{t+1}, b^{t+1}; g^{t+1})]} \right\}^{\frac{1}{2}} \\ &= \frac{1+\vec{D}_o^t(x^t, y^t, b^t; g^t)}{1+\vec{D}_o^{t+1}(x^{t+1}, y^{t+1}, b^{t+1}; g^{t+1})} \times \left\{ \frac{[1+\vec{D}_o^{t+1}(x^t, y^t, b^t; g^t)]}{[1+\vec{D}_o^t(x^t, y^t, b^t; g^t)]} \times \frac{[1+\vec{D}_o^{t+1}(x^{t+1}, y^{t+1}, b^{t+1}; g^{t+1})]}{[1+\vec{D}_o^t(x^{t+1}, y^{t+1}, b^{t+1}; g^{t+1}]} \right\}^{\frac{1}{2}} \\ &= EFFCH \times TECH \end{aligned} \tag{9}$$

The directional distance functions can be calculated as solutions to linear programming (LP) problems. Four LP problems must be solved, two LP problems are solved in which all of the observations are from the same period, there are also two mixed period LP problems as the follows:

$$\vec{D}_0^t(x^{t,k'},y^{t,k'},b^{t,k'};y^{t,k'},-b^{t,k'})=\max\beta$$
$$s.t.\ \sum_{k=1}^{K} z_k^t y_{km}^t \geq (1+\beta)y_{k'm}^t, m=1,2,...,M$$
$$\sum_{k=1}^{K} z_k^t b_{ki}^t = (1+\beta)b_{k'i}^t, i=1,2,...,I$$
$$\sum_{k=1}^{K} z_k^t x_{kn}^t \leq x_{k'n}^t, n=1,2,...,N$$
$$z_k^t \geq 0, k=1,...,K$$

$$\vec{D}_0^{t+1}(x^{t+1,k'},y^{t+1,k'},b^{t+1,k'};y^{t+1,k'},-b^{t+1,k'})=\max\beta$$
$$s.t.\ \sum_{k=1}^{K} z_k^{t+1} y_{km}^{t+1} \geq (1+\beta)y_{k'm}^{t+1}, m=1,2,...,M$$
$$\sum_{k=1}^{K} z_k^{t+1} b_{ki}^{t+1} = (1+\beta)b_{k'i}^{t+1}, i=1,2,...,I$$
$$\sum_{k=1}^{K} z_k^{t+1} x_{kn}^{t+1} \leq x_{k'n}^{t+1}, n=1,2,...,N$$
$$z_k^{t+1} \geq 0, k=1,...,K$$

$$\vec{D}_0^{t+1}(x^{t,k'},y^{t,k'},b^{t,k'};y^{t,k'},-b^{t,k'})=\max\beta$$
$$s.t.\ \sum_{k=1}^{K} z_k^{t+1} y_{km}^{t+1} \geq (1+\beta)y_{k'm}^t, m=1,2,...,M$$
$$\sum_{k=1}^{K} z_k^{t+1} b_{ki}^{t+1} = (1+\beta)b_{k'i}^t, i=1,2,...,I$$
$$\sum_{k=1}^{K} z_k^{t+1} x_{kn}^{t+1} \leq x_{k'n}^t, n=1,2,...,N$$
$$z_k^{t+1} \geq 0,\quad k=1,...,K$$

$$\vec{D}_0^t(x^{t+1,k'},y^{t+1,k'},b^{t+1,k'};y^{t+1,k'},-b^{t+1,k'})=\max\beta$$
$$s.t.\ \sum_{k=1}^{K} z_k^t y_{km}^t \geq (1+\beta)y_{k'm}^{t+1}, m=1,2,...,M$$
$$\sum_{k=1}^{K} z_k^t b_{ki}^t = (1+\beta)b_{k'i}^{t+1}, i=1,2,...,I$$
$$\sum_{k=1}^{K} z_k^{t+1} x_{kn}^{t+1} \leq x_{k'n}^t, n=1,2,...,N$$
$$z_k^t \geq 0, k=1,...,K$$

3. Data and Results.

3.1. Description of Data. In order to ensure statistical coverage compatible, this paper uses the "good" output and the "bad" output, capital input and labor input of 36 industrial sub-sectors with all state and non-state industrial enterprise from 2001 to 2008 in China. All data are from "China statistical yearbook" from 2002 to 2009.

The "good" output is specified by Gross Domestic Product. In order to eliminate the influence of inflation, we calculate the real GDP on the base year of 2001. The "bad" output is specified by discharges of sulfur dioxide (SO2). The number of labor force is calculated by total employed persons at the year-end. The number of capital input is calculated by Annual Average Balance of Net Value of Fixed Assets.

3.2. Empirical Analysis. Table 1 lists the mean of industrial technical efficiency from 2001 to 2008 with two kinds of cases .Case 1 means the consideration of environmental factors and case 2 do not take into account environmental factors (the same below). Comparing case 1 to 2, the study finds that the mean of industrial technical efficiency with case 1 (0.52) is greater than with case 2(0.38), and for every year, the technical efficiency with case 1 is always greater than with case 2.

Table 2 shows the total factor productivity index and its decompositions from 2001 to 2008. The results of case 1 include that the average annual growth rate of China's industrial total factor productivity from 2001 to 2008 is 11.1%, the average annual growth of technological progress is 10.4%, and the average annual increase of technical efficiency is 0.6%. The results of case 2 include that the average annual growth rate of China's industrial total factor productivity from 2001 to 2008 is 12.1%, the average annual growth of technological progress is 16.7%, and the average annual decrease of technical efficiency is 3.9%.Total factor productivity indexes under two kinds of cases are always greater than 1. This indicates China's industrial economic development mode shows some improvement. And the contribution rate of technological progress is more than 90% for the growth of total factor productivity.

TABLE 1. Mean technical efficiency of 36 sectors (2001 – 2008)

	2001	2002	2003	2004	2005	2006	2007	2008
Case 1	0.54	0.49	0.50	0.50	0.51	0.53	0.54	0.55
Case 2	0.39	0.33	0.33	0.34	0.34	0.33	0.30	0.28

TABLE 2. Total factor productivity index and its decompositions (2001-2008)

Time	index of technical efficiency		index of technical progress		index of total factor productivity	
	Case 1	Case 2	Case 1	Case 2	Case 1	Case 2
2001- 2002	0.90	0.85	1.22	1.31	1.10	1.12
2002- 2003	1.03	0.99	1.09	1.17	1.13	1.16
2003- 2004	1.01	1.06	1.10	1.11	1.11	1.17
2004- 2005	1.02	1.00	1.05	1.09	1.07	1.09
2005- 2006	1.03	0.99	1.07	1.11	1.10	1.10
2006- 2007	1.03	0.91	1.15	1.26	1.19	1.15
2007- 2008	1.02	0.95	1.06	1.13	1.08	1.08
mean	1.01	0.96	1.10	1.17	1.11	1.12

TABLE 3-1. Total factor productivity index of 36 industrial sectors and their decompositions (2001-2008)

Sector	index of technical efficiency		index of technical progress		index of total factor productivity	
	Case 1	Case 2	Case 1	Case 2	Case 1	Case 2
H1	1.01	0.99	1.12	1.17	1.13	1.16
H2	1	0.92	1.08	1.19	1.08	1.08
H3	1	0.99	1.1	1.17	1.1	1.16
H4	1.01	1.03	1.1	1.17	1.11	1.2
H5	1.02	1.04	1.11	1.17	1.14	1.21
H6	0.98	0.96	1.1	1.17	1.07	1.12
H7	0.96	0.94	1.11	1.17	1.07	1.1
H8	0.98	0.96	1.11	1.17	1.08	1.12

TABLE 3-2. Total factor productivity index of 36 industrial sectors and their decompositions (2001-2008)

Sector	index of technical efficiency		index of technical progress		index of total factor productivity	
	Case 1	Case 2	Case 1	Case 2	Case 1	Case 2
H9	1	1	1.1	1.18	1.1	1.18
H10	0.97	0.94	1.11	1.17	1.07	1.1
H11	0.97	0.9	1.08	1.17	1.05	1.05
H12	0.98	0.93	1.09	1.17	1.06	1.08
H13	1	0.99	1.11	1.17	1.11	1.15
H14	1.02	0.92	1.08	1.17	1.1	1.07
H15	0.95	0.93	1.12	1.17	1.07	1.09
H16	1.02	0.92	1.09	1.17	1.11	1.07
H17	1.02	0.89	1.11	1.17	1.13	1.04
H18	0.97	0.96	1.12	1.19	1.09	1.13
H19	0.98	0.98	1.12	1.17	1.1	1.14
H20	0.95	0.91	1.11	1.17	1.05	1.06
H21	1	0.99	1.13	1.18	1.13	1.17
H22	0.97	0.94	1.11	1.17	1.08	1.1
H23	0.98	0.94	1.09	1.17	1.07	1.1
H24	0.97	0.95	1.12	1.17	1.08	1.11
H25	0.99	0.99	1.11	1.16	1.11	1.15
H26	1	1	1.11	1.17	1.11	1.17
H27	0.99	0.95	1.11	1.17	1.1	1.11
H28	1.02	0.96	1.11	1.17	1.13	1.12
H29	1.03	0.95	1.11	1.17	1.14	1.11
H30	1.04	0.96	1.09	1.17	1.14	1.12
H31	1.05	0.95	1.08	1.17	1.13	1.11
H32	1	0.88	1.07	1.17	1.07	1.03
H33	1.03	0.95	1.08	1.17	1.11	1.1
H34	0.99	0.98	1.12	1.19	1.11	1.16
H35	1.07	1.08	1.14	1.16	1.22	1.26
H36	1.07	0.92	1.11	1.16	1.18	1.07

H1 (Coal Mining and Dressing)、H2(Petroleum and Natural Gas Extraction)、H3(Ferrous Metals Mining and Dressing)、H4 (Nonferrous Metals Mining and Dressing)、H5(Nonmetal Minerals Mining and Dressing)、H6 (Farm Products Processing)、H7(Food Manufacturing)、H8 (Beverage Manufacturing)、H9(Manufacture of Tobacco)、H10 (Textile Industry)、H11(Textile, Clothes, Shoes & Hats)、H12(Leather, Furs and Related Products)、H13 (Timber Processing, Bamboo, Cane, Palm Fiber and Straw Products)、H14 (Furniture Manufacturing)、H15(Paper and Paper Products)、H16 (Printing and Record Medium Reproduction)、H17(Cultural, Educational and Sports Goods)、H18 (Petroleum Processing)、H19(Chemical Industry)、H20(Medicine Industry)、H21 (Chemical Fiber Industry)、H22(Rubber Products)、H23 (Plastic Products)、H24(Smelting and Pressing of Nonmetals)、H25 (Smelting and Pressing of Ferrous Metals)、H26 (Smelting and Pressing of Non Ferrous Metals)、H27(Metal Products Manufacturing)、H28 (Ordinary Machinery Manufacturing)、H29(Special Purpose Equipment Manufacturing)、H30 (Transportation Equipment Manufacturing)、H31(Manufacturing of Electric Machinery and Equipment)、H32(Electronic and Telecommunications Equipments)、 H33(Instrument, meters and Other Equipment Manufacturing)、H34(Electric Power and Heat Power)、H35 (Gas Production and Supply)、H36 (Production and Supply of Water)

Table 3 shows total factor productivity index of 36 industrial sectors and their decompositions from 2001 to 2008. The study discovers that total factor productivity index of most sectors is falling after considering of environmental factors. Five sectors which have apparent drop on total factor productivity in turn are H4(Nonferrous Metals Mining and Dressing)、H9(Manufacture of Tobacco)、H5(Nonmetal Minerals Mining and Dressing)、H3(Ferrous Metals Mining and Dressing)、H26(Smelting and Pressing of Non Ferrous Metals). They are focused on the sectors with more serious environmental pollution.

3.3. Results. According to Malmquist-Luenberger Index, this paper re-estimates the industrial total factor productivity growth with considering the constraints of the environmental pollution, and analyzes the impacts that environmental constraints have on total factor productivity. Based on the empirical study with Panel Data (36 industrial sectors from 2001 to 2008), this study has found:

Firstly, the case ignoring the environmental factors will underestimate the level of technical efficiency, mainly because the central, local authorities and enterprises have been actively increasing inputs so as to update obsolete equipment. The equipments in return serve to reduce pollution and improve productivity. It also reflects that in recent years China has made significant achievements in dealing with environmental issues through legislation and law enforcement. However, considering the fact that China's economic development foundation is weak and lagging behind the national system of environmental protection, as well as the distortions in the local government administrative intervention, market forces have not been fully reflected; so that the technical efficiency improvement is relatively slow, resulting that China's industrial total factor productivity growth is mainly dependent on the development of technological progress.

Secondly, the case ignoring environmental factors will underestimate the technical efficiency index, but at the same time, will overestimate the technological progress index and total factor productivity index. Kumar(2006)believes the reason is that the technology is not environmentally friendly during the development process. When the development level is relatively low, the technological progress will represent the increasing of the "good" and "bad" output at the same time. Generally, such development of technology will increase the emission of production waste so that the contribution from technological progress is comparatively low when considering the environment constraints.

Since industrial sector's technical efficiency level and technical efficiency index are relatively low in China, the government should encourage technological innovation, accelerate the promotion of technological progress, and focus on effective resource allocation. For example, increasing the expenditure on government's environmental services, encouraging enterprises to equip facility of reducing the pollution so as to improve technical efficiency of industrial economic growth, thereby contributing to a "quality and speed" development in economy.

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FUZZY GENERALIZED INTEGER SHARING PROBLEM WITH FUZZY CAPACITY CONSTRAINTS

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ABSTRACT. *The sharing problem is a method to find an equitable distribution of resources by maximizing the smallest value of all tradeoff function where a tradeoff function is a function of the flux to a sink node. In this paper, we propose a fuzzy generalized integer sharing problem with fuzzy capacity constraints. Our model has bi-criteria, i.e., minimal satisfaction degree among all fuzzy capacity constraints and that among fluxes to all sink nodes, both of which are to be maximized. Usually, since optimal flow pattern maximizing two objectives at a time does not exist, we propose an algorithm to find non-dominated flow patterns after defining non-domination and give the time complexity of the algorithm.*

Keywords: Sharing Problem; Integer Flow; Fuzzy Capacity; Bi-criteria; Non-dominated Flow Pattern

1. Introduction. Until now, many network flow problems have been well studied. But recently, some extensions have been done. Jansen (2006) proposed an approximation algorithm for the general max-min resource sharing problem with nonnegative concave constraints on a convex set. Theory and algorithms for solving the multiple objective minimum cost flow problem have been reviewed by Hamacher et al. (2007). Nace et al. (2008) provided a study of max-min fair multi-commodity flows. Lin (2007) discussed the system capacity for a two-commodity multistate flow network with unreliable nodes and capacity weight.

This paper proposes a new sharing problem. Sharing problem, originated by Brown (1979), is a method to find an equitable distribution of resources. Its objective is to maximize the smallest value of all tradeoff function where a tradeoff function is a function of the flux to a sink node (i.e., demand point), and which took a weight for the sink node into account. The sharing problem assumes that weights are constant. However, in actuality, it is difficult but essential to determine the values. Thus, it is proper to think them with flexibility. For instance, about a distribution of goods under a disaster, the information about the number of victims in a shelter is vague because of the emergence. Then, to improve the matter, Tada et al. (1989) took account of a membership function of the fuzzy weight and considered a fuzzy sharing problem, each membership function designates the satisfaction degree of the flux to each sink node. In some situations, the equitable distribution should be done under the constraint that the received amount of resources at each sink node is a multiple of some block-unit (e.g., a dozen), thus, the author (Tada et al., 1989) considered a generalized version of the fuzzy sharing problem under the constraint that the received amount at each sink node is restricted to be multiple of some certain positive integer value. To deal with the case that the violation of capacity constraints of distribution network arcs is acceptable in a certain range, Ishii and Itoh (1996) considered a fuzzy integer sharing problem with fuzzy capacity constraints (that is, upper limit of capacity for each arc is flexible), this model is bi-criteria one, bi-criteria are minimal satisfaction degree among all fuzzy capacity constraints and that among fluxes to all sink nodes, both of which are to be maximized. Besides, in some situation, the flow passing through each arc is also a multiple of some block-unit. In actual situation, all the above conditions may be happened simultaneously, we need to find a distribution method has a 'possibility large satisfaction degree of demander' and which simultaneously in the 'possibility best way' satisfies the capacity constraints. Base on this, we considered a fuzzy generalized integer sharing problem with fuzzy capacity constraints such that the received amount at each sink node and the flow passing through each arc are restricted to be multiple of some certain positive integer values.

Section 2 formulates our problem and defines non-dominated flow pattern since usually there does not exist an optimal flow pattern maximizing two objectives at a time. Section 3 proposes a solution algorithm to find some non-dominated flow patterns and clarifies its validity. Section 4 discusses its complexity. Section 5 shows how our algorithm runs by an example. Finally, section 6 concludes this paper and discusses further research problems.

2. Problem Formulation. Let $G=(N,A)$ be a distribution network where N is the set of nodes including special nodes, called source nodes (i.e., distribution points) and sink nodes (i.e., demand points) and A the set of directed arcs connecting nodes. Let S, T be the set of source nodes and sink nodes, respectively. Further, we add the super source node σ and super sink node u with the arc set $\{(\sigma,s)\mid s\in S\}$ and $\{(t,u)\mid t\in T\}$ to G and define the extended network G', i.e.,

$$G'=(N',A')=(N\cup\{\sigma\}\cup\{u\},A\cup\{(\sigma,s)\mid s\in S\}\cup\{(t,u)\mid t\in T\}).$$

Let f_{ij} denote the flow value in arc (i,j), and we use a simplified notation $f_t=f_{tu}$ for $t\in T$. Each arc $(i,j)\in A$ has a fuzzy capacity with the membership function:

$$\mu_{ij}(f_{ij})=\begin{cases}1 & (f_{ij}\le c_{ij})\\ \dfrac{\overline{c}_{ij}-f_{ij}}{\overline{c}_{ij}-c_{ij}} & (c_{ij}<f_{ij}<\overline{c}_{ij})\\ 0 & (f_{ij}\ge\overline{c}_{ij})\end{cases}$$

where $c_{ij}<\overline{c}_{ij}$ and c_{ij}, $\overline{c}_{ij}$ are integers.

We assume the capacity of each arc $(\sigma,s)\,(s\in S)$ is $C(\sigma,s)=\infty\,(s\in S)$. While, the capacity of each arc $(t,u)\,(t\in T)$, denoted as $C(t,u)\,(t\in T)$, is one of the key points and it may be determined and updated as to maximize the second criteria under the membership functions $\mu_t(f_t)$ (which is simplified notations of $\mu_{w_t}(f_t)$) characterizing the fuzzy weights w_t of sink node $t \in T$ given as follows.

$$\mu_t(f_t) = \begin{cases} 0 & (f_t \le a_t) \\ \dfrac{f_t - a_t}{b_t - a_t} & (a_t < f_t < b_t) \\ 1 & (f_t \ge b_t) \end{cases}$$

where $a_t < b_t$ and a_t, b_t are integers. Each membership function designates the satisfaction degree of flux to the sink node.

Further we restrict flow values f_{ij}, f_t to be nonnegative integer. In some situations, the equitable distribution should be under the constraint that the received amount of resources at each sink node is a multiple of some block-unit (e.g., a dozen). Thus, we assume that for each sink node $t \in T$, the received amount be a multiple of a certain positive integer d_t (we call it d_t-multiple), i.e., $f_t \equiv 0(\mathrm{mod}\, d_t),\ t \in T$. Further, the flow passing through each arc is also a multiple of some block-unit, thus we assume $f_{ij} \equiv 0(\mathrm{mod}\, d),\ (i,j) \in A$, d is also a certain positive integer. In order to assure the feasibility, we assume that each $d_t\ (t \in T)$ is a multiple of d, that is, $d_t = k_t d\ (t \in T)$, where k_t is positive integer, $t \in T$.

Under the above setting, we consider the bi-criteria, i.e., minimal satisfaction degree among all fuzzy capacity constraints and that among fluxes to all sink nodes, both of which are to be maximized. Then the fuzzy generalized integer sharing problem with fuzzy capacity constraints is formulated as follows.

$$\begin{aligned} \text{P:}\quad & \text{Maximize } \min_{(i,j)\in A} \mu_{ij}(f_{ij}),\ \text{Maximize } \min_{t\in T} \mu_t(f_t) \\ & \text{subject to } \sum_{i \in N' - \{u\}} f_{ij} = \sum_{k \in N' - \{\sigma\}} f_{jk},\ j \in N \\ & \qquad f_{ij} \equiv 0(\mathrm{mod}\, d),\ (i,j) \in A,\ f_t \equiv 0(\mathrm{mod}\, d_t),\ t \in T \\ & \qquad f_{ij} : \text{nonnegative integer},\ (i,j) \in A \end{aligned}$$

Next we define a flow pattern vector of flow pattern $\mathbf{f} = (f_{ij})$ to be

$$\mathrm{v}(\mathbf{f}) = (f^1, f^2) = (\min_{(i,j)\in A} \mu_{ij}(f_{ij}), \min_{t\in T} \mu_t(f_t)).$$

Generally speaking, optimal flow pattern maximizing two objectives at a time does not exist and so we seek non-dominated flow patterns which definition is given as follows.

Definition 2.1. For two flow patterns $\mathrm{f_a}$ and $\mathrm{f_b}$, if $f_a^1 \ge f_b^1$, $f_a^2 \ge f_b^2$ and $(f_a^1, f_a^2) \ne (f_b^1, f_b^2)$, we say $\mathrm{f_a}$ dominates $\mathrm{f_b}$. And, if there exists no flow pattern dominating f , f is called non-dominated flow pattern.

3. Solution Procedure. Since all flow values f_{ij}, f_t are integer, we only need to consider integer capacity values.

Let $v(1)^*$ and $v(0)^*$ be the total desired amount of supply value under the capacity c_{ij}

and $\overline{c}_{ij}$, respectively. First we solve the following fuzzy sharing problem P(1) and P(0), find the non-dominated flow pattern f(1) and f(0) whose corresponding flow pattern vector has the value 1 and 0 as the first component, respectively.

$$\text{P(1):}\quad \text{Maximize} \quad \min_{t\in T} \mu_t(f_t)$$

$$\text{subject to} \quad \sum_{t\in T} f_t = v(1)^*, \quad \sum_{i\in N'-\{u\}} f_{ij} = \sum_{k\in N'-\{\sigma\}} f_{jk},\ j\in N$$

$$f_{ij} \equiv 0(\operatorname{mod} d),\ (i,j)\in A,\ \ f_t \equiv 0(\operatorname{mod} d_t),\ \ t\in T$$

$$0 \le f_{ij} \le c_{ij},\ \ (i,j)\in A$$

$$\text{P(0):}\quad \text{Maximize} \quad \min_{t\in T} \mu_t(f_t)$$

$$\text{subject to} \quad \sum_{t\in T} f_t = v(0)^*, \quad \sum_{i\in N'-\{u\}} f_{ij} = \sum_{k\in N'-\{\sigma\}} f_{jk},\ j\in N$$

$$f_{ij} \equiv 0(\operatorname{mod} d),\ (i,j)\in A,\ \ f_t \equiv 0(\operatorname{mod} d_t),\ \ t\in T$$

$$0 \le f_{ij} \le \overline{c}_{ij},\ \ (i,j)\in A$$

Set $f'_{ij} = f_{ij}/d$, $(i,j)\in A$, $f'_t = f_t/d$, $t\in T$, then in order to solve P(1), we only need to solve the following problem P(1)'.

$$\text{P(1)}':\quad \text{Maximize} \quad \min_{t\in T} \mu'_t(f'_t)$$

$$\text{subject to} \quad \sum_{t\in T} f'_t = v(1)'^*, \quad \sum_{i\in N'-\{u\}} f'_{ij} = \sum_{k\in N'-\{\sigma\}} f'_{jk},\ j\in N$$

$$f'_t \equiv 0(\operatorname{mod} k_t),\ \ t\in T$$

$$0 \le f'_{ij} \le c'_{ij} (= [c_{ij}/d]),\ \ (i,j)\in A$$

where $\mu'_t(f'_t) = \begin{cases} 0 & (f'_t \le a'_t) \\ \dfrac{f'_t - a'_t}{b'_t - a'_t} & (a'_t < f'_t < b'_t) \\ 1 & (f'_t \ge b'_t) \end{cases}$, $a'_t = a_t/d$, $b'_t = b_t/d$ and $v(1)'^* = v(1)^*/d$.

We use P(1)'' to denote an auxiliary problem of P(1)' as following and give the algorithm to solve P(1)'.

$$\text{P(1)}'':\quad \text{Maximize} \quad \min_{t\in T} \mu'_t(f'_t)$$

$$\text{subject to} \quad \sum_{t\in T} f'_t = v(1)'^*, \quad \sum_{i\in N'-\{u\}} f'_{ij} = \sum_{k\in N'-\{\sigma\}} f'_{jk},\ j\in N$$

$$0 \le f'_{ij} \le c'_{ij},\ \ (i,j)\in A$$

Algorithm for P(1)'

Step 1. By using the algorithm similar to Algorithm FSP by Tada et al. (1989) for integer case (only let $C'(t,u)$ ($\square\, C(t,u)/d$) be integer in each step), solve the fuzzy sharing problem P(1)''. If $f'_t \equiv 0(\operatorname{mod} k_t)$ for all $t\in T$, then terminate, the current flow is optimal. Otherwise, set $i=1$ and $C'_i(t,u) = \lfloor C'_0(t,u)/k_t \rfloor \cdot k_t,\ t\in T$, where $C'_0(t,u)$ denotes the capacity from t to u in the final network realized by Algorithm of P(1)'', then go to Step 2.

Step 2. Find a maximum flow f'_i from σ to u and its value v'_i, then go to Step 3.

Step 3. If $v_i' < v(1)'^*$, go to Step 4. Otherwise, terminate, the current flow is optimal.

Step 4. Denote F_i to be the set of $t \in T$ such that there exists an augmenting path from σ to u via t when $C_i'(t,u)$ for every $t \in T$ is updated to $C_{i+1}'(t,u) = C_i'(t,u) \ +k_t$. If F_i is empty, then terminate, it is infeasible. Otherwise, find a sink node $\tilde{t} \in F_i$ such that $\mu_{\tilde{t}}'(C_i'(\tilde{t},u)) = \min_{t \in F_i} \mu_t'(C_i'(t,u))$, and set $C_{i+1}'(\tilde{t},u) = C_i'(\tilde{t},u) + k_{\tilde{t}}$, then go to Step 5.

Step 5. Set $i = i+1$ and return to Step 2.

It is obvious that the Algorithm is valid and so we discuss the complexity of the Algorithm.

Lemma 3.1. $v(1)'^* - v_1' \le \sum_{t \in T}(k_t - 1)$.

Proof: Let $f_t'^*$ be the flux to sink node t in case the flow is optimal without k_t-multiple constraint. Then

$$v(1)'^* - v_1' = \sum_{t \in T} f_t'^* - \Big(\sum_{t \in T} \lfloor C_0'(t,u)/k_t \rfloor \cdot k_t\Big) = \sum_{t \in T}\big(f_t'^* - \lfloor C_0'(t,u)/k_t \rfloor \cdot k_t\big) \le \sum_{t \in T}(k_t - 1).$$

Lemma 3.2. *If* $v_i' < v(1)'^*$, then $v_{i+1}' = v_i' + k_{\tilde{t}}$, $F_{i+1} \subseteq F_i$, where $\tilde{t}$ is defined in Step 4 of the above algorithm.

Proof: It is clear from the definition of F_i.

Theorem 3.1. The time complexity of P(1)' is $\mathrm{O}(R\,|T|^2\, cf(n,m))$, where $n = |N|$, $m = |A|$, $R = \lceil \max_{t \in T} k_t / \min_{t \in T} k_t \rceil$, $cf(n,m)$ is the time bound of the maximum flow problem for a graph (N, A) (Iri, 1979).

Proof: Step 1 takes at most $\mathrm{O}(|T|\, cf(n,m))$ operations. For the iterations from Step 2 to Step 5, Step 2 is $\mathrm{O}(cf(n,m))$ and Step 4 is $\mathrm{O}(|T|\, cf(n,m))$. From the above lemmas, it is clear that the Algorithm for P(1)' takes at most $R\,|T|$ ($R = \lceil \max_{t \in T} k_t / \min_{t \in T} k_t \rceil$) times iterations. Thus, the Algorithm for P(1)' take at most $\mathrm{O}(R\,|T|^2\, cf(n,m))$.

We denote the optimal flow pattern and optimal value of P(1)' be $\mathbf{f}'(1)$ and $f'(1)^2$, respectively. So it is obvious that the optimal flow pattern and optimal value of P(1) are $d \cdot \mathbf{f}'(1)$ and $f'(1)^2$, respectively, i.e., $\mathbf{f}(1) = d \cdot \mathbf{f}'(1)$, $f(1)^2 = f'(1)^2$. It is similar for the optimal flow pattern $\mathbf{f}(0)$ and optimal value $f(0)^2$ of P(0).

Now sorting $\mu_{ij}(kd)$, k is integer and $k \in (c_{ij}', \overline{c}_{ij}']$, $(i,j) \in A$, here $\overline{c}_{ij}' = [\overline{c}_{ij}/d]$, and let the result be $1 \equiv \mu^0 > \mu^1 > \cdots > \mu^l > \mu^{l+1} \equiv 0$ (l is the number of different $\mu_{ij}(kd) \in (0,1)$).

Let $v(\mu^q)^*$ be the total desired amount of supply value under the capacity $c_{ij}^q (= [(1-\mu^q)\overline{c}_{ij} + \mu^q c_{ij}])$, $q = 1, \cdots, l$. We use $\mathrm{P}(\mu^q)$ $(q = 1, \cdots, l)$ to denote the following problem.

$$\begin{aligned}
\mathrm{P}(\mu^q):\ \ &\text{Maximize}\ \ \min_{t\in T}\mu_t(f_t)\\
&\text{subject to}\ \ \sum_{t\in T} f_t = v(\mu^q)^*,\ \ \sum_{i\in N'-\{u\}} f_{ij} = \sum_{k\in N'-\{\sigma\}} f_{jk},\ j\in N\\
&\qquad\qquad f_{ij}\equiv 0(\mathrm{mod}\ d),\ (i,j)\in A,\ \ f_t\equiv 0(\mathrm{mod}\ d_t),\ t\in T\\
&\qquad\qquad 0\le f_{ij}\le c_{ij}^q,\ \ (i,j)\in A
\end{aligned}$$

By the solution procedure similar to problem P(1), solve the problem $\mathrm{P}(\mu^q)$. Let an optimal flow pattern and the optimal value of $\mathrm{P}(\mu^q)$ be $\mathbf{f}(\mu^q)$ and $f(\mu^q)^2$, respectively.

Next, we give the algorithm for P as follows.

Algorithm for P

Step 1. Set $q=1$, $DS=\{\mathbf{f}(1)\}$ and $DV=\{(1,f(1)^2)\}$, then go to Step 2.

Step 2. Solve $\mathrm{P}(\mu^q)$. If $\mathbf{f}(\mu^q)$ is dominated by some flow pattern of DS, then go to Step 3 directly. Otherwise, set $DS=DS\cup\{\mathbf{f}(\mu^q)\}$ and $DV=DV\cup\{(\mu^q,f(\mu^q)^2)\}$, then go to Step 3.

Step 3. Set $q=q+1$. If $q\ne l+1$, then return to Step 2. Otherwise, check whether $\mathbf{f}(0)$ is dominated by some flow pattern of DS. If dominated, terminate. Otherwise, set $DS=DS\cup\{\mathbf{f}(0)\}$ and $DV=DV\cup\{(0,f(0)^2)\}$, terminate.

Validity of the above algorithm is clear from the fact that it check all possibilities of the first component of non-dominated flow pattern vectors and the greater the flow value sent from σ to u in G' then so is $\min_{t\in T}\mu_t(f_t)$.

4. Complexity of the Algorithm for P. The time complexity of the Algorithm for P is as follows.

Theorem 4.1. The Algorithm for P obtains non-dominated flow patterns in at most $\mathrm{O}(L\cdot\max(\log L, R|T|^2\,cf(n,m)))$ computational times, where $L=\sum_{(i,j)\in A}(\overline{c}_{ij}-c_{ij})/d$.

Proof: Solving P(0) and P(1) both takes at most $\mathrm{O}(R|T|^2\,cf(n,m))$ operations. Because we treating integer flow, then $l\le L$ holds. Therefore, sorting $\mu^0,\mu^1,\cdots,\mu^{l+1}$ takes at most $\mathrm{O}(L\log L)$ operations. On Step 2, solving $\mathrm{P}(\mu^q)$ takes at most $\mathrm{O}(R|T|^2\,cf(n,m))$ operations, check whether there exists a flow pattern in DS which dominates $\mathbf{f}(\mu^q)$ or not needs at most $\mathrm{O}(L)$ operations. On Step 3 without going to Step 2, judging whether there exists a flow pattern in DS which dominates $\mathbf{f}(0)$ or not needs at most $\mathrm{O}(L)$ operations. As Step 2 to Step 3 is repeated at most L times, solving $\mathrm{P}(\mu^q)$ for all μ^q takes $\mathrm{O}(LR|T|^2\,cf(n,m))$ computational times. Therefore, the total complexity is $\mathrm{O}(\max(L\log L, LR|T|^2\,cf(n,m)))=\mathrm{O}(L\cdot\max(\log L, R|T|^2\,cf(n,m)))$.

5. Numerical Example. In this section, we show how our algorithm runs by an example.

We consider the extended network shown in FIGURE 1, where $S=\{1,2\}$, $T=\{4,5,6\}$ and $A=\{(1,3),(2,3),(2,5),(2,6),(3,4),(3,5)\}$.

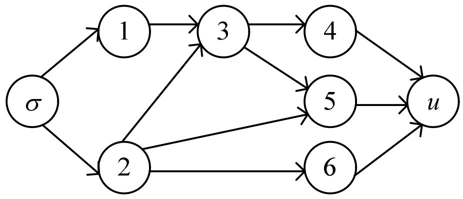

FIGURE 1. Initial network

For each arc $(i,j)\in A$, fuzzy capacity is given as follows:

$$\mu_{13}(f_{13})=\begin{cases}1 & (f_{13}\le 5)\\ \dfrac{10-f_{13}}{5} & (5<f_{13}<10)\\ 0 & (f_{13}\ge 10)\end{cases},\ \mu_{23}(f_{23})=\begin{cases}1 & (f_{23}\le 2)\\ \dfrac{4-f_{23}}{2} & (2<f_{23}<4)\\ 0 & (f_{23}\ge 4)\end{cases},\ \mu_{25}(f_{25})=\begin{cases}1 & (f_{25}\le 2)\\ \dfrac{6-f_{25}}{4} & (2<f_{25}<6)\\ 0 & (f_{25}\ge 6)\end{cases},$$

$$\mu_{26}(f_{26})=\begin{cases}1 & (f_{26}\le 2)\\ \dfrac{7-f_{26}}{5} & (2<f_{26}<7)\\ 0 & (f_{26}\ge 7)\end{cases},\quad \mu_{34}(f_{34})=\begin{cases}1 & (f_{34}\le 3)\\ \dfrac{7-f_{34}}{4} & (3<f_{34}<7)\\ 0 & (f_{34}\ge 7)\end{cases},\ \mu_{35}(f_{35})=\begin{cases}1 & (f_{35}\le 2)\\ \dfrac{6-f_{35}}{4} & (2<f_{35}<6)\\ 0 & (f_{35}\ge 6)\end{cases}.$$

Besides, for each sink node $t\in T$, fuzzy weight is given as follows:

$$\mu_4(f_4)=\begin{cases}0 & (f_4\le 0)\\ \dfrac{f_4}{10} & (0<f_4<10)\\ 1 & (f_4\ge 10)\end{cases},\quad \mu_5(f_5)=\begin{cases}0 & (f_5\le 2)\\ \dfrac{f_5-2}{3} & (2<f_5<5)\\ 1 & (f_5\ge 5)\end{cases},\quad \mu_6(f_6)=\begin{cases}0 & (f_6\le 2)\\ \dfrac{f_6-2}{5} & (2<f_6<7)\\ 1 & (f_6\ge 7)\end{cases}.$$

The network with capacity c_{ij} and $\overline{c}_{ij}$ for 1 and 0 are shown in FIGURE 2 and FIGURE 3, respectively, where the left number attached to each arc denotes its capacity and the right one the current flux through it hereafter.

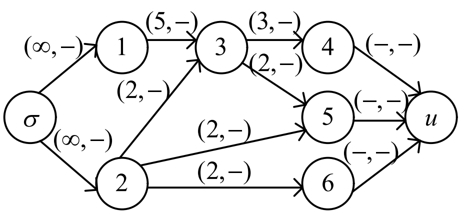

FIGURE 2. Network with capacity c_{ij}

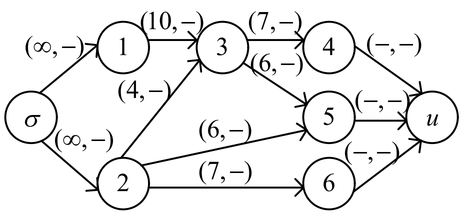

FIGURE 3. Network with capacity $\overline{c}_{ij}$

Let $d=3$, $d_4=3, d_5=6, d_6=3$, then $k_4=1, k_5=2, k_6=1$ and

$$\mu_4'(f_4')=\begin{cases}0 & (f_4'\le 0)\\ \dfrac{f_4'}{10/3} & (0<f_4'<10/3)\\ 1 & (f_4'\ge 10/3)\end{cases},\ \mu_5'(f_5')=\begin{cases}0 & (f_5'\le 2/3)\\ \dfrac{f_5'-2/3}{1} & (2/3<f_5'<5/3)\\ 1 & (f_5'\ge 5/3)\end{cases},\ \mu_6'(f_6')=\begin{cases}0 & (f_6'\le 2/3)\\ \dfrac{f_6'-2/3}{5/3} & (2/3<f_6'<7/3)\\ 1 & (f_6'\ge 7/3)\end{cases}.$$

Figure 4 And Figure 5 show the network with capacity c_{ij}' and $\overline{c}_{ij}'$, respectively.

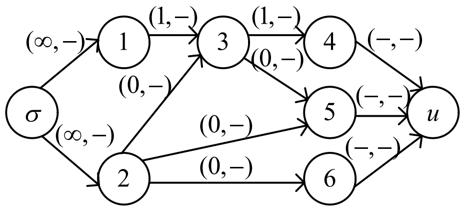

FIGURE 4. Network with capacity c'_{ij}

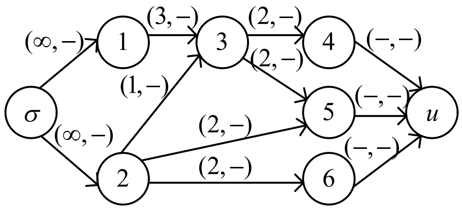

FIGURE 5. Network with capacity $\overline{c}'_{ij}$

Now sorting $\mu_{ij}(kd)$, k is integer and $k \in (c'_{ij}, \overline{c}'_{ij}]$, $(i,j) \in A$, and let the result be $1 \equiv \mu^0 > \mu^1 = 0.8 > \mu^2 = 0.75 > \mu^3 = 0.5 > \mu^4 = 0.25 > \mu^5 = 0.2 > \mu^6 \equiv 0$, $l = 5$.

Let $v(1)^* = 3$, $v(0.8)^* = 6$, $v(0.75)^* = 12$, $v(0.5)^* = 12$, $v(0.25)^* = 15$, $v(0.2)^* = 18$, $v(0)^* = 18$. Next solving problem P(1)" and P(0)".

Algorithm for P(1)" performs as follows:

Step 1. Since $\mu = \dfrac{1-(0+2/3+2/3)}{10/3+1+5/3} = -\dfrac{1}{18} < 0$, terminate, the optimal value is 0.

It is obvious that the optimal value for P(1) is 0.

Algorithm for P(0)" performs as follows:

The first iteration, $i = 1$.

Step 1. Since $\mu = \dfrac{6-(0+2/3+2/3)}{10/3+1+5/3} = \dfrac{7}{9} > 0$, each capacity is set as follows: $C'(4,u) = [\frac{7}{9} \cdot \frac{10}{3} + 0] = 2$, $C'(5,u) = [\frac{7}{9} \cdot 1 + \frac{2}{3}] = 1$, $C'(6,u) = [\frac{7}{9} \cdot \frac{5}{3} + \frac{2}{3}] = 1$.

Step 2. The result of max-flow computation is shown in FIGURE 6.

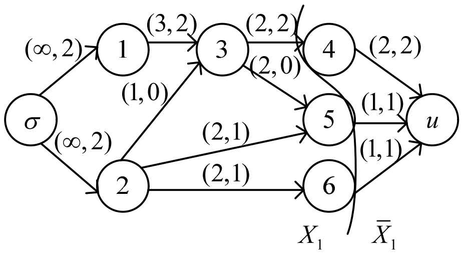

FIGURE 6. The first association network for p(0)"

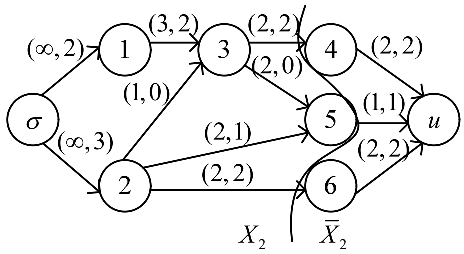

FIGURE 7. The second association network for P(0)"

Step 3. Since $v_1 = 4 < 6 = v(0)'^*$, go to Step 4.

Step 4. Since $\overline{X}_1 \cap T = \{4\} \neq \phi$, it follows that $F_{\overline{X}_1} = 2$. Thus, $\mu_{\overline{X}_1} = \dfrac{2-0}{10/3} = \dfrac{3}{5}$, $\mu_{X_1} = \dfrac{6-2-(2/3+2/3)}{1+5/3} = 1$, and each capacity is reset as follows: $C'(4,u) = [\frac{3}{5} \cdot \frac{10}{3} + 0] = 2$, $C'(5,u) = [1 + \frac{2}{3}] = 1$, $C'(6,u) = [\frac{5}{3} + \frac{2}{3}] = 2$. Return to Step 2.

The second iteration, $i = 2$. FIGURE 7 shows the network obtained in Step 2.

Step 3. Since $v_2 = 5 < 6 = v(0)'^*$, go to Step 5.

Step 5. Since $\bar{X}_1 \cap \bar{X}_2 \cap T = \{4\}$, it follows that $F_{\bar{X}_1 \cap \bar{X}_2} = 2$. Thus, $\mu_{\bar{X}_1 \cap \bar{X}_2} = \frac{2-0}{10/3} = \frac{3}{5}$ and $C'(4,u) = [\frac{3}{5} \cdot \frac{10}{3} + 0] = 2$. Also since $X_1 \cap \bar{X}_2 \cap T = \{6\}$, we have $F_{X_1 \cap \bar{X}_2} = 2$. Thus $\mu_{X_1 \cap \bar{X}_2} = \frac{2-2/3}{5/3} = \frac{4}{5}$, $\mu_{X_1 \cap X_2} = \frac{6-2-2-2/3}{1} = \frac{4}{3}$, and $C'(6,u) = [\frac{4}{5} \cdot \frac{5}{3} + \frac{2}{3}] = 2$, $C'(5,u) = [\frac{4}{3} \cdot 1 + \frac{2}{3}] = 2$. Return to Step 2.

The third iteration, $i = 3$. FIGURE 8 shows the network obtained in Step 2.

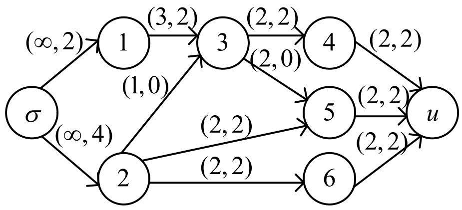

FIGURE 8. The third association network for P(0)"

Step 3. Since $v_3 = 6 = v(0)'^*$, the current flow is optimal. $\mu_4'(f_4') = \mu_4'(2) = 0.6$, $\mu_5'(f_5') = \mu_5'(2) = 1$, $\mu_6'(f_6') = \mu_6'(2) = 0.8$, therefore $\text{maximize}(\min \mu_t'(f_t')) = 0.6$.

Since $f_4' = 2 \equiv 0 (\bmod 1)$, $f_5' = 2 \equiv 0 (\bmod 2)$, $f_6' = 2 \equiv 0 (\bmod 1)$, the current flow is optimal for P(0)'. Further, the optimal flow pattern $\mathbf{f}(0)$ of P(0) is given as follows: $f_{13} = f_{25} = f_{26} = f_{34} = 6, f_{23} = f_{35} = 0$ and the optimal value is 0.6.

Finally, we solve the problem P.

Algorithm for P performs as follows:

Step 1. Set $q = 1$, $DS = \{\mathbf{f}(1)\}$ and $DV = \{(1,0)\}$, then go to Step 2.

The first iteration. Step 2. Solve P(0.8). The optimal flow pattern $\mathbf{f}(0.8)$ is given as follows: $f_{13} = f_{26} = f_{34} = 3, f_{23} = f_{25} = f_{35} = 0$ and optimal value is 0. It is obvious that $\mathbf{f}(0.8)$ is dominated by $\mathbf{f}(1)$, so go to Step 3 directly.

Step 3. Set $q = 2$. Since $q \neq 6$, then return to Step 2.

The second iteration. Step 2. Solve P(0.75). The optimal flow pattern $\mathbf{f}(0.75)$ is given as follows: $f_{13} = 6$, $f_{23} = 0$, $f_{25} = f_{26} = f_{34} = f_{35} = 3$ and optimal value is 0.2. It is obvious that $\mathbf{f}(0.75)$ is not dominated by $\mathbf{f}(1)$, set $DS = DS \cup \{\mathbf{f}(0.75)\} = \{\mathbf{f}(1), \mathbf{f}(0.75)\}$ and $DV = DV \cup \{(0.75, 0.2)\}$, then go to Step 3.

Step 3. Set $q = 3$. Since $q \neq 6$, then return to Step 2.

The third iteration. Step 2. Solve P(0.5). The optimal flow pattern $\mathbf{f}(0.5)$ is given as follows: $f_{13} = f_{23} = f_{25} = f_{26} = f_{34} = f_{35} = 3$ and optimal value is 0.2. It is obvious that $\mathbf{f}(0.5)$ is dominated by $\mathbf{f}(0.75)$, so go to Step 3 directly.

Step 3. Set $q = 4$. Since $q \neq 6$, then return to Step 2.

The fourth iteration. Step 2. Solve P(0.25). The optimal flow pattern $\mathbf{f}(0.25)$ is given as follows: $f_{13} = f_{34} = 6, f_{23} = f_{25} = f_{26} = f_{35} = 3$ and optimal value is 0.2. It is obvious that $\mathbf{f}(0.25)$ is dominated by $\mathbf{f}(0.75)$, so go to Step 3 directly.

Step 3. Set $q = 5$. Since $q \neq 6$, then return to Step 2.

The fifth iteration. Step 2. Solve P(0.2). The optimal flow pattern $\mathbf{f}(0.2)$ is given as follows: $f_{13} = f_{26} = f_{34} = 6, f_{23} = f_{25} = f_{35} = 3$ and optimal value is 0.6. It is obvious that $\mathbf{f}(0.2)$ is not dominated by any flow pattern of DS, so set $DS = DS \cup \{\mathbf{f}(0.2)\} = \{\mathbf{f}(1), \mathbf{f}(0.75), \mathbf{f}(0.2)\}$ and $DV = DV \cup \{(0.2, 0.6)\} = \{(1,0), (0.75, 0.2), (0.2, 0.6)\}$, then go to Step 3.

Step 3. Set $q = 6$. Since f(0) is dominated by f(0.2), terminate.

6. Conclusions. In this paper, we proposed a fuzzy generalized integer sharing problem with fuzzy capacity constraints and developed an efficient algorithm to find non-dominated solutions, further, showed how our algorithm runs by an example. There may be many non-dominated flow patterns with some corresponding flow pattern vector but our algorithm only find one of them. Further though in the worst case there exists $O(l)$ non-dominated flow patterns, we should refine the algorithm by taking not such a case into account since the algorithm check all possibilities in this case also. These are further research problems. Another is extend the problem to more general case that for each arc, flow value is restricted to multiple of their own certain positive integer. Besides, we think generalized case of sharing theory may be fruitful and interesting. Especially so more general models of fuzzy sharing problem reflecting actual situations are to be solved.

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OPTIMAL TAXABLE CAPACITY: STOCHASTIC FRONTIER APPROACH

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ABSTRACT. *In this paper we apply a nonparametric model of stochastic frontier to estimate the elastic coefficient matrix of four exogenous variables, which influence tax burden of all economic regions in Hangzhou. Meanwhile, we estimate the tax efficiency of all these regions. After analyzed the relationship between elastic coefficient of four exogenous variables and efficiency of tax burden, we give a suggestion on an optimal taxable capacity. The innovations of this paper lies in providing an optimal decision-making on how to increase the capacity of tax burden in all economic areas to efficiency frontier.*
Keywords: Stochastic Frontier Approach; Tax Efficiency; Elastic Coefficient; Optimal Taxable Capacity

1. Introduction. Tax efficiency is an important content of tax principle under the socialist market economy and a reflection of the ability to tax revenue. Tax revenue capacity contains two meanings: the ability to pay tax and the ability to levy tax. The ability to pay tax, also named taxable capacity, is used to describe the maximum degree of tax compliance to tax payers in countries or regions (Liang, 2007; Qiao et al., 2009). To improve efficiency is common pursuit to the goal of tax revenue management and supervision department.

Analysis to tax efficiency can make tax revenue further play the role of macro-control and promote efficient allocation of resources. it also can make the competent tax offices further exert tax administrative function and promote to govern by law. The exploration of tax efficiency can further understand the important meaning of the new tax system and promote our national economy to sustained, rapid, healthy development.

In the study of tax efficiency, many foreign literature adopted regression comparative method and nonparametric method. For example, Stotsky and Ariam (1997) estimated a regression equation with tax and some variables (such as per capita GDP, industrial structure, etc.), and then predict tax share, they believe that the difference between the actual share and forecast share was just the tax efficiency. Thirtle and Colin (2000) using the data envelopment analysis (DEA) studied tax efficiency of 15 nations from 1990 to 1993 in India. Finn and Sverre (2006) studied the Norway's tax efficiency with the same method. In China, the level of the analysis of tax efficiency is almost still stays in the qualitative analysis. In addition, the basic research on tax efficiency is Solow's growth equation used by Zhou and Wang (2002) and description statistics applied by Dan (1997). Xie (2009) employed a standard model of DEA and Malmquist index to evaluate the tax efficiency of Chinese provinces and regions from1995 to2004. The new tax system reform will start in China. The analysis of change track of Tax efficiency from the quantitative angle has the important practical significance to elect tax policy goals and design tax system for the future.

The objective of this paper is to research tax efficiency of Hangzhou in China with nonparametric estimators of random production frontiers (Henderson, 2005). This model is neither necessary to specific form of stochastic frontier function nor to suppose distribution of the random error and inefficiency term. Also, this model not only inherited flexibility of DEA method but also considered the random errors. Further, the elastic coefficient of the frontier function in this paper is changed with time and individual; these may more accord with the actual and have more significant economic meaning.

The remainder of this paper is organized in following way: Section 2 outlines model structure of nonparametric random frontier and parameter estimation. In Section 3, we study the elastic coefficient of fixed assets (FA), long-term investments (LI), total profit (TP) and Current assets (CA), as well as tax efficiency of all 14 economic regions in Hangzhou. After analyzing the relationship between elastic coefficient of four exogenous variables and efficiency of tax burden, we give a suggestion on optimal taxable capacity. A brief conclusion of the main findings is offered in section4.

2. Model Structure and Parameter Estimation. Let us consider nonparametric random frontier model as follows:

$$y_{it} = f(x_{it}) + v_{it} - u_i, \tag{1}$$

Where $i = 1,...,N, t = 1,...,T,$ is the endogenous variable, x_{it} is a vector of *k* exogenous variables, $f(.)$ is an unknown smooth function, u_i is known as the individual effect and v_{it} is the random error. The individual effect is what separates the one-way error component model from the classical nonparametric regression model, it is constant over time and is specific to each cross-sectional unit *i*. The above model is also known as the fixed effects or random effects model, if u_{it} is treated as fixed random respectively. In this paper, we consider the random effects model.

We make the following assumptions:

(1) $u_i \sim iid(\mu, \sigma_u^{\ 2})$ and $u_i \geq 0$,

(2) $v_{it} \sim iid(0, \sigma_v^{\ 2})$.

(3) u_i and v_{jt} are uncorrelated for all i and j, j=1,2,…,N, because the random variables u_i mean value may be not equal to zero , so model(1) can be modified the the following one:

$$y_{it} = m(x_{it}) + u_i^* + v_{it}, \tag{2}$$

Where $m(x_{it}) = f(x_{it}) - \mu$ and $u_i^* = \mu - u_i$, so $u_i^* \sim iid\left(0, \sigma_u^{\ 2}\right)$.

In model (2), let $u_i + v_{it} = \varepsilon_{it}$, then the model (2) is changed to model (3)

$$y_{it} = m(x_{it}) + \varepsilon_{it}, \tag{3}$$

the ε_{it} is a composite error in model (3). The $\varepsilon_i = [\varepsilon_{i1}, \varepsilon_{i2}, ..., \varepsilon_{iT}]^{\mathrm{T}}$ be a $T \times 1$ vector. The $V \equiv E(\varepsilon_i \varepsilon_i^{\ \mathrm{T}})$ en, takes the form $V = \sigma_v^{\ 2} I_T + \sigma_u^{\ 2} i_T i_T^{\ \mathrm{T}}$, where I_T is an identity matrix of dimension T and i_T is a $T \times 1$ column vector of ones. Since the observations are independent over i and j, the covariance matrix for the full $NT \times 1$ disturbance vector ε, let $\Omega = E(\varepsilon \varepsilon^{\mathrm{T}})$, namely $\Omega = I_N \otimes V$.

Nonparametric kernel estimation of $\hat{\delta}(x) = \left(\hat{m}(x), \hat{\beta}(x)\right)^{\mathrm{T}}$ can be obtained by using local linear least squares (LLLS) estimation. This is obtained by minimizing the local least squares of errors

$$\min \sum_i \sum_t \left(y_{it} - X_{it}\delta(x)\right)^2 K\left(\frac{x_{it} - x}{h}\right) = \left(y - X\delta(x)\right)^{\mathrm{T}} K(x)\left(y - X\delta(x)\right)$$

Where $\beta(x) = \nabla m(x)$, ∇ is the gradient vector of m(x), denotes the Elastic coefficient a vector of k exogenous variables, y is a $NT \times 1$ vector, X is a $NT \times (k+1)$ matrix generated by $X_{it} = \left(1, \left(x_{it} - x\right)\right)$, $\delta(x) = \left(m(x), \beta(x)\right)^{\mathrm{T}}$ is a $(k+1) \times 1$ vector, $K(x)$ is an $NT \times NT$ diagonal matrix of kernel functions $K\left(\frac{x_{it} - x}{h}\right)$ and h is the bandwidth (smoothing) parameter. The estimator obtained is

$$\hat{\delta}(x) = \left(\hat{m}(x), \hat{\beta}(x)\right)^{\mathrm{T}} = \left(X^{\mathrm{T}} K(x) X\right)^{-1} X^{\mathrm{T}} K(x) y \tag{4}$$

and is called the LLLS estimator.

Now, we consider the information contained in the disturbance vector covariance matrix Ω .it is a new estimator called Local Linear Weighted Least Squares (LLWLS), by minimizing $\left(y - X\delta(x)\right)^{\mathrm{T}} W(x)\left(y - X\delta(x)\right)$ with respect to $\delta(x)$, where $W(x) = \sqrt{K(x)}\Omega^{-1}\sqrt{K(x)}$ is a kernel based weight matrix. This provides the kernel estimating equations for $\delta(x)$ as $X^{\mathrm{T}} W(x)\left(y - X\delta(x)\right) = 0$, which gives

$$\hat{\delta}(x) = \left(X^{\mathrm{T}} \sqrt{K(x)}\Omega^{-1}\sqrt{K(x)} X\right)^{-1} X^{\mathrm{T}} \sqrt{K(x)}\Omega^{-1}\sqrt{K(x)} y \tag{5}$$

The LLWLS estimator in Eq. (5), however, depends upon the unknown parameters $\sigma_u^{\ 2}$ and $\sigma_v^{\ 2}$. The spectral decomposition of Ω leads to consistent estimators of the variance components as

$$\hat{\sigma}_1^{\ 2} = \frac{T}{N} \sum_t \hat{\bar{\varepsilon}}_i^2 ;\ \hat{\sigma}_v^{\ 2} = \frac{1}{N(T-1)} \sum_i \sum_t \left(\hat{\varepsilon}_{it} - \hat{\bar{\varepsilon}}_i\right)^2$$

Where $\sigma_1^{\ 2} = T\sigma_u^{\ 2} + \sigma_v^{\ 2}, \hat{\bar{\varepsilon}}_i = \frac{1}{T} \sum_t \hat{\varepsilon}_{it}$ and $\hat{\varepsilon}_{it} = y_{it} - \hat{m}(x_{it})$ is the LLLS residual based on the first stage estimator of $\hat{\delta}(x)$ in Eq. (4). The estimate of σ_u^2 can be obtained as $\hat{\sigma}_u^{\,2} = \frac{\left(\hat{\sigma}_1^{\,2} - \hat{\sigma}_v^{\,2}\right)}{T}$, $\hat{\sigma}_v^{\,2} = \frac{1}{N(T-1)}\sum_i\sum_t\left(\hat{\varepsilon}_{it} - \hat{\bar{\varepsilon}}_i\right)^2$. Substituting the estimates of $\sigma_u^{\,2}$ and $\sigma_v^{\,2}$ from Eq. (10) into Eq. (5) gives a new Feasible Nonparametric Weighted Least Squares

$$\hat{\delta}(x) = \left(X^{\mathrm{T}}\sqrt{K(x)}\hat{\Omega}^{-1}\sqrt{K(x)}X\right)^{-1} X^{\mathrm{T}}\sqrt{K(x)}\hat{\Omega}^{-1}\sqrt{K(x)}y$$

the estimates of u_i^* comes as $\hat{u}_i^{\,*} = \hat{\theta}\sum_t \hat{v}_{it}$, where $\hat{\theta} = \frac{\hat{\sigma}_u^{\,2}}{\hat{\sigma}_v^{\,2} + T\hat{\sigma}_u^{\,2}}$ and $\hat{v}_{it} = y_{it} - \hat{m}(x_{it})$.

First, the estimates of u_i are obtained by means of the normalization $\hat{u}_i = \max \hat{u}_i^* - \hat{u}_i^{\,*}$ and estimates of technical efficiency can be defined as $\hat{TE}_i = \exp(-\hat{u}_i)$.

3. Measure and Analysis of the Tax Efficiency in Hangzhou.

3.1. Data Processing and Variable Selection. In the current study we employ the model (1) to examine the tax efficiency of every economic regions in Hangzhou over the period 2004 - 2009. In order to keep the research consistency, we select taxable amount each year as the value of single endogenous variable y_{it}, fixed assets, long-term investments, total profit and main income of every economic regions as the value of a vector of four exogenous variables. The empirical data about the financial index of the local enterprises and the main economic indicators is supplied by Hangzhou tax bureau。In order to narrow the fitting data error，all the data are logarithm.(Empirical analysis is based on balance a Panel Data, including Hangzhou economic area of 14 2004-2009. Due to the large amount of data, so here no longer list.) the 14 economic regions in Hangzhou is Shangcheng (SC), Xiacheng (XC), Gongshu (GS) Jianggan (JG), Xihu (XH), Gao xin (GX), Aifa (KF), Tonglu (TL), Fuyang (FY), Linan (LA), Yuhang (YH), Jiande (JD), Chunan (CA), Xiaoshan (XS).

3.2. The Bandwidth Selection. Where we selected the bandwidths of four exogenous variables provided by Henderson (2003):

$$h_1 = 1.06\cdot\sigma(X_1)\cdot(nt)^{-\frac{1}{q+4}},$$

$$h_2 = 1.06\cdot\sigma(X_2)\cdot(nt)^{-\frac{1}{q+4}},\ h_3 = 1.06\cdot\sigma(X_3)\cdot(nt)^{-\frac{1}{q+4}},$$

$$h_4 = 1.06\cdot\sigma(X_4)\cdot(nt)^{-\frac{1}{q+4}}.\ n = 14, t = 6, q = 4$$

3.3. Elastic Coefficient Analysis. To analyze economic impact on every economic region in Hangzhou under the changes of four exogenous variables of fixed assets, long-term investments, total profit and main income, as well as to find the reason for tax income gap between all economic area. We program with Matlab to the estimation for nonparametric stochastic frontier and get the elastic coefficient of fixed assets (FA), long-term investments (LI), total profit (TP) and Current assets (CA). In order to shorten the pages of the paper, where we only gives the results for elastic coefficient matrix estimates of fixed assets in table 1.

The results show in the table1 that fixed assets elasticity in different years are distinguishing in the different economic area or the same area. but, do you notice nearly all fixed assets elasticity is negative, This shows that fixed assets change in opposite directions with the change of tax burden in various regional economic, that is to say, when the consume of fixed assets increases, the region will reduce the tax burden ability. the mean of elastic coefficient of fixed assets is -0.17 in Shangcheng region, it mean that fixed assets investment one unit, the tax burden capacity will reduce 0.17 in shangcheng. so we should reduce the investment of fixed assets to improve the ability of tax burden. the same analysis to elastic coefficient matrix estimates of long-term investments (LI), total profit (TP) and Current assets (CA).

TABLE 1. Elastic coefficient matrix estimates of fixed assets

FA	SC	XC	JG	GS	XH	GX	KF	TL	FY	LA	YH	JD	CA	XS
2004	-0.09	-0.14	-0.23	-0.11	-0.20	-0.11	0.23	0.13	-0.12	-0.55	-0.05	0.29	-0.18	-0.33
2005	-0.04	-0.17	-0.32	0.15	-0.20	-0.22	-0.32	-0.26	0.13	-0.25	0	-0.3	-0.13	-0.38
2006	-0.06	-0.30	-0.16	0.12	-0.21	-0.12	-0.12	-0.52	-0.15	-0.25	0	-0.23	0.06	-0.48
2007	-0.15	-0.28	-0.09	-0.07	-0.23	-0.24	-0.54	-0.18	-0.10	-0.25	-0.38	-0.02	0.08	-0.51
2008	-0.31	-0.26	-0.17	0.21	-0.30	-0.42	-0.49	-0.26	0.08	-0.21	-0.42	0.03	-0.62	-0.51
2009	-0.36	-0.31	-0.4	-0.18	-0.33	-0.51	-0.39	-0.33	-0.11	-0.11	-0.53	-0.26	-0.57	-0.49

Based on all elastic coefficient value of FA, LI, TP, CA, we calculate elastic coefficient average of 4 exogenous variables in each economic regions from 1999 to 2008, as shown in figure1.

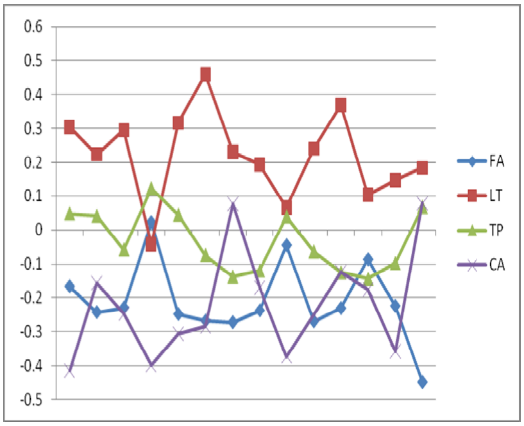

FIGURE 1. Elasticity coefficient

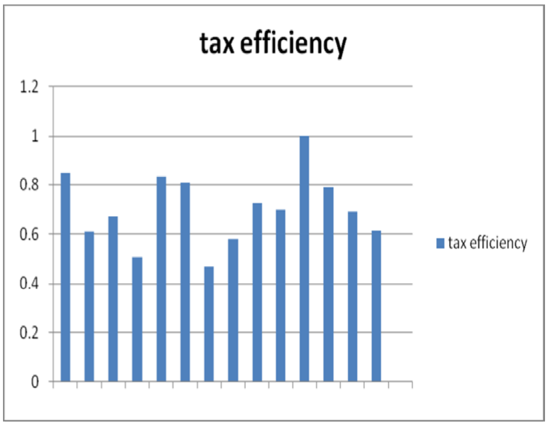

FIGURE 2. Tax efficiency

From figure1, we find the mean value of elastic coefficient of long-term investments is the biggest in all elastic coefficient. Especially, the elastic coefficient of long-term investment in Shangcheng, Gaoxin, Yuhang regions exceed 0.2, which means a long-term investment increase 1 unit ,the tax burden ability can increase 0.2 units in these areas. we also find from the figure1 that the increase of the total profit in shangcheng, gongshu,xihu,gaoxin,fuyang regions can also improve their tax burden capacity. the elasticity of Current assets is the lowest in chunan. So we should reduce the input of current assets to enhance the ability to tax burden in chunan.

3.4. Analysis of Tax Efficiency. In the previous section, we have established the model of nonparametric random frontier, through programming MATLAB, The mean value from 2004 to 2009 of tax burden efficiency of 14 areas in Hangzhou are estimated as above figure. This picture expresses the tax ability of the economic regions in the sample period. some from the results can be found as follows:

First, in the sample period, the tax efficiency for overall economic regions is not high, the average value is 0.703, the capacity of tax burden for Hangzhou city should be improved.

Second, the difference of tax efficiency is very obvious between the economic regions. the capacity of tax burden in Yuhang is the highest, value of tax efficiency is one (assuming the best efficiency of the frontier for Hangzhou) which is well above the average pay tax levels about 0.30.the lowest tax efficiency is kaifa, the value is only 0.49, the difference of efficiency value between kaifa and Yuhang is more than 0.5. There are obvious differences in the ability of tax burden between economic regions.

3.5. Optimal Taxable Capacity. The relationship between elastic coefficient of Fixed asset, long-term investments, total profit, Current assets and efficiency of tax burden is obvious. Which can be observed from figure 1, elasticity coefficient curve of Long-term investment obviously far higher than other 3 elasticity coefficient curve, excluding gongshu economic region. in addition the elasticity coefficient of Long-term investment are greater than zero. Therefore, not considering gongshu, if we fix the value of total profit, fixed assets, Current assets of every economic regions, improve the value of Long-term investment according to elastic coefficient in the corresponding regions. we can get optimum value of Long-term investment in 12 regions, namely make tax burden of regions get to efficiency frontier to achieve optimal capacity of tax burden. in gongshu economic region , total profit is the biggest influence on tax burden ability, Also, the total profit margins increase can also make tax burden of the gongshu district to achieve optimal capacity. the formula for calculating the optimal value reasoning as follows:

Elastic formula is:

$$E_c = \frac{V_o - V}{V} / \frac{I_o - I}{I} \quad \text{Deformation to} \quad V_o = \left(1 + E_c\left(\frac{I_0}{I} - 1\right)\right)V \tag{6}$$

Where V_0 denotes the optimal value, V denotes the original value; I_0 denotes the ideal tax burden value, which can make the capacity of tax burden get to frontier in this region. I denotes the actual value of tax burden in this region. Ec denotes elastic coefficient. I/I_0 denotes tax efficiency.

So, based above formula, we get optimal values of long-term investments in Shang cheng, Xiacheng, Jianggan, Xihu, Gaoxin, Kaifa, Tonglu, Fuyang, Linan, Jiande, Chunan, Xiaoshan are1.05V,1.14V,1.14V,1.06V,1.11V,1.26V,1.14V,1.02V,1.07V,1.12V. If fixed the value of fixed assets, total profit and Current assets meanwhile the value of long-term investments take the optimal values, then the capacity of tax burden in this area will get frontier. the optimal values of total profit in gongshu is 1.12 times of the original total profit value. If fixed the value of fixed assets, long-term investments and Current assets meanwhile the value of total profit take the optimal values, then the capacity of tax burden in Gongshu will get frontier too.

4. Conclusion. This paper proposes nonparametric model of stochastic frontier to estimate tax efficiency. this technique allows for more efficient estimation of complex technologies. the nonparametric method is suggested be used in practice because the true technology is generally unknown. we use this method to estimate the elastic coefficient matrix of Fixed assets, long-term investments, total profit and Current assets as well as the tax efficiency of Shang Cheng, Xiacheng, Jianggan, Gongshu, Xihu, Gaoxin, Kaifa, Tonglu, Fuyang, Linan, Yuhang, Jiande, Chunan,Xiaoshan, all economic regions in hangzhou. After analyzing the relationship between elastic coefficient of Fixed asset, long-term investments, total profit, Current assets and efficiency of tax burden, we give a suggestion on optimal taxable capacity. it provides a theoretical decision-making to Hangzhou tax departments on how to improve the efficiency of tax burden in all economic areas .

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BILINEAR VOLATILITY MODEL OF ENERGY STOCK MARKETS INDEX

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ABSTRACT. *The success of modeling volatility with conditional heteroscedastic data, such as energy stock index, Energy & Utilities, and Transportation & Logistics Sectoral indexed have been intensive studied recently. In this paper, we present a Bilinear GARCH X models for modeling volatility with the world crude oil price, including Nymex, Brent, Dubai, and Singapore crude oil market. We find that the oil prices plays an important role in the Bilinear GARCH X model of Transportation & Logistics Sectoral indexed. While the the Brent oil price in the Bilinear GARCH model of Energy & Utilities sector, only the AIC and SIC from Bilinear models show the lesser value than the classic GARCH-type model. The Portmanteau test for testing Autocorrelation and Heteroscedastic of Bilinear ARIMA and Bilinear GARCH models are compared with the classic GARCH-type model that illustrate the same conclusion.*
Keywords: Conditional Heteroscedastic Models; Bilinear Time Series Model; Bilinear X Time Series Model; The CHARMA Model

1. Introduction. It was estimated that the demand of world energy come from exhaustible resource about 85 percent, uranium and mainly fossil fuels. The oil supply covers with about 34 % by far the largest share followed by coal (24%), natural gas (21.5%), nuclear (5.5%) and renewables (15%), including traditional biomass. Asia with the strongest rise in demand during 2009 has come to the top of its production capacities.

The oil depletion certainly will influence the economic development of the emerging Asian countries China and India. The Asian oil balance is highly negative since Asia is a huge net importer of oil. China became the world's second largest oil consumer with close to 6 Mb/day behind the USA (~20 Mb/day) and in front of Japan with 5.4 Mb/day. While Japan has to import all of its oil, China produced about 55% from domestic sources. But while the demand strongly increases, domestic production is flat and within this decade will presumably start to decline. India's production covers only about 30 percent of consumption with a declining share. In 2006, Thailand by Economic Sector, the agricultural sector consumed a total energy of 3,312 ktoe and accounted for 5.2% of the total final energy consumption. The major energy consumed in this sector were petroleum products, shared 99.4% of its total energy consumption and the remaining was electricity. Energy consumption in manufacturing sector in 2006 was 23,442 ktoe and accounted for 37.1% of the final energy consumption, up 3.5% over last year. The major energy consumed was coal, shared 31.9% of the energy consumption in this sector, followed by new & renewable energy, electricity, petroleum products, and natural gas, which shared 23.8% 21.1% 14.0% and 9.2% respectively.

Energy consumption in transportation sector in 2006 was 22,985 ktoe and accounted for 36.3% of the final energy consumption, down 2.2% over last year. Most of the energy consumed in this sector were petroleum products, comprising diesel (including palm diesel) 51.3%, gasoline (including gasohol) 23.0%, jet fuel 16.1%, fuel oil 6.9%, and LPG 2.3%. Moreover, a small volume of natural gas for vehicles (0.4%) was consumed by some air conditioned buses in Bangkok Metropolitan Region and electricity was used by sky trains and subway, Energy Situation In Thailand (2006).

"Oil is so significant in the international economy that forecasts of economic growth are routinely qualified with the caveat: 'provided there is no oil shock.'', Faff (1999) Sadorsky confirms that oil prices and oil price volatility both play important roles in affecting economic activity, Sadorsky (1999). His results suggest that changes in oil prices impact economic activity but, changes in economic activity have little impact on oil prices. Impulse response functions show that oil price movements are important in explaining movements in stock returns. The positive shocks to oil prices depress real stock returns while shocks to real stock returns have positive impacts on interest rates and industrial production. There is also evidence that oil price volatility shocks have asymmetric effects on the economy. There are the dynamic interactions among interest rates, real oil prices, real stock returns, industrial production and the employment. The oil prices are also important in explaining stock price movements. For both specifications the results suggest that a positive oil price shock depresses real stock returns. Stock returns do not rationally signal (or lead) changes in real activity and employment, Papapetrou (2001).

Investors who invest in Thailand stock market need the accurate information for decision. Particularly the volatility of Thailand stock indexes, they are the important information to evaluate the risk. However, the stock volatility is that it is not directly observable. The volatility models are referred to as conditional heteroscedastic models. Volatility is an important factor in options trading. The different from the actual volatility is that implied volatility of an asset return tends to be larger than that obtained by using a GARCH type of volatility model. Although volatility is not directly observable, it has some characteristics that are commonly seen in asset returns. First, there exist volatility may be high for certain periods and low for other periods. Second, volatility evolves over time in a continuous manner that is volatility jumps are rare. Third, volatility within some fixed range is often stationary. Fourth, volatility seems to react differently to price varying referred to as the leverage effect. These properties play an important role in the development of volatility models,Tsay and Ruey (2005). Some volatility models were proposed specifically to correct the weaknesses of the existing ones for their inability to capture the characteristics mentioned earlier. The structure ARIMA and GARCH model is assumed no impact in the modeling. However, the two variables are related then their covariance structure might be important in any modeling process. The Bilinear ARIMA and Bilinear GARCH models take into account variations between the variables, (Rao et al. (1983), Pham and Tran (1981)). It is very important in the study of financial market. The primary aim in the study is to present the Bilinear ARIMA and Bilinear GARCHX models as another useful tool for modeling volatility. The Question as to whether the covariance structure of the bilinear model may be relevant in volatility measure is very essential in this study.

2. Bilinear ARIMA and Bilinear GARCHX Model. Linear models have been used quite successfully for analyzing time series data but some linear time series models may not be adequate in explaining some situation. Moreover, in financial market the two variables are related then their covariance structure might be important in any modeling process. The Bilinear ARIMA and Bilinear GARCH models take into account variations between the variables. Jones (1978), Granger and Andersen (1978a), Haggan and Ozaki (1980), Priestley (1980), Tong and Lim (1980) and Rao (1981) have considered particular types of non linear time series models. The nonlinear models considered by Granger and Andersen (1978a) and Rao (1981) are known as bilinear time series models. This class of time series has been found to provide a better fit as well useful in many areas including biological sciences, ecology and engineering (Mohler, 1973), Bruni et al. (1974)).

A time series Xt is a bilinear process of order (p, q, r, s) if it satisfies the model

$$X_t = \sum_{i=1}^{p} \varphi_i X_{t-i} + e_t - \sum_{j=1}^{q} \phi_j e_{t-j} + \sum_{i=1}^{r}\sum_{j=1}^{s} \beta_{ij} X_{t-i} e_{t-j} \tag{1}$$

where {et}is a sequence of independent, identically distributed random variables with mean zero and variance σ^2. The model is invertible and have a realization $\{x_1, x_2, \ldots, x_n\}$ on the time series {xt}. Denotation (1.1) is BL (p, q, r, s). This model was considered by Granger and Andersen (1978a). A major problem with bilinear time series modelling is the problem of model selection. The problem is considerably more difficult than the autoregressive moving average case (i.e. r = s = 0).

Bilinear GARCH models have been proposed in the literature to describe the evolution of the conditional variance σ_t^2. The conditional heteroscedastic ARMA (CHARMA) model uses random coefficients to produce conditional heteroscedasticity, Tsay (1987). The Bilinear GARCH model is not the same as the GARCH model, but the two models have similar second-order conditional properties. A CHARMA or Bilinear GARCH model is defined as

$$\sigma_t^2 = \sum_{i=1}^{l} \alpha_l \sigma_{t-l}^2 + \sum_{j=1}^{m} \delta_m e_{t-m}^2 + \sum_{i=1}^{n}\sum_{j=1}^{o} \iota_{no} \sigma_{t-n} e_{t-o} + \eta_t \tag{2}$$

$$\sigma_t^2 = \sum_{i=1}^{l} \alpha_l \sigma_{t-l}^2 + \sum_{j=1}^{m} \delta_m e_{t-m}^2 + \sum_{i=1}^{n}\sum_{j=1}^{o} \iota_{no} \sigma_{t-n} e_{t-o} + \beta x + \eta_t \tag{3}$$

where { ηt } is a Gaussian white noise series with mean zero and variance σ_η^2 is a sequence of iid random vectors with mean zero and non-negative definite covariance matrix Ω, and { et } is independent of {ηt }. the Akaike Information Criterion (AIC) and Schwarz information criterion (SIC) in selecting the right combination of p, q, r , s for Bilinear ARIMA and l, m, n, o for Bilinear GARCH ,Chen et al. (2001), Hagga and Oyetunji (1980) and x is exogeneous variable. This is also used in this paper.

2.1. The Process. To test unit root, the raw daily sector index data are collected from reuters. The selecting model are considered by minimum values of SIC and AIC criteria.

The interaction parameters values in bilinear GARCH model are estimate in each Asia stock index. The variances are estimated from each model and plotted them.

Here is summary the Process.

Step1. Classical GARCH model are selected by the least value of SIC and AIC criteria

Step2. Testing serial correlation and heteroscedasticity are tested by Ljung Box and Q-statistic

Step3. Determining the Bilinear GARCH models are defined by following the selected classical GARCH model with exogenous variable.

Step4. Serial correlation and heteroscedasticity problems of Bilinear GRACH model are tested by Ljung Box and Q-statistic.

Step5. Plotted Variance between classic GARCH and Bilinear GARCH are compared by graph.

This paper study the relatively between The Stock Exchange of Thailand (SET); Energy & Utilities and Transportation & Logistics sectoral indexed. And crude oil price per barrel; Nymex, Brent, Dubai, and Singapore crude oil market. For study the crude oil price in each market that affect to The Stock Exchange of Thailand (SET) in Energy & Utilities and Transportation & Logistic sectoral which compare by using Vector Auto Regression (VAR) and Bayesian Vector Auto regression (BVAR) methods.

3. Scope of This Study. In this study we collect data by Energy Information Administration for crude oil price per barrel, including Nymex, Brent, Dubai, and Singapore crude oil market which greatly influence of crude oil price change, in the period March 1, 2005 to July 30, 2009, weekly. And by Reuters for The Stock Exchange of Thailand (SET) especially Energy & Utilities and Transportation & Logistics Sectoral indexed.

The ADF unit root tests for the all variables, as well as their log differences (or rates of return). The original time series in logarithms are checked for stationary. In figure 1, it is clear that the sector indexes are non-stationary, while their rates of return are stationary. The results of the rates of return are stationary compared with the 1 % critical values to indicate rejection of the unit root null hypothesis.

Table 1 show the result from linear GARCHX and Bilinear GARCHX model of Energy & Utilities Sectoral. The linear GARCHX model are selected by minimize AIC and SIC. The model bilinear GARCHX are determined the same as linear GARCHX model. All of AIC and SIC from bilinear GARCHX are less than linear GARCHX model .There are a little different values of AIC and SIC between bilinear GARCH and bilinear GARCHX model. The linear GARCHX and bilinear GARCHX models, which add interaction variables in variance equation and exogeneous variable, are estimated by Maximum likelihood BHHH. The interactions (δ2) and exogeneous variable (ι12) in linear GARCHX model and Bilinear GARCHX of Energy & Utilities Sectoral indexed are not different from zero. They have not interaction effect in Bilinear GARCHX model and all return of crude oil price does not effect to volatility of Energy & Utilities Sectoral return.

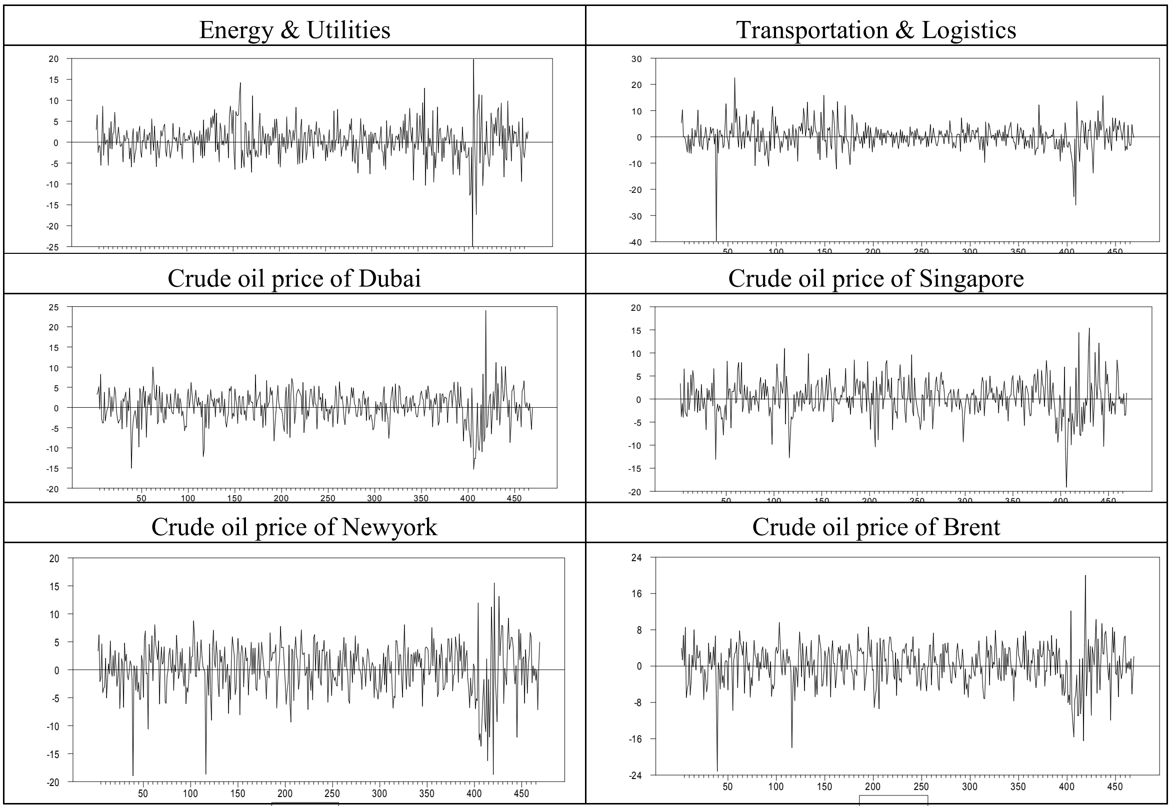


FIGURE 1. The returns of crude oil price and stock index

TABLE 1. GARCHX model of energy & utilities sectoral indexed of Thailand stock market

	Dubai		Singapore		Newyork		Brent	
Variable	Coeff	Std Error	Coeff	Std Error	Coeff	Std Error	Coeff	Std Error
φ0	0.420	0.168**	0.416	0.169**	0.420	0.169**	0.424	0.169
α0	1.530	0.747**	1.587	0.762**	1.547	0.757**	1.548	0.759**
α1	0.173	0.046***	0.173	0.047***	0.176	0.047***	0.175	0.047***
δ2	0.736	0.082***	0.731	0.084***	0.732	0.083***	0.732	0.083***
X	-0.067	0.077	-0.084	0.069	-0.051	0.079	-0.055	0.073
AIC	4239.077		4239.077		4239.077		4239.077	
SIC	4259.819		4259.819		4259.819		4259.819	
Bilinear GARCHX Model of Energy & Utilities Sectoral indexed of Thailand Stock Market								
Variable	Coeff	Std Error	Coeff	Std Error	Coeff	Std Error	Coeff	Std Error
φ0	0.495	0.183***	0.469	0.180***	0.481	2.626***	0.508	0.177***
α0	1.773	0.475***	1.836	0.410***	1.749	3.486***	1.549	0.486***
α1	0.363	0.067***	0.373	0.062***	0.360	4.730***	0.325	0.074***
δ2	0.636	0.067***	0.626	0.062***	0.639	8.403***	0.674	0.074***
ι12	0.039	0.073	0.027	0.074	0.036	0.431	0.063	0.063
X	-0.177	0.129	-0.149	0.108	-0.165	-1.518	-0.185	0.087
AIC	4195.895		4195.895		4195.895		4195.895	
SIC	4220.721		4220.721		4220.72		4220.721	

* ,** and *** indicate significance at 0.10 ,0.05 and 0.01 levels, respectively.

TABLE 2. GARCHX model of transportation & logistics sectoral indexed of Thailand stock market

	Dubai		Singapore		Newyork		Brent	
Variable	Coeff	Std Error	Coeff	Std Error	Coeff	Std Error	Coeff	Std Error
$\varphi 0$	-0.100	0.234	0.292	0.247	-0.109	0.222	-0.088	0.223
$\alpha 0$	0.848	0.218***	43.437	3.212***	0.820	0.193***	0.842	0.204***
$\alpha 1$	0.946	0.006***	0.005	0.004	0.027	0.006***	0.022	0.006***
$\delta 2$	0.941	0.01***	-0.743	0.106***	0.944	0.009***	0.947	0.010***
X	-0.448	0.078***	-1.299	0.233***	-0.515	0.086***	-0.515	0.088***
AIC	4406.172		4406.172		4406.172		4406.172	
SIC	4426.914		4426.914		4426.914		4426.914	
Bilinear GARCHX Model of Logistics Sectoral indexed of Thailand Stock Market								
Variable	Coeff	Std Error	Coeff	Std Error	Coeff	Std Error	Coeff	Std Error
$\varphi 0$	-0.373	0.211*	-0.329	0.210	-0.357	0.203*	-0.292	0.214
$\alpha 0$	0.912	0.130***	0.950	0.180***	0.784	0.167***	0.701	0.144***
$\alpha 1$	0.058	0.012***	0.072	0.016***	0.060	0.014***	0.048	0.012***
$\delta 2$	0.941	0.012***	0.927	0.016***	0.939	0.014***	0.951	0.012***
$\iota 12$	-0.089	0.022***	-0.080	0.023	-0.073	0.019***	-0.079	0.017***
X	-0.681	0.071***	-0.571	0.089	-0.646	0.098***	-0.613	0.093***
AIC	4361.204		4361.204		4361.204		4361.204	
SIC	4386.031		4386.031		4386.03		4386.031	

* ,** and *** indicate significance at 0.10 ,0.05 and 0.01 levels, respectively.

Table 2 show the result from linear GARCHX and Bilinear GARCHX model of Transportation & Logistics Sectoral. The model bilinear GARCHX are determined the same as linear GARCHX model. All of AIC and SIC from bilinear GARCHX are less than linear GARCHX model . The interactions ($\delta 2$) and exogeneous variable ($\iota 12$) in linear GARCHX model and Bilinear GARCHX of Energy & Utilities Sectoral indexed are different from zero. They have interaction effect in Bilinear GARCHX model and all return of crude oil price has effect to volatility of Energy & Utilities Sectoral return but the relationship between volatility of Transportation & Logistics Sectoral and Crude oil price of Singapore .

Table 3 shows the Serial correlation testing by Ljung Box and Q-statistic, which based on Chi-square distribution. Heteroscedasticity are tested by square residual in the way of Ljung Box and Q-statistic. The results of linear GARCHX and bilinear GARCHX model do not show this problem.

Figure 2 is variance values from Linear GARCHX model and variance values from bilinear GARCHX model. The graph demonstrate that at the high frequency of return, the values of bilinear GARCHX variance are greater than the linear GARCHX model.

TABLE 3. Ljung-Box Q-Statistics for serial correlation testing and heteroscedasticity testing

	Energy & Utilities				Transportation & Logistics			
	Dubai	Singapore	Newyork	Brent	Dubai	Singapore	Newyork	Brent
Testing Residual in GARCH model								
Q(10)	8.865	8.827	9.1169	9.0245	9.306	13.242	9.5734	9.2800
Q(20)	18.085	18.088	18.500	18.387	25.424	31.605**	25.0545	25.5498
Q(30)	30.311	30.337	30.633	30.554	30.711	37.530	31.7543	31.7169
Q(40)	45.313	45.204	45.869	45.827	44.344	51.052	45.7834	45.7442
Testing Square Residual in GARCH model								
Q(10)	15.9265	15.238	16.646	16.399	0.986	13.344	1.1901	1.1888
Q(20)	21.3792	20.525	22.068	21.931	16.672	47.962**	16.9253	19.3046
Q(30)	34.5630	33.788	35.164	35.044	17.424	53.054**	17.9290	20.2311
Q(40)	42.3933	41.557	43.023	42.936	23.022	62.933*	24.6934	26.3419
Testing Residual in Bilinear GARCHX model								
Q(10)	6.281	6.847	6.925	6.113	8.154	6.3580	8.3164	7.2563
Q(20)	13.853	14.850	14.923	14.104	15.806	19.3988	20.6282	17.2519
Q(30)	25.921	26.713	26.749	26.152	21.678	26.2294	27.2946	24.6553
Q(40)	37.086	37.705	38.292	38.190	74.685***	42.0553	38.5990	49.4065
Testing Square Residual in Bilinear GARCHX model								
Q(10)	14.0838	12.569	15.459	14.634	0.170	0.5725	0.9900	0.6794
Q(20)	23.6116	20.660	24.319	23.222	0.531	15.2373	13.8074	9.3990
Q(30)	32.1267	28.832	33.238	32.7678	0.592	16.4469	15.2896	10.2544
Q(40)	37.1955	34.193	38.045	36.9674	58.837*	38.0140	21.5433	203.7044***
* ,** and *** indicate significance at 0.10 ,0.05 and 0.01 levels, respectively.								

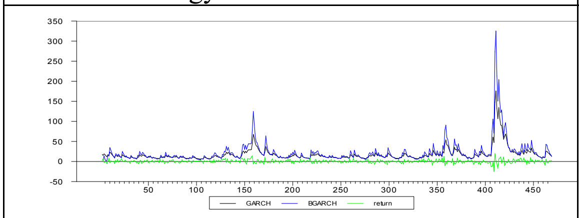
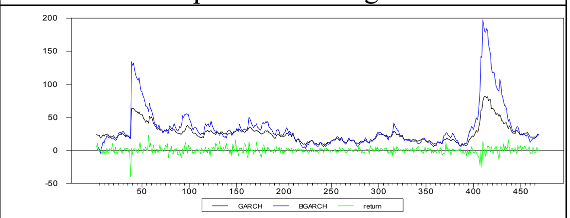
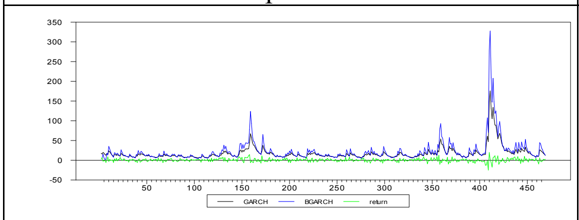
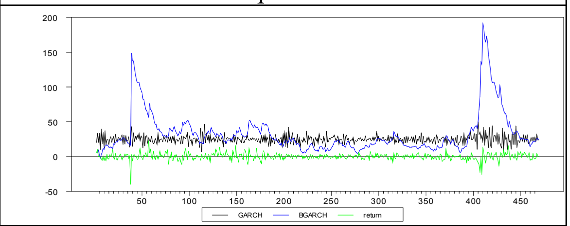
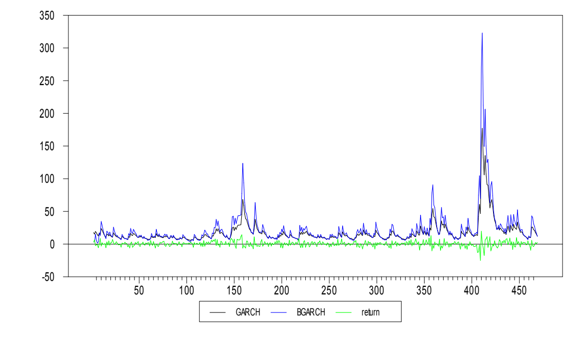
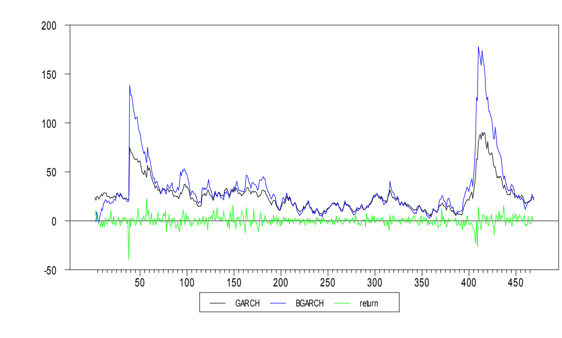
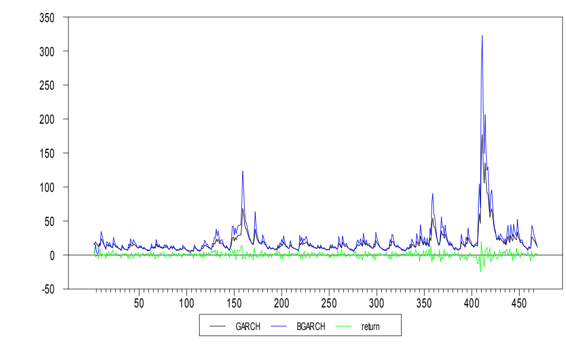
Energy & Utilities Sectoral	Transportation & Logistics
	
Crude oil price of Dubai	Crude oil price of Dubai
	
Crude oil price of Singapore	Crude oil price of Singapore

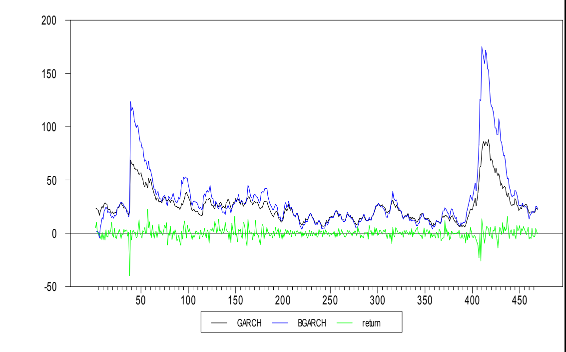
FIGURE 2-1.





Crude oil price of Newyork	Crude oil price of Newyork





Crude oil price of Brent	Crude oil price of Brent

FIGURE 2-2.

4. Conclusion. The log differences (or rates of return) are checked for stationary. it is clear that the sector indexes are non-stationary, while their rates of return are stationary. The results of the rates of return are stationary compared with the 1 % critical values to indicate rejection of the unit root null hypothesis.

The result from linear GARCHX and Bilinear GARCHX model of Energy & Utilities and Transportation & Logistics Sectoral are selected by minimize AIC and SIC. All of AIC and SIC from bilinear GARCHX are less than linear GARCHX model .There are a little different values of AIC and SIC between bilinear GARCH and bilinear GARCHX model. The linear GARCHX and bilinear GARCHX models, which add interaction variables in variance equation and exogeneous variable, are estimated by Maximum likelihood BHHH. The interactions (δ2) and exogeneous variable (ι12) in linear GARCHX model and Bilinear GARCHX of Energy & Utilities Sectoral indexed are not different from zero. They have not interaction effect in Bilinear GARCHX model and all return of crude oil price does not effect to volatility of Energy & Utilities Sectoral return. However, the interactions (δ2) and exogeneous variable (ι12) in linear GARCHX model and Bilinear GARCHX of Energy & Utilities Sectoral indexed are different from zero. They have interaction effect in Bilinear GARCHX model and all return of crude oil price has effect to volatility of Energy & Utilities Sectoral return but the relationship between volatility of Transportation & Logistics Sectoral and Crude oil price of Singapore . The results of linear GARCHX and bilinear GARCHX model do not show serial correlation and heteroscadasticity problem. The variance value of all bilinear GARCHX models are greater than the linear GARCHX model.

The main contribution of this paper is that we provide a bilinear model for the financial and econometric data. In comparison with linear GARCHX model and bilinear GARCH model, our approach offer several advantages: The research offers initial knowledge about risk evaluation in bilinear GARCH model, which are bigger than Linear GARCH model at the high frequency returns. The global investors have more information to evaluate their portfolio especially in Thailand Stock Indexed. We can compare the financial and econometrics model based on bilinear model.

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EFFECT OF CONSUMPTION EXPERIENCE ON BRAND AND LOYALTY: RESEARCH IN REPURCHASE OF POPULAR ENTERTAINMENT PRODUCTS

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ABSTRACT. *The study gives the research system from the three factors: customer, product and element of the experience. The result shows that: (1) Customer expectation experience does not have significant positive correlation with the satisfaction and loyalty; (2) Expectation experience has negative correlation with customer loyalty; (3) The effects of experience program on loyalty and other variables are variant according to the experience product and the related industry; (4) Experience environment has the most significant positive correlation with the customer satisfaction and loyalty, especially for the consumer entertainment industry such as KTV, its impact is more than the core products and services.*

Keywords: Element of the Experience; Customer Loyalty; Influencing Factors; Mechanism

1. Introduction. Experience is the intrinsic to certain stimuli (Pine et.al.,1998), which refers to the enterprise provide consumption situation, customers and enterprise's products, services and other things in the process of interaction of perception and affective reactions, different feelings and responses to customer loyalty, and the influence of different consumer loyalty is experiencing the formation process of experiencing some brand or enterprises loyalty (Wang and Zhou,2008).With the improvement of people's living standard and leisure time, experience and entertainment, more and more attention (Pine et.al.,1998), hence, experiential consumption mode will be our future consumer market, one of the top ten trend for the diversity of experience has become China's consumer fashion, the traditional marketing model and the customer loyalty, and how to cultivate challenged in the era of experience to satisfy customer demand diversity of modern enterprise should be the important issues. However, the lack of the theoretical research of customer experience is still in the early stages, many problems such as experience factors of loyalty and its influence, and its influence mechanism path and how to wait for a problem is lack of effective explain and demonstration of the enterprise management is the first information required. Based on this, the paper from customers, product factors and experience factors on three elements research system, using the mass entertainment goods as empirical experience into customer loyalty and function of the influence factors for the mass entertainment path, business and provide reference for subsequent research.

2. Related Literature Review.

2.1. Experience Loyalty. Numerous studies show that the customer experience on the formation and maintenance of customer loyalty has a significant effect. Oliver(1999) found that experience behavior on customer loyalty has significant explanatory power; Berry (2000) created "service brand equity model", with particular emphasis on customer experience in building service brand equity and loyalty which has a key role; Bolton (2000), such that the customer service experience will affect the company's evaluation and re-patronage; Research of Gentile et.al. (2007) shows that experience in identifying customer preferences play a fundamental role, and then affect purchase decision; Chang et.al. (2008) that the experience is an important variable to understand consumer behavior, experience and re-patronage behaviors. Li et al. (2006), Hu (2007), Wu (2008) and other related research also show that experience has obvious effect on customer loyalty.

2.2. Impact Nature of Experience Loyalty. Many scholars' studies show that experience of the customer loyalty has significant positive relationship. Mano and Oliver (1997) demonstrated that the emotional experience of the satisfaction showed a positive effect, and with word of mouth, whereas the pleasure and practical experience of the combined effect of consumer satisfaction with cognitive behavior; Wakefifeld (1996) and Baker(1992) made it clear that the excitement of shopping experience the feelings and re-patronage intentions positively related; Wakefifeld (1999) and Baker(1994) on the value of their customer experience and satisfaction and repeat patronage relationship between the quantitative empirical analysis, that there is a positive correlation between the two factors; Babin (2005) found that experience of such value and retail preferences, future patronage intentions are related.

2.3. Impact Path of Experience Loyalty. Chang et al. (2008) when studying the e-commerce customer loyalty that the impact of the Internet experience, customer loyalty through three paths: a direct impact; by Satisfaction; affect user switching costs and ultimately affect the user loyalty. Oliver (1980) that the accumulation of customer satisfaction over time, the overall customer experience of products and services based on an overall evaluation, the customer experience through customer satisfaction and customer loyalty; Flavián et.al. (2006) discovered that the customer experience, customer loyalty has a direct impact on the role of ; Bennett et.al. (2005) believe that customer satisfaction and customer experience through the two types of factors involved in customer service attitude of loyalty; and made a low experience level groups customer loyalty through customer participation in service delivery mainly the formation of customer loyalty, and high experience groups in the formation of customer loyalty through customer satisfaction Chinese scholars Wang's study (2007) indicates that the experience of the impact on customer loyalty are three paths: the direct impact of customer satisfaction through the indirect effects, the role of indirect effects on customer value.

In summary, the domestic and foreign research of the customer experience impact on customer loyalty centers around the relationship between the two and the impact on customer loyalty customer experience are two aspects of the path to start, and most scholars of the current focus on the former, while on the customer experience. The role of customer loyalty and mechanism of the path of research results although some scholars involved but the overall problem of inadequate; addition to Chang, HH & Chen, SW 2008 model year of the logical relations clearer, the remaining majority of (Bennett et.al., 2005; Flavián et.al., 2006) related research and adequate explanation of the lack of a strong argument, especially the lack of empirical researches.

3. Factor Specification and Analysis of Experience on Customer Loyalty.

3.1. Experience Category. Product categories and features will affect the customer experience and the resulting formation of customer loyalty. Foreign scholars have studied the different industries, but the conclusions of these studies between the different services there are the more obvious inconsistencies (Lu, 2007), this indicates that the products of different categories of services are different in experience of customer loyalty. Farly (1964) had clearly stated product categories have significant effect on brand loyalty Professor Lu Taihong in our study consumer loyalty to the brand loyalty is the formulation of the act when a particular brand of continuing to repeat purchase, but in the end how many times could be counted as continuing to buy loyalty to academia is no uniform measurement standard, depending on measurement product category.

In addition Yanhao Ren, Lu Juan, Liu servant, Liu, Zhao Kai, Han Junmei and other scholars have products in different industry experience as a positive object of loyalty research, the study also indicate that different industries and product characteristics affect customer experience loyalty effect; We can see that the product categories and attributes do affect the consumer experience, thereby affecting consumer loyalty and the loyalty that is the type of attitude or behavior loyalty loyalty, so as for experience the loyalty of customers must first define the product category . This study is the mass entertainment product that is divided from the point of purchase frequency of consumables, mostly within one year at least 2-3 times repeated consumer products, according to Dick and Basu (1994) and Gremler and Brown (1998) study to experience the attitude of loyalty is defined as acts of loyalty and loyalty to the unity .

3.2. Experience Factors.

3.2.1. Environment of Experience. Experience situation, which is the business experience available to the consumer participation in physical environment, including climate, surrounding environment, external decoration and interior decoration and design factors, these will affect the participants experience the feelings and subsequent consumer behavior (Bitner, 1990, 1992; Baker and Cameron, 1996; Wakefield and Blodgett, 1996), Russell (1978) proposed spending environment will lead to emotional changes of participants, affecting the consumer experience of engagement (participation) and, ultimately, individual the avoidance behavior. Subsequent scholars Baker et.al.(1992), Donovan and Rossiter

(1982) other studies in different situations to conduct verification of this model are that the physical environment and customer behavior attitude or obvious effect Pine II and Gilmore claim must first create a business attractive place for consumers to use their products, and immersed in the experience; and Hong (2005) made it clear that purchasing situations have a direct impact on purchase behavior.

H1: The experience situation has a significant positive effect on the engagement of the customer experience;
H2: The experience situation has a significant positive effect on the impression of the customer experience;
H3: The experience situation has a significant positive effect on the satisfaction of the customer experience.

3.2.2. Core of Experience. Grönroos (1984) defined the core product manufacturing process is completed when the customer left the compound , and in 1990 further clarified the core services that consumers are in the fundamental reason for the enterprise (Debra and Cass, 2005). The core of the experience of the impact on customer satisfaction Howard and Sheth conducted in 1969 related to research and discussion; since a large number of scholars such as Oliver (1977,1979,1980) ; Swan and Trawick (1980); Churchil and Surprenant (1982) and other studies show that the core product performance directly and significantly affect the satisfaction of the formation of; and the particularly worth mentioning is that Brady and Cronin (2001) in the construction quality of service model, emphasizing output nature of the core experiences of other means and whether consumers experience the level of the evaluation are, still able to control whether consumers believe the service output of a good or bad attributes. As the core experience is the most essential needs of the customer experience, the core experience of the products and services even greater impact on customer satisfaction, thereby establishing the following assumptions:

H4: The core experience design has a significant positive effect on the engagement of the customer experience;
H5: The core experience design has a significant positive effect on the impression of the customer experience;
H6: The core experience design has a significant positive effect on the satisfaction of the customer experience.

3.2.3. Program of Experience. Experience process also means the experience of the event, especially a business experience for the customers, but set a series of performance procedures and processes(Cui Benshun,2004) Experience the process of setting the complexity, rationality, interest, knowledge on customer experience and the experience level of customer satisfaction engagement has a direct impact. Liu Chengde in the experience design process, in addition to the customers at the Huo Dong Zi Shen, the customer also take into account each other's Guanxi, or Hen Rongyidailai negative of Tiyan, and the hypotheses here are built based on the above theories:

H7: The experience process has a significant positive effect on the engagement of the customer experience;

H8: The experience process has a significant positive effect on the impression of the customer experience;

H9: The experience process has a significant positive effect on the satisfaction of the customer experience.

3.2.4. Engage of Experience. Engagement degree (engage), also known as intervention degrees (involement), defined as a person from internal needs, values and interests and perceived relevance with the subject (Judith et.al, 1994). Bennett et.al (2005) believe that customer satisfaction and customer loyalty intervention affect customer attitudes; and made a low experience level of the main groups of customer loyalty through customer participation in the formation of customer loyalty in service mode, and high customer satisfaction through the experience of groups the formation of customer loyalty, that is when the customer's experience level is low, with interventions based cognitive variables become loyal attitude of the dominant elements of Experience an unforgettable impression of the process arises when the higher level of customer participation, experience higher satisfaction and therefore experience the impression that the maintenance of long-term customer relationship is an important factor (Guohua, 2004); Bloemer and Ruyter (1997), Lin and Huang (2005), Lin et.al. (2005), the results confirmed the participation of customers affect the formation of customer satisfaction.

H10**:** Experience engagement / participation has a significant positive effect on the satisfaction of customer experience

3.2.5. Effect of Experience. Experience the impression that the consumer perception of events and products experience a variety of attributes, the overall impression made by the architecture or attitude, through past experience and understanding to produce a unique cognitive structure (Kunkel and Berry, 1968). Bloemer and Ruyter (1997) in their analysis of empirical studies Swiss department store found in store image and customer loyalty are significantly related, and customer satisfaction for both the intervening variables. H11: Effect (Experience impression) has a significant positive impact on the satisfaction of customer experience.

3.3. Expectations of Customer Experience. Satisfaction is the consumer products and services meet the expectations of the level of the actual level of cognitive subjective comparison. Often expected to experience about their own evaluation of the product, thereby affecting their satisfaction and loyalty. Customer experience, customer satisfaction or loyalty has a direct impact, dissatisfied customers, while 91% will not re-consumption, and the customer experience will be conveyed bad evaluation from 8 to 10 (Christopher et.al, 1990); In addition, a large number of studies show that dissatisfied customers will have experience of purchase after the conflict and lead to dissatisfaction with the behavior (Lu, 2005), according to Oliver (1980), Bennett et.al (2005) findings, the direct impact of customer satisfaction Customer loyalty; with deep experience, customer satisfaction has become the main factors affecting the attitude of loyalty .

H12: The experience expectations has a significant positive effect on the customer satisfaction;
H13: The experience expectations has a significant positive effect on the formation of the customer loyalty;
H14: The experience satisfaction has a significant positive effect on the formation of the customer loyalty.

Thus, this paper theoretical model is shown in Figure 1:

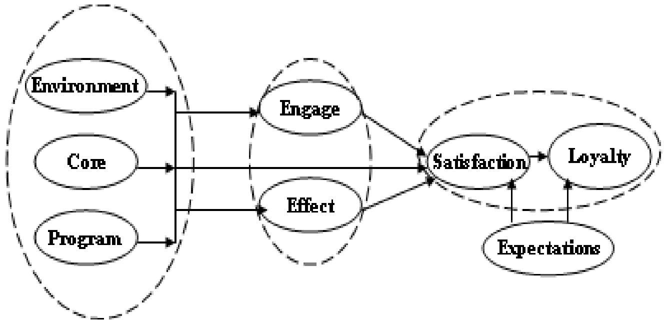

FIGURE 1. Theoretical model

4. Empirical Study Design.

4.1. Scale Design. This study included eight variables, using Likert 5 item scale designed to measure Q, which are as follows: experience situations (Enviorement, ENT) refer to Baker (1986), Bitner (1992), Wakefield and Blodgett (1994,1999), Chen Yifeng and other research designed to measure response question 8; experience the process (Program, PRO), experience of the core (Core, COE) reference Guohua, Cui this Shun (2004), studies were designed Q items 2 and 8; experience the impression (Effect, EF) reference to Boulding, Martineau (1958), Engel, Blackwell and Miniard (1990) results of research designed to measure response question 4; experience engagement (Engage, ENG) reference Judith lynne zaichkowsky (1994) the key measure of research design 5; experience expectations (Expectation, EXP), experience the satisfaction (Satisfaction, SAT) and the experience of loyalty (Loyalty, LOY) is according to Wu (2005), Liu (2003), Guiry (1992) studies were designed to measure Q Item 3, 3 and 6. In the specific operation, the paper cited in the literature as far as possible with good validity and reliability of the scale with reference to acceptance of a higher number of qualitative research findings, but also with the characteristics of discount-style KTV industry, one by one revision and development of the questionnaire variables measurement items, and completed the initial questionnaire development. Questionnaire included 47 items, involving a total of eight variables asked 39 items, screening items of question 3, and measuring the key characteristics of detecting the consumer 5.

4.2. Sample Collection. In this paper, discount style KTV consumption are taken as empirical subjects, 89 valid questionnaires through the first test (Pretest) and test measurement (Pilot Test), to amend a number of items with the ambiguity of the question, remove the ENT1, ENT3, ENT4, COE8, ENG1, EF4, LOY3 items in seven questionnaire sentences to make the final questionnaire reliability and validity have improved significantly. Formal survey began in November 2009, the survey to a higher level of education, between the ages of 18-35 years old students in school (mainly degree or above), just to participate in the work of teachers and staff of enterprises and institutions Main; release the city mainly in Beijing, Shanghai, Xiamen, Nanjing, Taiyuan, Guangzhou, Tianjin, Suzhou, Qingdao and Xuzhou areas, which can be representative of various cities in China. Written release by the network survey (MSN, QQ, E-Mail) is not combined anonymously to ensure the authenticity of the data, as of January 2010 were 543 valid questionnaires were returned.

4.3. Data Analysis.

4.3.1. Sample Structure. In terms of gender, male and female respondents respectively 323 and 220, and male respondents are slightly more than female, which KTV Consumption and China's sex ratio basically. In the age of 40 years of age together accounted for about 97.05% of respondents, this population is representative of KTV's major consumer groups. In the distribution of occupational groups, students and staff of enterprises and institutions most, accounting for 40.33 percent of those surveyed and 39.78%. Degree in education, undergraduate major is the largest share of 56.17 percent. Monthly income from the individual indexes, the cumulative number of 3,000 yuan income of 48.25% of total population, of which no income groups were students, accounting for 31.68%, the basic line Han (2008) and Pan (2007) on the KTV consumption groups of survey research results.

4.3.2. Validity and Reliability of Data Analysis. By using the SPSS13.0 software on the validity and reliability analysis of eight variable scale items of experience, the items with factor loading less than 0.5 items were removed (ENT2, ENT4, COE2, COE6, COE7, EF2) in the exploratory factor analysis, The results are shown in Table 1.

This measurement of the 25 items of the KMO value is 0.908, which is greater than 0.9 degrees to achieve a good fit. 25 measurements can be well distributed in the eight factors of potential public and the measurement of items in their respective latent variable measured on the load factor greater than 0.5, the questionnaire data shows good convergent validity; the measurement items on the other latent variable factor loadings were less than 0.5, indicating both good discriminant validity. Through analysis: Cronbach's α value of each variable were greater than 0.7, indicating that the questionnaire had high internal consistency, meet high reliability standards. The value of the overall reliability of the questionnaire up to 0.9, indicating that factors internal variable structure is reliable and credible, see Table 2.

TABLE 1. Reliability analysis result of data index

variable	EXP	ENT	COE	PRO	ENG	EF	SAT	LOY	Total
αValue	0.746	0.747	0.761	0.715	0.726	0.743	0.713	0.892	0.9

TABLE 2. Rotated component matrix (n = 543)

	Component							
	1	2	3	4	5	6	7	8
LOY4	.817	.162	.099	.107	.166	.114	.031	.133
LOY2	.793	.123	.154	.051	.107	.187	.058	.165
LOY1	.785	.103	.120	.032	.108	.088	.129	.218
LOY5	.740	.199	.100	.126	.095	.243	-.057	.112
LOY6	.659	.194	.243	.040	.077	.367	.006	-.063
ENT7	.226	.748	.040	.179	.096	.050	.032	.036
ENT8	.128	.675	.124	.138	.277	-.021	.033	.072
ENT6	.156	.642	.219	.177	.169	.132	.028	.118
ENT5	.137	.631	-.010	.187	.042	.327	-.024	.115
ENG3	.130	.153	.811	.028	.027	.047	.086	.004
ENG2	.106	.015	.741	.066	.156	.128	.094	.225
ENG5	.270	.108	.714	.076	.016	.147	-.128	.095
EXP2	.083	.134	.059	.808	.132	.097	.000	.013
EXP1	.061	.168	.100	.769	.098	.081	.033	.135
EXP3	.091	.249	.000	.721	.156	.137	.065	.002
COE4	.210	.097	.020	.225	.811	.115	.013	-.053
COE5	.218	.211	.062	.064	.774	.176	.025	.002
COE3	.003	.218	.138	.158	.683	.052	.069	.267
SAT1	.190	.103	.116	.181	.170	.721	.004	.257
SAT3	.272	.210	.050	.072	.103	.682	.036	-.020
SAT2	.311	.025	.228	.135	.097	.651	-.099	.127
PRO1	.040	.070	.007	-.017	.014	.066	.887	-.022
PRO2	.059	-.020	.049	.097	.061	-.100	.857	.010
EF3	.361	.195	.217	.094	.085	.131	-.010	.735
EF1	.404	.162	.200	.096	.096	.268	-.031	.620

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

4.4. Model Fitting. In this paper, intermediary effect of testing on the initial model building, using LISREL8.70, fixed load method, on the path of T is less than 196 amendments, from the fit indices and chi-square analysis of changes in value terms by the customer experience, loyalty impact study Optimal structural equation model shown in Figure 2.

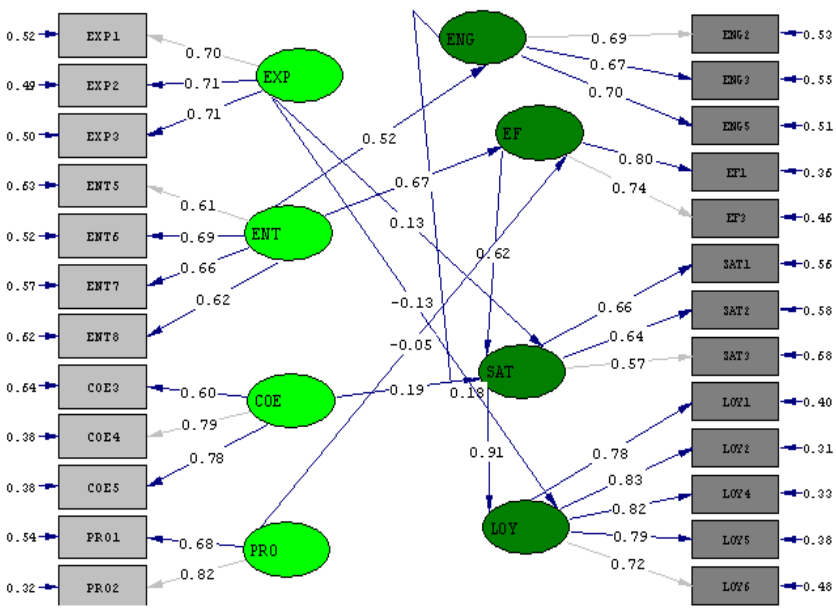

FIGURE 2. Estimation of optimal SEM model

Latent variable measure items in the factor loading values greater than 0.5 and highly significant, indicating the effectiveness of the higher measurement. In addition to the path of PRO→ Ef and the other all through the T test, Table 3, Figure 3 and 4.

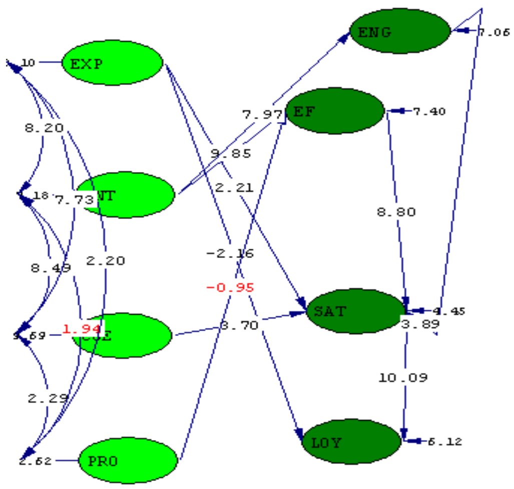

FIGURE 3. T-Value of optimal SEM model

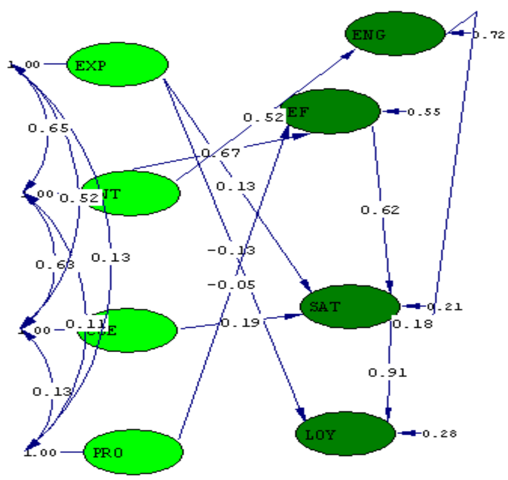

FIGURE 4. S. V of optimal SEM model

TABLE 3. Standardized path coefficients (S.V=standardized value)

Path	EXP →LOY	EXP →SAT	COE →SAT	ENT →EF	ENT →ENG	PRO →EF	EF →SAT	ENG →SAT	SAT →LOY
S. V	-0.13	0.13	0.19	0.67	0.52	-0.05	0.62	0.18	0.91
T-Value	-2.16	2.21	3.7	9.85	7.97	-0.95	8.8	3.89	10.09

Indirect effects of each variable as shown in Table 4, the total effect and the theory of hypothesis testing in Table 5.

TABLE 4. Indirect effects of each variable (V.R=variable relationship;I.E=indirect effects)

V.R	ENT→SAT	PRO→SAT	EXP→LOY	COE→LOY	EF→LOY	ENG→LOY	ENT→LOY	PRO→LOY
I.E	0.52	-0.03	0.12	0.17	0.57	0.17	0.47	-0.03

TABLE 5-1. The total effect and the theory of hypothesis testing is summarized

	Hypothesis	V.R	Total Effect	Conclusion
H1	The experience situation has a significant positive effect on the engagement of the customer experience	ENT →ENG	0.52	Support
H2	The experience situation has a significant positive effect on the impression of the customer experience	ENT →EF	0.67	Support
H3	The experience situation has a significant positive effect on the satisfaction of the customer experience	ENT →SAT	0.52	Support

TABLE 5-2. The total effect and the theory of hypothesis testing is summarized

	Hypothesis	V.R	Total Effect	Conclusion
H4	The core experience design has a significant positive effect on the engagement of the customer experience	COE →ENG	—	—
H5	The core experience design has a significant positive effect on the impression of the customer experience	COE →EF	—	—
H6	The core experience design has a significant positive effect on the satisfaction of the customer experience	COE →SAT	0.19	Support
H7	The experience process has a significant positive effect on the engagement of the customer experience	PRO →ENG	—	—
H8	The experience process has a significant positive effect on the impression of the customer experience	PRO →EF	-0.05	—
H9	The experience process has a significant positive effect on the satisfaction of the customer experience	PRO →SAT	-0.03	—
H10	Experience engagement / participation has a significant positive effect on the satisfaction of customer experience	ENG →SAT	0.18	Support
H11	Effect (Experience impression) has a significant positive impact on the satisfaction of customer experience	EF →SAT	0.62	Support
H12	The experience expectations has a significant positive effect on the customer satisfaction	EXP →SAT	0.13	Support
H13	The experience expectations has a significant positive effect on the formation of the customer loyalty	EXP →LOY	-0.01	—
H14	The experience satisfaction has a significant positive effect on the formation of the customer loyalty	SAT→LOY	0.91	Support

5. Hypotheses Test & Conclusions. According to the model fitting results, six out of the fourteen hypotheses have passed, those are H4, H5, H7, H8, H9, H13, in which all the variables related to experience the process did not pass, and the remaining eight hypotheses all passed the test, in which H14 , H1, H2, H3 and H11 the total effect could be over 0.5, showing a high correlation trend, a good validation of the hypothesis, as follows:(1) Experience situation that is KTV's interior comfort, interior design, consumer convenience, facilities, health, temperature and other factors on the experience of smell engagement, experiential impressions and experience positive correlation between satisfaction is very clear, direct effect values were 0.52,0.67 and 0.52; At the same time experience the situation of the customer experience, loyalty to the indirect effect of 0.47, shows like KTV in the consumption of mass entertainment industry, the impact of experience over the core products and services, to become the most important customer loyalty of factors.(2) The advanced nature of the core experience of the equipment, songs, update speed, sound effects and services to consumers and the impression of engagement no significant degree of positive influence, but the formation of customer satisfaction and loyalty shown clear positive influences. (3) Experience process in this study on the impact of other variables was not significant, this is the Shun (2004) and Cui (2004) conclusions of the IMF. Although not significantly affected, but still found some valuable information: ①

experience process of the impact of other variables on the experience and the type and characteristics of the product; ② experience process of image formation on the customer experience is the opposite direction, which means experience process to some extent the more complex the longer experience of those who wait, customers need to learn the knowledge and experience of more links, the customer experience worse impression.(4) The extent of the customer experience, which engaged in a significant positive effect on customer satisfaction and experience the impression of a highly positive effect on the relationship between customer satisfaction; its direct effect to 0.62, indicating that when the customer experience, the deeper the impression, customer satisfaction the higher. (5) Effects of expectation on the experience of satisfaction and loyalty are not entirely in the same direction, experience the expected direct effects on customer satisfaction is 0.13. while the positive effects on customer loyalty effect is -0.01, the customer experience is expected to impact on satisfaction nature and impact expected by the customer with the actual perception of the gap between the nature of products and experience of those affected by such factors as level of education; when close to the actual perception and consumer expectations, the impact is positive but relatively weak; when the actual perception than expected level of consumption impact is positive and the impact will increase; when the consumer actually much lower than expected level of perceived consumer satisfaction will be greatly reduced, which means a high degree of experience is expected to affect consumer satisfaction with the reverse. The study found that further complement the Wu (2005) research results. Also, according to previous conclusions: the amount of experience the consumer context and core product services that the impact effect on customer satisfaction is much higher than expected consumption, so here the impact of consumer expectations was weakening effect on assimilation. (6) This study reflects the attitude of loyalty and behavioral loyalty customer loyalty, positive experiences found in the KTV consumer satisfaction on customer loyalty in the positive impact of the direct effect of 0.91, showed highly significant positive effect, indicating the true customer satisfaction in terms of attitude or behavior on customer loyalty are significantly positive effect and experience higher satisfaction with their higher customer loyalty, which is consistent with a number of research scholars.

6. Suggestions. (1) The impact of customer expectation on the satisfaction and loyalty is complex, and consumers expected to experience the satisfaction of the acceptance of the existence of certain bounded domain; general, customers expect from a reverse effect on customer loyalty, and therefore companies should be expected to use scientific methods to lead the customers, and avoid exaggerating the merits of products and businesses is expected to cause consumers to enhance customer satisfaction and loyalty in turn lead to lower results. (2) Experience situation should be given sufficient attention. In most cases, enterprises will find ways to improve enterprise core products and services, while ignore the experience situational factors; In the fact, according to this empirical result: as for the mass entertainment, experiential scenario of the design to some extent the core product better customer satisfaction and Zhong Cheng Ying Xiang. Based on this, enterprises should experience situations such as experience in customer comfort room (temperature, humidity, reasonable space), interior design aesthetics (lighting, furniture, murals), service facilities, cleanliness and experience the atmosphere and so prominent feature of to meet customer psychology, rapid engagement experience to lead the consumer products and events, and the final formation of customer loyalty. (3) Strengthen the experience design process. Process design experience, scientific, rational, fun on customer experience have a greater influence, completely open-ended free play by consumers easily lead to experience the impression of light; overly complex process will be impressed with, but also prone to lead to consumer resentment, so those interested in how to design an experience possible without complicated procedures, which must be taken into account by the operators of public entertainment.

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VARYING COEFFICIENT STOCHASTIC PRODUCTION FRONTIER MODEL WITH AN APPLICATION TO CHINESE ECONOMIC GROWTH

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Abstract. *In this paper we propose a stochastic production frontier model with varying coefficient specification for the input covariates. A simple two-step estimation procedure is established to estimate the unknown parameters, as well as the technical inefficiency. The proposed method is applied to Chinese technical efficiency analysis in the economic growth function. The analysis is on the basis of cross - province data in the selected years.*
Keywords: Varying coefficient, stochastic frontier, technical efficiency.

1. **Introduction.** The stochastic production fortier model is an important tool to analyze the productive efficiency. The theoretical literature of productive efficiency was first pointed out by Koopermans (1951), which gave a formal definition of technical efficiency. Debreu (1951) and Shephard (1953) extended to the multiple output cases by introducing a distance function. Inspired by their work, Farrel (1957) measured productive efficiency empirically. The linear programming method he used leads to the development of DEA by Charnes, Cooper and Rhodes (1978), which is now a widely applied efficiency measurement technique in management science. Since 1970's stochastic frontier analysis (SFA) had appeared by the following two papers: Meeusen and Broeck (1977); Aigner , Lovell , and Schmidt (1977). Soon SFA model became another important tool to measure the productive inefficiency and many work had been done ever since, please see Kumbhakar and Lovel (2000) for more detail.

When considering the productive efficiency, we often use Cobb-Douglas production function because of its simple structure, meaningful parameter and easy estimation. The classical form Cobb-Douglas production function is:

$$Y = AK^{\alpha}L^{\beta},$$

where A is the efficiency coefficient, K and L are capital and labor respectively, α and β represent the output elasticities of capital and labor respectively. The classical setup assumes the elasticity to be constants, since Cobb and Douglas developed this model by statistical evidence that labor and capital shares of total output were constant over time in developed countries. When we consider the situation for developing countries like China, it is really doubtful about the constancy of the output elasticities. Statistically, a natural way is to extend the constant elasticities to a functional form, ie, a varying coefficient form. It has abundant literature referring to this nonparametric technique, see Fan and

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Zhang (1999), Huang, Wu, and Zhou (2002) and so on. For the production function, Xu and Wu (2007) applied a nonparametric method to estimate the varying elasticity of the capital and the labor; Luo , Yang , and Zhou (2009) introduces the nonparametric varying-coefficients model to estimate varying output elasticity of capital and labor force; Zhang and Gu (2010) established the varying-elasticity production function and applied to an empirical research on Chinese provincial data.

In this paper we extend the stochastic production frontier model to the varying elasticity form, thus the technical inefficiency are estimated under the non-constant output elasticities situation. To the best of our knowledge, there exists no literature on the estimation of efficiency when the output elasticities are allowed to change by a functional form.

The paper are organized as follows, the section 2 will establish the model and the estimation procedure; the section 3 will apply the introduced model to an empirical study on Chinese GDP growth; and the section 4 states the conclusion and possible further discussion.

2. **The Model and Estimation Method.** The general form of classical stochastic frontier model is as following,

$$y_i = f(x_i; \beta)TE_i,$$

where y_i is the scalar output and x_i is a vector of inputs used by producer i. $f(x_i; \beta)$ is the production frontier, and TE_i measures the technical inefficiency for each producer i. When applying the Cobb-Douglas production function, and take the logarithm, we have typically have the following linear form,

$$lny_i = \beta_0 + \sum_n \beta_n lnx_{ni} + v_i - u_i, \tag{1}$$

or more specifically,

$$lny_i = \beta_0 + \beta_1 lnK_i + \beta_2 lnL_i + v_i - u_i, \tag{2}$$

where y_i is the scalar output, K_i and L_i are capital and labor measurements, v_i is the two sided noise component, and u_i is the nonnegative technical inefficiency component of the error term. Notice here β_1 and β_2 are exactly the output elasticities for capital and labor respectively. Now we allow the elasticities could change by a functional form, and consider the following model,

$$lny_i = \beta_0(z) + \beta_1(z) lnK_i + \beta_2(z) lnL_i + v_i - u_i, \tag{3}$$

where z is an observed covariate vectors. This is a more flexible model in the sense that it keeps the linear structure of the term lnK_i and lnL_i, but allow the original constant coefficient to vary with certain characteristics. In the model (3), if we let

$$\begin{aligned} z &= (lnK, lnL) \\ \beta 1(z) &= \beta_k + \beta_{kk} lnK + \rho\beta_{KL} lnL \\ \beta 2(z) &= \beta_L + \beta_{LL} lnL + (1-\rho)\beta_{KL} lnK \end{aligned}$$

where ρ is between 0 and 1, then the above model in fact comprises a translog production function. Therefore our model is quite general in the sense of the production functional form.

Now for the simplicity of the notation, in the following estimation procedure we would assume that z is a scalar. The whole estimation procedure extends the method of MOLS, see Afriat (1972).

We first write the model (3) in the following form,

$$lny_i = (\beta_0(z) - E(u_i)) + \beta_1(z)lnK_i + \beta_2(z)lnL_i + v_i - (u_i - E(u_i)). \quad (4)$$

Denote $\beta_0^*(z) = \beta_0(z) - E(u_i)$ and $\epsilon_i^* = v_i - (u_i - E(u_i))$, we have

$$lny_i = \beta_0^*(z) + \beta_1(z)lnK_i + \beta_2(z)lnL_i + \epsilon_i^*. \quad (5)$$

Now we have zero mean and constant variance error terms, and the above model (5) can be estimated by the standard nonparametric method. Here we use the local linear regression to estimate the parameters and the errors. For any z in a small neighborhood of z_0, we approximate the functions $\beta_0^*(z)$, $\beta_1(z)$ and $\beta_2(z)$ locally as:

$$\begin{aligned}
\beta_0^*(z) &\approx \beta_0^*(z_0) + \beta_0^{*'}(z - z_0) \equiv a_0 + b_0(z - z_0),\\
\beta_1(z) &\approx \beta_1(z_0) + \beta_1'(z - z_0) \equiv a_1 + b_1(z - z_0),\\
\beta_2(z) &\approx \beta_2(z_0) + \beta_2'(z - z_0) \equiv a_2 + b_2(z - z_0).
\end{aligned}$$

And it leads to the following weighted least square problem: minimize

$$\sum_{i=1}^{I}(lny_i - \sum_{j=0}^{2}(a_j + b_j(z_i - z_0)x_{ji}))^2 K_h(z_i - z_0),$$

where $x_{0i} = 1$, $x_{1i} = lnK_i$ and $x_{2i} = lnL_i$, for $i = 1, ..., I$. Here $K_h(.) = K(./h)/h$ with $K(.)$ a kernel function and a bandwidth h.

Denote $Y = (lny_1, lny_2, ..., lny_I)^T$, $\beta = (a_0, a_1, a_2, b_0, b_1, b_2)^T$, the design matrix Z as:

$$Z = \begin{pmatrix} 1 & lnK_1 & lnL_1 & (z_1 - z_0) & (z_1 - z_0)lnK_1 & (z_1 - z_0)lnL_1 \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ 1 & lnK_I & lnL_I & (z_I - z_0) & (z_I - z_0)lnK_I & (z_I - z_0)lnL_I \end{pmatrix},$$

and the weight matrix $W = diagK_h(z_1 - z_0), ..., K_h(z_I - z_0)$. Then the solution of the weighted least square is given by

$$\hat{\beta} = (Z^T W Z)^{-1} Z^T W Y.$$

We now finish the first part of the estimation procedure by getting the estimates of the varying coefficients and residuals as following:

$$\begin{aligned}
\hat{\beta}_0^*(z) &= \hat{a}_0,\\
\hat{\beta}_1(z) &= \hat{a}_1,\\
\hat{\beta}_2(z) &= \hat{a}_2.\\
\hat{\epsilon}_i^* &= lny_i - \hat{\beta}_0^*(z_i) - \hat{\beta}_1(z_i)lnK_i - \hat{\beta}_2(z_i)lnL_i
\end{aligned}$$

For the second part of the estimation, we need to estimate the variance of v_i and u_i in order to get the estimates of technical inefficiency. Therefore we need the distribution assumptions on the error components and apply the method of moments to estimate the variances. Many assumptions could be made to v_i and u_i, here we will use the most frequently used distribution assumption: $v_i \sim N(0, \sigma_v^2)$ and u_i follows a half normal distribution. Then we have

$$\begin{aligned}
E(u_i) &= \sqrt{2/\pi}\sigma_u,\\
V(u_i) &= ((\pi - 2)/\pi)\sigma_u^2,\\
E(u_i^3) &= -\sqrt{2/\pi}(1 - 4/\pi)\sigma_u^3.
\end{aligned}$$

Thus the second and the third central moments of ϵ_i^* are $\mu_2 = \sigma_v^2 + ((\pi-2)/\pi)\sigma_u^2$ and $\mu_3 = \sqrt{2/\pi}(1-4/\pi)\sigma_u^3$. Let m_2 and m_3 be the second and third central sample moment of $\hat{\epsilon}_i^*$, we have:

$$\hat{\sigma}_u^2 = (\frac{m_3}{\sqrt{2/\pi}(1-4/\pi)})^{2/3},$$
$$\hat{\sigma}_v^2 = m_2 - (1-2/\pi)\hat{\sigma}_u^2.$$

and

$$\hat{\beta}_0(z) = \beta_0^*(z) + \sqrt{2/\pi}\hat{\sigma}_u.$$

After getting these consistent estimates, we now apply JLMS technique, developed by Jondrow et al.(1982), to obtain the estimates of technical inefficiency.

Denote $\sigma^2 = \sigma_u^2 + \sigma_v^2$ and $\epsilon_i = v_i - u_i$, then the estimates of u_i are given by:

$$\hat{u}_i \equiv \hat{M}(u_i|\epsilon_i) = \begin{cases} -\hat{\epsilon}_i\frac{\hat{\sigma}_u^2}{\sigma^2} & \text{if } \hat{\epsilon}_i \leq 0 \\ 0 & \text{otherwise.} \end{cases}$$

Finally we can obtain the technical inefficiency estimates by the following form:

$$TE_i = exp\{-\hat{u}_i\}.$$

As stated in Kumbhakar and Lovel (2000), although the inefficiency estimates are inconsistent, they are the best we can do with the cross-sectional data.

3. **The Empirical Example.** In this section we apply the varying coefficient stochastic production frontier model to Chinese provincial economic growth data, and get the estimates of provincial technical inefficiency.

3.1. **The Data Description.** The economic data contains the Gross Domestic product , Capital, Labour force and Human Capital. We choose the 28 provinces of China at the year 2003 and the year 2007. CPI's are considered and all the currencies are converted to the values of the base year 1952. Gross Domestic Product, which stands for output in the paper, is calculated by expenditure approach. The number of labour force is calculated by total employed persons at the year-end. In this paper, we follow Zhang (2004) to measure the capital, and follow Tang (2006) to measure the human capital.

3.2. **The Model Fitting.** We now apply the model (3) to the data. Since we are doing the empirical analysis, we would like to put one more restriction:

$$\beta_1(z) + \beta_2(z) = 1,$$

which is the so called constant return to scale condition. Then the model can be deduced to:

$$lny_i^* = \beta_0(z) + \beta_1(z)lnk_i^* + v_i - u_i, \tag{6}$$

where $lny_i^* = lny_i - lnL_i$ and $lnk_i^* = lnK_i - lnL_i$.

During the estimating procedure, we choose the bandwidth based on the Silverman's rule of thumb, but increased a little bit to get more smooth fit due to the relatively small sample size. We choose the provincial education index as the covariate z, since the education level is usually thought to be an indicator of the human capital, which is another common factor that can affect the production function and may not be linear. When applying the model to all the 28 provincial data, two provinces's data are out of the rational scale, so we removed these two provinces and applied the method to the remaining 26 provincial data samples. The numerical results of technical efficiency are presented in the TE_i column of table 1, and the figure 1 is showing the comparisons of the provincial technical efficiency between year 2003 and 2007 graphically.

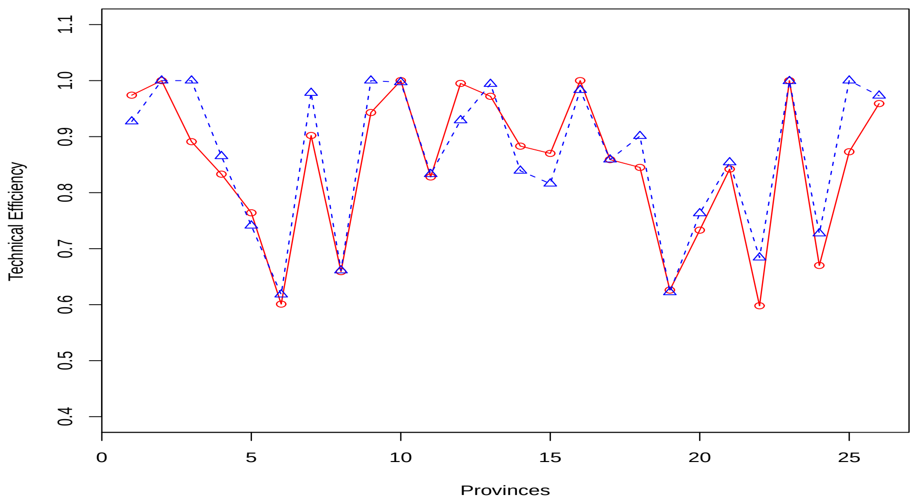

FIGURE 1. Technical Efficiency of year 2003 and 2007

In the figure 1, the x axis is coding of different provinces and y axis is the technical efficiency. The solid line in the figure represents the efficiency of year 2003 and dotted line for year 2007. From the graph, we can see a slight overall increase of the technical efficiency from year 2003 to 2007. A descriptive statistic shows that the average technical efficiency of year 2003 and 2007 are 0.851 with a standard error 0.132 and 0.868 with a standard error 0.129 respectively. So from the data of these two years, we see the average technical efficiency not only has a slowly increase tendency but also has a slowly decreased variation among different provinces. If paying attention to the provinces with relatively low technical efficiency, like Guangxi, Guizhou, Xingjiang, SanXi, and Sichuan, we can find they are mainly located in the west part of China, which might indicate a strong correlation between technical efficiency and the district of China.

From the table, we can also find the estimated capital elasticities for different province. An interested finding might be that the capital elasticity shows a slightly decreasing tendency and the statistic shows the average of year 2003 and 2007 are 0.662 and 0.637 respectively. However, the majority is above 0.60, which indicates the investment in capital still have a bigger impact for the economic growth.

In order to do a comparison, we also tried the traditional stochastic production frontier model on the same data set. With the same setup as before, we consider:

$$lny_i^* = \beta_0 + \beta_1 lnk_i^* + v_i - u_i, \tag{7}$$

where the only difference is that β_0 and β_1 are now scalars.

The lTE_i column of table 1 shows the numerical results of this model. Comparing with the results from varying coefficient model, we find the average of the technical efficiency from traditional model are higher and the variations across the province are smaller for both years. The following two figures show direct comparisons of the technical efficiency estimates.

Table 1. The empirical results for provincial technical efficiency analysis

Province	TE_i		β_1		lTE		z	
	2003	2007	2003	2007	2003	2007	2003	2007
Anhui	0.974	0.927	0.643	0.411	1.000	1.000	7.956	7.410
Fujian	1.000	1.000	0.683	0.613	1.000	1.000	8.276	8.270
Ganshu	0.891	1.000	0.497	0.326	0.765	0.783	7.371	7.009
Guangdong	0.833	0.865	0.808	0.862	0.870	0.915	8.985	9.395
Guangxi	0.764	0.741	0.687	0.646	0.853	0.858	8.311	8.451
Guizhou	0.601	0.618	0.480	0.334	0.716	0.771	7.321	7.049
Hebei	0.902	0.978	0.822	0.667	0.924	0.952	9.040	8.585
Henan	0.659	0.661	0.705	0.659	0.757	0.778	8.467	8.530
Heilongjiang	0.943	1.000	0.805	0.781	0.955	1.000	8.973	9.137
Hubei	1.000	0.997	0.675	0.660	1.000	1.000	8.194	8.538
Hunan	0.828	0.833	0.715	0.671	0.904	0.932	8.538	8.610
Jilin	0.995	0.929	0.855	0.755	0.993	0.935	9.170	9.049
Jiangsu	0.972	0.994	0.699	0.684	0.899	0.935	8.418	8.700
Jiangxi	0.883	0.839	0.808	0.687	0.924	0.918	8.987	8.721
Neimenggu	0.870	0.816	0.685	0.676	0.845	0.813	8.288	8.649
Ningxia	1.000	0.983	0.611	0.579	0.943	0.937	7.788	8.115
Qianghai	0.859	0.859	0.449	0.428	0.728	0.781	7.230	7.482
Shandong	0.845	0.901	0.719	0.664	0.844	0.879	8.564	8.564
Shanxi	0.626	0.622	0.852	0.806	0.729	0.741	9.158	9.219
SanXi	0.733	0.763	0.724	0.672	0.801	0.836	8.600	8.616
Shanghai	0.842	0.854	0.126	0.838	1.000	1.000	11.253	11.413
Sichuan	0.598	0.684	0.629	0.461	0.649	0.698	7.873	7.626
Tianjing	1.000	0.999	0.952	1.000	1.000	1.000	10.134	10.461
Xingjiang	0.670	0.727	0.819	0.716	0.751	0.796	9.029	8.885
Yunnan	0.873	1.000	0.072	0.307	1.000	1.000	6.365	6.918
Zhejiang	0.959	0.973	0.705	0.654	0.914	0.929	8.471	8.499

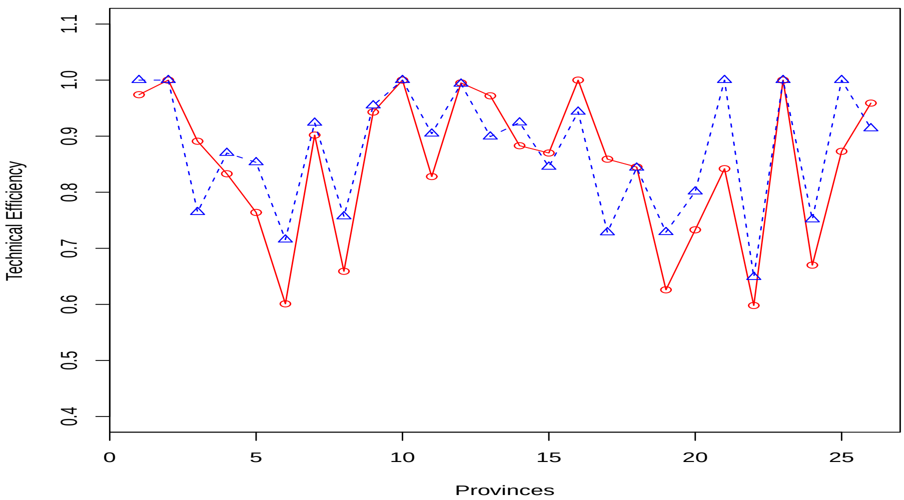

Figure 2. Technical Efficiency of year 2003 , varying vs constant model

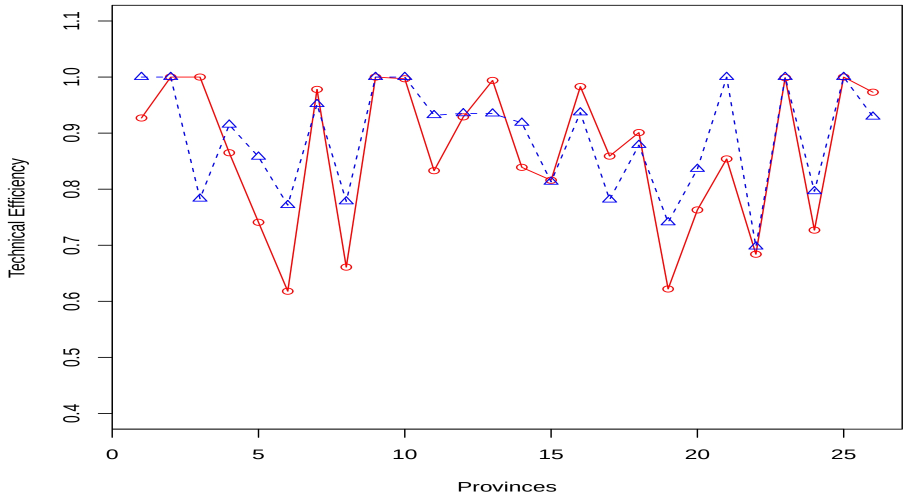

FIGURE 3. Technical Efficiency of year 2007 , varying vs constant model

In the figure 2 and 3 the solid lines are the estimates from varying coefficients model and the dotted lines are for the traditional model. We find that in many provinces lower estimates by the varying coefficient model are corresponding to relatively low education index, like Guizhou, Hebei, Jiangxi, Shanxi, Sichuan and so on. Although there are exceptions like Gansu and Ningxia, it might be one of the reasons to take the varying coefficient model since we usually think the low education level will cause a relatively low efficiency.

4. **Conclusion.** In this paper we propose a varying coefficient stochastic frontier model. And we suggest a two step procedure for the estimation of technical inefficiency. The proposed estimation procedure is easy to calculate and should be useful for applied researchers. We applied the method to the Chinese provincial economic growth data for an empirical example in the previous section.

Although the model is flexible and easy to compute, the limitation of our analysis still exists since we use the standard distribution assumptions in the second stage. We might be able to consider a nonparametric approach again for the error term which looses the restricted distribution assumption. This alternative is currently under investigation by the authors.

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INCONSISTENCY OF FINANCIAL RISK MEASURES UNDER ACTUAL PROBABILITY DISTRIBUTION EVALUATIONS

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Abstract. *This paper aims to examine the recent work of Treussard in which he compared the usual computations of two popular risk measures, the Value-at-Risk (VaR) and the Tail Value-at-Risk (TVaR), in the Black-Scholes model, using the actual probability distribution (of the underlying stock price stochastic process) with the computations using risk neutral probability distribution. His work only considered a simple case of one stock. His findings were that in order to achieve consistency with respect to time horizons, risk measures should be computed using risk neutral probability distribution.*

In our work, we examine Treussard's work in a more general setting, namely besides VaR and TVaR. We examine Wang's distortion-based risk measures, as well as general risk measures based upon general distortion functions. We show that the computations of these risk measures using actual probability distribution are also not consistent.
Keywords: Actual probability, distortion functions, financial risk measures, multiple asset models.

1. **Introduction.** From a financial engineering point of view, the correct computations of risks are essential for successful applications. Usually, risk measures are computed under the actual probability distribution of the underlying stock price random variable. Just like standard statistical procedures, the performance of a risk measure should be judged at least in terms of its consistency with respect to time. Recently, Treussard [1] pointed out that risk measures should be consistent in the sense that at time goes larger, the risk measures should increase. Based on this concept of consistency, Treussard set out to investigate two popular risk measures, the Value-at-Risk (VaR) and Tail Value-at-Risk (TVaR) in the Black-Scholes model with one stock. His findings were that these risk measures, computed under actual probability, are not consistent, whereas they are under risk neutral probability. As such, he suggested that for applications, one should compute risks using risk neutral probabilities.

It is clear that a recommendation of this magnitude needs more evidence ! In our present work, we look at the more realistic financial situation, namely the case of portfolios where multiple asset are involved rather just one stock as in Treussard's work. Moreover, we consider more general risk measures, namely those which are based on distortion functions, including the well-known Wang's distortions.

Our findings are that, as in the two special cases of Treussard, risk measures computed under actual probability are not consistent with time horizons, when asset variables are assumed to be comonotonic. It remains of courses to see what happens if the comonotonicity assumption is relaxed. Note that recently Nguyen et al[2] investigated also Treussard's

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work, for the case of one stock, but in a more realistic model than Black-Scholes model, namely Levy process models.

2. **Preliminaries.** It was Wang (1996)[3] who has first introduced the notion of distortion risk measure in actuarial literature. He defines a class of distortion risk measures by means of the concept of distortion function and popular risk measures in financial economics are of the form

$$\rho_h(X) = \int_0^{\infty} h(1 - F_X(x))dx + \int_{-\infty}^{0} [h(1 - F_X(x)) - 1]dx.$$

Let X is a loss random variable with distribution F_X and $h : [0,1] \to [0,1]$ be an increasing function with $h(0) = 0$ and $h(1) = 1$, The transform $F^*(x) = h(F_X(x))$ defines a distorted probability, where h call a distortion function. For example, the Value-at-Risk, $VaR_\alpha(X) = F_X^{-1}(\alpha)$ and the Tail Value-at-Risk, $TVaR_\alpha(X) = \frac{1}{1-\alpha}\int_\alpha^1 F_X^{-1}(t)dt$, correspond to distortion functions

$$h(u) = 1_{(1-\alpha,1]}(u) \text{ and } h(u) = min\{1, \frac{u}{1-\alpha}\}, \text{ respectively.}$$

2.1 Distortion risk measures obey the following properties :

1. Positive homogeneity: For any positive constant λ and any distortion function h

$$\rho_h(\lambda x) = \lambda\rho_h(x)$$

2. Additivity : If $X_1, X_2, \ldots, X_n$ are comonotonic and any distortion function h it holds

$$\rho_h(X_1 + X_2 + \ldots + X_n) = \sum_{i=1}^{n} \rho_h(X_i)$$

3. Monotonicity: If $X \le Y$ for all possible outcomes, then

$$\rho_h(X) \le \rho_h(Y)$$

4. Translation invariance: For any positive constant a and any distortion function h

$$\rho_h(X + a) = \rho_h(X) + a$$

2.2 Risk measure in Black-Scholes model

Let $V(t)$ denote a financial portfolio position at a time t. With initial value $V(0)$, the investor either puts $V(0)$ into the bank with risk-free rate r or put it on stock market. By time t, the investor either has $V(0)e^{rt}$ or $V(t)$. If the investor decides to invest money to the finance market, then

if $V(t) \ge V(0)e^{rt}$, he gains money,

if $V(t) < V(0)e^{rt}$, he loses money.

We will consider the risk of random variable

$$Y(t) = V(0)e^{rt} - V(t)$$

where we have portfolio $V(t) = n_1S_1(t) + n_2S_2(t) + \ldots + n_mS_m(t)$, n_i = number of stock $S_i(t)$, $i = 1, 2, \ldots, m$. Assume $S_i(t),\ i = 1, 2, \ldots, m$, are comonotonic.

And let the risk of random variable of stock $S_i(t)$

$$Y_i(t) = S_i(0)e^{rt} - S_i(t).$$

So that, the risk measure of portfolio $V(t)$ is

$$\rho_h(Y(t)) = \sum_{i=1}^{m} n_i\rho_h(Y_i(t))$$

Consider $V(t)$ is invest in stock with multiple asset model[4]

$$dB(t) = rB(t)dt$$

$$dS_i(t) = S_i(t)\Big(\sum_{j=1}^{m} \sigma_{ij}(t)dW_j(t) + \mu_i(t)dt\Big)$$

where $\{W_j(t)\}_{t\geq 0}$, $j = 1,\dots,m$, are independent Brownian motions. We assume that the matrix $\sigma = (\sigma_{ij})$ is invertible. By Itô formula

$$S_i(t) = S_i(0)exp\Big\{\int_0^t \big(\mu_i(s) - \frac{1}{2}\sum_{j=1}^{m}\sigma_{ij}^2(s)\big)ds + \int_0^t \sum_{j=1}^{m}\sigma_{ij}(s)dW_j(s)\Big\}$$

Let μ_i, σ_{ij} are constants and assume known. We have

$$S_i(t) = S_i(0)exp\Big\{\big(\mu_i - \frac{1}{2}\sum_{j=1}^{m}\sigma_{ij}^2\big)t + \sum_{j=1}^{m}\sigma_{ij}W_j(t)\Big\}$$

$i = 1, 2, \dots, m$ and $W_j(t) \backsim N(0, t) = \sqrt{t}z_j$. We have

$$S_i(t) = S_i(0)exp\Big\{\big(\mu_i - \frac{1}{2}\sum_{j=1}^{m}\sigma_{ij}^2\big)t + \sum_{j=1}^{m}\sigma_{ij}\sqrt{t}z_j\Big\}.$$

Then,

$$\begin{aligned} P(S_i(t) \leq x) &= P(S_i(0)exp\Big\{\big(\mu_i - \frac{1}{2}\sum_{j=1}^{m}\sigma_{ij}^2\big)t + \sum_{j=1}^{m}\sigma_{ij}\sqrt{t}z_j\Big\} \leq x) \\ &= P\big((\mu_i - \frac{1}{2}\sum_{j=1}^{m}\sigma_{ij}^2)t + \sum_{j=1}^{m}\sigma_{ij}\sqrt{t}z_j \leq ln(\frac{x}{S_i(0)})\big) \\ &= P(\sqrt{t}\sum_{j=1}^{m}\sigma_{ij}z_j \leq ln(\frac{x}{S_i(0)}) - (\mu_i - \frac{1}{2}\sum_{j=1}^{m}\sigma_{ij}^2)t). \end{aligned}$$

Since

$$\sum_{j=1}^{m}\sigma_{ij}z_j \backsim N(0, \sum_{j=1}^{m}\sigma_{ij}^2) \backsim \sqrt{\sum_{j=1}^{m}\sigma_{ij}^2}z$$

therefore the actual probability distribution of $S_i(t)$ is

$$\begin{aligned} F_t(x) = P(S_i(t) \leq x) &= P\left(z \leq \frac{ln(\frac{x}{S_i(0)}) - (\mu_i - \frac{1}{2}\sum_{j=1}^{m}\sigma_{ij}^2)t}{\sqrt{t\sum_{j=1}^{m}\sigma_{ij}^2}} \right) \\ &= \Phi\left(\frac{ln(\frac{x}{S_i(0)}) - (\mu_i - \frac{1}{2}\sum_{j=1}^{m}\sigma_{ij}^2)t}{\sqrt{t\sum_{j=1}^{m}\sigma_{ij}^2}} \right). \end{aligned}$$

3. **Main Results. 3.1 Value-at-Risk in Black-Scholes model**

For the case of $VaR_\alpha(.)$, the distortion function is

$$h_\alpha(u) = 1_{(\alpha,1]}(u).$$

Since

$$\begin{aligned} P(Y_i(t) > x) &= P(S_i(0)e^{rt} - S_i(t) > x) \\ &= P(S_i(t) < S_i(0)e^{rt} - x) \\ &= \begin{cases} \Phi\left(\dfrac{ln(\frac{S_i(0)e^{rt}-x}{S_i(0)}) - (\mu_i - \frac{1}{2}\sum\limits_{j=1}^{m}\sigma_{ij}^2)t}{\sqrt{t\sum\limits_{j=1}^{m}\sigma_{ij}^2}}\right) & \text{if } x < S_i(0)e^{rt} \\ 0 & \text{otherwise} \end{cases} \end{aligned}$$

then

$$h_\alpha(P(Y_i(t) > x)) = 1$$

if and only if

$$x < S_i(0)e^{rt} - S_i(0)exp\Big\{(\mu_i - \frac{1}{2}\sum_{j=1}^{m}\sigma_{ij}^2)t - \sqrt{t\sum_{j=1}^{m}\sigma_{ij}^2}\Phi^{-1}(1-\alpha)\Big\}.$$

Let

$$\begin{aligned} x^* &= S_i(0)e^{rt} - S_i(0)exp\Big\{(\mu_i - \frac{1}{2}\sum_{j=1}^{m}\sigma_{ij}^2)t - \sqrt{t\sum_{j=1}^{m}\sigma_{ij}^2}\Phi^{-1}(1-\alpha)\Big\} \\ &= S_i(0)e^{rt}\Big[1 - exp\Big\{(\mu_i - r - \frac{1}{2}\sum_{j=1}^{m}\sigma_{ij}^2)t - \sqrt{t\sum_{j=1}^{m}\sigma_{ij}^2}\Phi^{-1}(1-\alpha)\Big\}\Big] \end{aligned}$$

Case 1: If

$$\mu_i - r - \frac{1}{2}\sum_{j=1}^{m}\sigma_{ij}^2 \le 0$$

or

$$\mu_i - r - \frac{1}{2}\sum_{j=1}^{m}\sigma_{ij}^2 > 0 \text{ and } t \le \frac{\sqrt{\sum\limits_{j=1}^{m}\sigma_{ij}^2}\Phi^{-1}(1-\alpha)}{(\mu_i - r - \frac{1}{2}\sum\limits_{j=1}^{m}\sigma_{ij}^2)}$$

then

$$x^* > 0$$

So

$$\begin{aligned} VaR_\alpha(Y_i(t)) &= \int_0^{x^*} dx = x^* \\ &= S_i(0)e^{rt}\Big[1 - exp\Big\{(\mu_i - r - \frac{1}{2}\sum_{j=1}^{m}\sigma_{ij}^2)t - \sqrt{t\sum_{j=1}^{m}\sigma_{ij}^2}\Phi^{-1}(1-\alpha)\Big\}\Big] \end{aligned}$$

Case 2: If

$$\mu_i - r - \frac{1}{2}\sum_{j=1}^{m}\sigma_{ij}^2 > 0 \text{ and } t > \frac{\sqrt{\sum_{j=1}^{m}\sigma_{ij}^2}\Phi^{-1}(1-\alpha)}{(\mu_i - r - \frac{1}{2}\sum_{j=1}^{m}\sigma_{ij}^2)}$$

then

$$x^* < 0$$

So

$$VaR_\alpha(Y_i(t)) = \int_{x^*}^{0}(-1)dx = x^*$$

Therefore, in both cases. we have

$$VaR_\alpha(Y_i(t)) = x^* = S_i(0)e^{rt}\Big[1 - exp\Big\{(\mu_i - r - \frac{1}{2}\sum_{j=1}^{m}\sigma_{ij}^2)t - \sqrt{t\sum_{j=1}^{m}\sigma_{ij}^2}\Phi^{-1}(1-\alpha)\Big\}\Big]$$

Thus, if

$$\mu_i - r - \frac{1}{2}\sum_{j=1}^{m}\sigma_{ij}^2 > 0$$

then the value for $VaR_\alpha(Y_i(t))$, $i = 1, 2, \ldots, m$, will become negative for t large and keep decreasing afterwards.
From portfolio $V(t) = n_1S_1(t) + n_2S_2(t) + \ldots + n_mS_m(t)$, n_i = number of stock in $S_i(t)$ $i = 1, 2, \ldots, m$.
So that

$$\begin{aligned} VaR_\alpha(Y(t)) &= \sum_{i=1}^{m} n_i VaR_\alpha(Y_i(t)) \\ &= \sum_{i=1}^{m} n_i\Big(S_i(0)e^{rt}\Big[1 - exp\Big\{(\mu_i - r - \frac{1}{2}\sum_{j=1}^{m}\sigma_{ij}^2)t - \sqrt{t\sum_{j=1}^{m}\sigma_{ij}^2}\Phi^{-1}(1-\alpha)\Big\}\Big]\Big) \end{aligned}$$

if

$$\mu_i - r - \frac{1}{2}\sum_{j=1}^{m}\sigma_{ij}^2 > 0 \qquad \forall i, i = 1, 2, \ldots, m$$

Then the value for $VaR_\alpha(Y(t))$ will also become negative for t large and keeps decreasing afterwards. thus, under actual probability, $VaR_\alpha(Y(t))$ is not monotone with time horizons.

3.2 Tail Value-at-Risk in Black-Scholes model

The distortion function in $TVaR_\alpha(.)$ is

$$h_\alpha(u) = min\Big\{1, \frac{u}{\alpha}\Big\}.$$

Observe that

$$h_\alpha[P(Y_i(t) > x)] = 1$$

if and only if

$$x \le VaR_\alpha(Y_i(t))] = x^*$$

Case 1: If

$$x^* > 0$$

then

$$TVaR_\alpha(Y_i(t)) = \int_0^{x^*} dx + \int_{x^*}^{S_i(0)e^{rt}} \Big[\frac{P(Y_i(t) > x)}{\alpha}\Big] dx$$

$$= x^* + \int_{x^*}^{S_i(0)e^{rt}} \Big[\frac{1}{\alpha}\Phi\left(\frac{ln\Big(\frac{S_i(0)e^{rt} - x}{S_i(0)}\Big)}{\sqrt{t\sum_{j=1}^{m}\sigma_{ij}^2}} - \Big(\mu_i - \tfrac{1}{2}\sum_{j=1}^{m}\sigma_{ij}^2\Big)t\right)\Big] dx$$

By substitution and integration by parts, we have

$$TVaR_\alpha(Y_i(t)) = S_i(0)e^{rt}\Big[1 - \frac{1}{\alpha}exp\{(\mu_i - r)t\}\Phi\big[-\Phi^{-1}(1-\alpha) - \sqrt{t\sum_{j=1}^{m}\sigma_{ij}^2}\big]\Big]$$

Case 2 : If

$$x^* \leq 0$$

then

$$TVaR_\alpha(Y_i(t)) = \int_0^{\infty} \frac{P(Y_i(t) > x)}{\alpha} dx + \int_{x^*}^{0} \Big[\frac{P(Y_i(t) > x}{\alpha} - 1\Big] dx$$

$$= \frac{1}{\alpha}\int_0^{S_i(0)e^{rt}} \Phi\left(\frac{ln(\frac{S_i(0)e^{rt}-x}{S_i(0)}) - (\mu_i - \frac{1}{2}\sum_{j=1}^{m}\sigma_{ij}^2)t}{\sqrt{t\sum_{j=1}^{m}\sigma_{ij}^2}}\right) dx$$

$$+ \int_{x^*}^{0}\left[\tfrac{1}{\alpha}\Phi\left(\frac{ln(\frac{S_i(0)e^{rt}-x}{S_i(0)}) - (\mu_i - \frac{1}{2}\sum_{j=1}^{m}\sigma_{ij}^2)t}{\sqrt{t\sum_{j=1}^{m}\sigma_{ij}^2}}\right) - 1\right] dx$$

Again by substitution and integration by parts, we have

$$TVaR_\alpha(Y_i(t)) = S_i(0)e^{rt}\Big[1 - \frac{1}{\alpha}exp\{(\mu_i - r)t\}\Phi\big[-\Phi^{-1}(1-\alpha) - \sqrt{t\sum_{j=1}^{m}\sigma_{ij}^2}\big]\Big]$$

Hence, in the both cases, $TVaR_\alpha(Y_i(t))$ has the same form.
Since

$$\begin{aligned}\Phi\big[-\Phi^{-1}(1-\alpha) - \sum_{j=1}^{m}\sqrt{\sigma_{ij}t}\big] &> \Phi\big[-\Phi^{-1}(1-\alpha)\big] \\ &= \Phi\big[\Phi^{-1}(\alpha)\big] = \alpha\end{aligned}$$

then $TVaR_\alpha(Y_i(t))$, $i = 1, 2, \ldots, m$, will become negative for large value of t if $\mu_i - r > 0$.
From portfolio $V(t) = n_1S_1(t) + n_2S_2(t) + \ldots + n_mS_m(t)$, n_i = number of stock in $S_i(t)$ $i = 1, 2, \ldots, m$.

So that

$$
\begin{aligned}
TVaR_\alpha(Y(t)) &= \sum_{i=1}^{m} n_i TVaR_\alpha(Y_i(t)) \\
&= \sum_{i=1}^{m} n_i\Big(S_i(0)e^{rt}\Big[1-\frac{1}{\alpha}exp\{(\mu_i-r)t\}\Phi\big[-\Phi^{-1}(1-\alpha)-\sqrt{t\sum_{j=1}^{m}\sigma_{ij}^2}\big]\Big]\Big)
\end{aligned}
$$

Then $TVaR_\alpha(Y(t))$ will also becoming negative for large value of t if $\mu_i - r > 0\ \forall i, i = 1, 2, \ldots, m$. So, in actual probability measure $TVaR_\alpha(Y(t))$ is not monotone with time as well.

3.3 Risks based on Wang's distortion function in Black-Scholes model

$$
\rho_W(Y_i(t)) = \int_0^{\infty} h_\lambda(P(Y_i(t)>x))dx + \int_{-\infty}^{0}[h_\lambda(P(Y_i(t)>x))-1]dx
$$

where

$$
h_\lambda(u) = \Phi\big[\Phi^{-1}(u)+\lambda\big],\ \lambda > 0
$$

We have

$$
\begin{aligned}
\rho_W(Y_i(t)) &= S_i(0)e^{rt} - S_i(0)exp\Big\{\mu_i t - \sqrt{t\sum_{j=1}^{m}\sigma_{ij}^2\lambda}\Big\} \\
&= S_i(0)e^{rt}\Big[1-exp\Big\{(\mu_i-r)t-\sqrt{t\sum_{j=1}^{m}\sigma_{ij}^2\lambda}\Big\}\Big]
\end{aligned}
$$

If $\mu_i - r > 0$ then $\rho_W(Y_i(t))$ is becoming negative for t large.
As same as VaR_α and $TVaR_\alpha$. We have risks measures of portfolio is

$$
\rho_W(Y(t)) = \sum_{i=1}^{m} n_i\Big(S_i(0)e^{rt}\Big[1-exp\Big\{(\mu_i-r)t-\sqrt{t\sum_{j=1}^{m}\sigma_{ij}^2\lambda}\Big\}\Big]\Big)
$$

If $\mu_i - r > 0\ \forall i, i = 1, 2, \ldots, m$ then $\rho_W(Y(t))$ is also becoming negative for t large.

Next, we consider the general case of strictly concave distortion function h.

3.4 General case for risk in Black-Scholes model

Note that since h is increasing, h has countable discontinuity points. Moreover, for coherent risk measures, the distortion h is strictly concave which implies that h' is continuous everywhere.
We have

$$
\begin{aligned}
\rho(Y_i(t)) &= S_i(0)\Bigg(\int_{-\infty}^{C_i} h(\Phi[z_i])\sqrt{t\sum_{j=1}^{m}\sigma_{ij}^2}\ exp\Big\{\Big(\mu_i-\frac{1}{2}\sum_{j=1}^{m}\sigma_{ij}^2\Big)t+\sqrt{t\sum_{j=1}^{m}\sigma_{ij}^2}z_i\Big\}dz_i \\
&\quad + \int_{C_i}^{\infty}[h(\Phi[z_i])-1]\sqrt{t\sum_{j=1}^{m}\sigma_{ij}^2}\ exp\Big\{\Big(\mu_i-\frac{1}{2}\sum_{j=1}^{m}\sigma_{ij}^2\Big)t+\sqrt{t\sum_{j=1}^{m}\sigma_{ij}^2}z_i\Big\}dz_i\Bigg) \\
&= S_i(0)e^{rt}\Big[1-e^{(\mu_i-r)t}\int_{-\infty}^{\infty}h'(\Phi[z_i])\frac{1}{\sqrt{2\pi}}exp\Big\{-\frac{1}{2}\Big(z_i-\sqrt{t\sum_{j=1}^{m}\sigma_{ij}^2}\Big)^2\Big\}dz_i\Big]
\end{aligned}
$$

where

$$C_i = \frac{rt - (\mu_i - \frac{1}{2}\sum_{j=1}^{m}\sigma_{ij}^2)t}{\sqrt{\sum_{j=1}^{m}\sigma_{ij}^2 t}}$$

if $\mu_i - r \geq 0$ and $\int_{-\infty}^{\infty} h'(\Phi[z_i])\frac{1}{\sqrt{2\pi}}exp\Big\{-\frac{1}{2}\Big(z_i - \sqrt{t\sum_{j=1}^{m}\sigma_{ij}^2}\Big)^2\Big\}dz_i$ is never equal to 0 then $\rho(Y_i(t))$ is eventually negative at long horizons. Then

$$\begin{aligned}\rho(Y(t)) &= \sum_{i=1}^{m} n_i\rho(Y_i(t))\\ &= \sum_{i=1}^{m} n_iS_i(0)e^{rt}\Big[1 - e^{(\mu_i - r)t}\int_{-\infty}^{\infty} h'(\Phi[z_i])\frac{1}{\sqrt{2\pi}}exp\Big\{-\frac{1}{2}\Big(z_i - \sqrt{t\sum_{j=1}^{m}\sigma_{ij}^2}\Big)^2\Big\}dz_i\Big]\end{aligned}$$

is eventually negative at long horizons.
The following Theorems illustrate the situation under some conditions.

Theorem 1 If $h'(\Phi(z_i))$ is bounded by some constant $C \neq 0$ on $[0,1]$ then $\rho(Y(t))$ is negative as t goes to ∞.

Proof. We have

$$\begin{aligned}&\int_{-\infty}^{\infty} h'(\Phi[z_i])\frac{1}{\sqrt{2\pi}}exp\Big\{-\frac{1}{2}\Big(z_i - \sqrt{t\sum_{j=1}^{m}\sigma_{ij}^2}\Big)^2\Big\}dz_i\\ \geq& C\int_{-\infty}^{\infty}\frac{1}{\sqrt{2\pi}}exp\Big\{-\frac{1}{2}\Big(z_i - \sqrt{t\sum_{j=1}^{m}\sigma_{ij}^2}\Big)^2\Big\}dz_i\\ \geq& C > 0\end{aligned}$$

Therefore

$$e^{(\mu_i - r)t}\int_{-\infty}^{\infty} h'(\Phi[z_i])\frac{1}{\sqrt{2\pi}}exp\Big\{-\frac{1}{2}\Big(z_i - \sqrt{t\sum_{j=1}^{m}\sigma_{ij}^2}\Big)^2\Big\}dz_i$$

tends to ∞ as $t \to \infty$. So, $\rho(Y_i(t))$ is negative for t large.
Hence $\rho(Y(t))$ is negative as t goes to ∞. $\blacksquare$

Theorem 2 if $\mu_i - r - \frac{1}{2}\sum_{j=1}^{m}\sigma_{ij}^2 > 0$ then $\rho(Y(t))$ is negative as t goes to ∞.

Proof. Note that since h is increasing then $h'(\Phi[z_i])$ is nonnegative. Moreover, since h' is continuous and h' cannot be 0 (due to the definition of $\rho(Y_i(t))$, there exists a closed subset A_i of $[0,1]$ with non-zero measure and a constant a_0^i such that

$$h'(u) \geq a_0^i \text{ for all } u \in A_i$$

then

$$\int_{-\infty}^{\infty} h'(\Phi[z_i])\frac{1}{\sqrt{2\pi}}exp\Big\{ -\frac{1}{2}\Big(z_i-\sqrt{t\sum_{j=1}^{m}\sigma_{ij}^2}\Big)^2\Big\}dz_i$$

$$=\int_{\Phi^{-1}(A_i)} h'(\Phi[z_i])\frac{1}{\sqrt{2\pi}}exp\Big\{ -\frac{1}{2}\Big(z_i-\sqrt{t\sum_{j=1}^{m}\sigma_{ij}^2}\Big)^2\Big\}dz_i$$

$$+\int_{R\backslash\Phi^{-1}(A_i)} h'(\Phi[z_i])\frac{1}{\sqrt{2\pi}}exp\Big\{ -\frac{1}{2}\Big(z_i-\sqrt{t\sum_{j=1}^{m}\sigma_{ij}^2}\Big)^2\Big\}dz_i$$

$$\geq\int_{\Phi^{-1}(A_i)} a_0^i\frac{1}{\sqrt{2\pi}}exp\Big\{ -\frac{1}{2}\Big(z_i-\sqrt{t\sum_{j=1}^{m}\sigma_{ij}^2}\Big)^2\Big\}dz_i$$

$$+\int_{R\backslash\Phi^{-1}(A_i)} h'(\Phi[z_i])\frac{1}{\sqrt{2\pi}}exp\Big\{ -\frac{1}{2}\Big(z_i-\sqrt{t\sum_{j=1}^{m}\sigma_{ij}^2}\Big)^2\Big\}dz_i$$

A_i is close subset of $[0,1]$, we can assume that A_i is an interval in $[0,1]$. Therefore,$\Phi^{-1}(A_i)$ is also an interval and assume that

$$\Phi^{-1}(A_i)=[a_i,b_i]$$

where $a_i\neq b_i$, Hence,

$$\int_{-\infty}^{\infty} h'(\Phi[z_i])\frac{1}{\sqrt{2\pi}}exp\Big\{ -\frac{1}{2}\Big(z_i-\sqrt{t\sum_{j=1}^{m}\sigma_{ij}^2}\Big)^2\Big\}dz_i$$

$$\geq\int_{a_i}^{b_i} a_0^i\frac{1}{\sqrt{2\pi}}exp\Big\{ -\frac{1}{2}\Big(z_i-\sqrt{t\sum_{j=1}^{m}\sigma_{ij}^2}\Big)^2\Big\}dz_i$$

$$+\int_{R\backslash A_i} h'(\Phi[z_i])\frac{1}{\sqrt{2\pi}}exp\Big\{ -\frac{1}{2}\Big(z_i-\sqrt{t\sum_{j=1}^{m}\sigma_{ij}^2}\Big)^2\Big\}dz_i$$

$$\geq a_0^i\Big[\Phi\Big(b_i-\sqrt{t\sum_{j=1}^{m}\sigma_{ij}^2}\Big)-\Phi\Big(a_i-\sqrt{t\sum_{j=1}^{m}\sigma_{ij}^2}\Big)\Big]$$

$$+\int_{R\backslash A_i} h'(\Phi[z_i])\frac{1}{\sqrt{2\pi}}exp\Big\{ -\frac{1}{2}\Big(z_i-\sqrt{t\sum_{j=1}^{m}\sigma_{ij}^2}\Big)^2\Big\}dz_i$$

By Mean Value Theorem, we have

$$[\Phi\Big(b_i-\sqrt{t\sum_{j=1}^{m}\sigma_{ij}^2}\Big)-\Phi\Big(a_i-\sqrt{t\sum_{j=1}^{m}\sigma_{ij}^2}\Big)\Big]\geq(b_i-a_i)exp\Big\{-\frac{1}{2}\Big(b_i-\sqrt{t\sum_{j=1}^{m}\sigma_{ij}^2}\Big)^2\Big\}$$

Therefore

$$e^{(\mu_i-r)t}\int_{-\infty}^{\infty} h'(\Phi[z_i])\frac{1}{\sqrt{2\pi}}exp\Big\{ -\frac{1}{2}\Big(z_i-\sqrt{t\sum_{j=1}^{m}\sigma_{ij}^2}\Big)^2\Big\}dz_i$$

$$\geq e^{(\mu_i - r)t} a_0^i (b_i - a_i) exp\Big\{ -\frac{1}{2}\Big(b_i - \sqrt{t\sum_{j=1}^{m}\sigma_{ij}^2}\Big)^2\Big\}$$

$$\geq a_0^i (b_i - a_i) exp\Big\{\Big(\mu_i - r - \frac{1}{2}\sum_{j=1}^{m}\sigma_{ij}^2\Big)t - z_i\sqrt{t\sum_{j=1}^{m}\sigma_{ij}^2} - \frac{1}{2}z_i^2\Big\}$$

implies

$$e^{(\mu_i - r)t}\int_{-\infty}^{\infty} h'(\Phi[z_i])\frac{1}{\sqrt{2\pi}} exp\Big\{ -\frac{1}{2}\Big(z_i - \sqrt{t\sum_{j=1}^{m}\sigma_{ij}^2}\Big)^2\Big\}dz_i$$

is getting larger than 1 for t large and therefore $\rho(Y_i(t))$ is becoming negative for t large. Hence $\rho(Y(t))$ is negative as t goes to ∞. ■

Theorem 3 If $h'(1) > 0$ then $\rho(Y(t))$ is negative as t goes to ∞.

Proof.(Note that we are considering the concave distortion function, so h' is deceasing)

Indeed, we have

$$\int_{-\infty}^{\infty} h'(\Phi[z_i])\frac{1}{\sqrt{2\pi}} exp\Big\{ -\frac{1}{2}\Big(z_i - \sqrt{t\sum_{j=1}^{m}\sigma_{ij}^2}\Big)^2\Big\}dz_i$$

$$\geq \int_{-\infty}^{\sqrt{t\sum_{j=1}^{m}\sigma_{ij}^2}} h'(\Phi[z_i])\frac{1}{\sqrt{2\pi}} exp\Big\{ -\frac{1}{2}\Big(z_i - \sqrt{t\sum_{j=1}^{m}\sigma_{ij}^2}\Big)^2\Big\}dz_i$$

$$\geq \frac{1}{2}h'\Big(\sqrt{t\sum_{j=1}^{m}\sigma_{ij}^2}\Big)$$

$$\geq \frac{1}{2}h'(1) > 0$$

Therefore

$$e^{(\mu_i - r)t}\int_{-\infty}^{\infty} h'(\Phi[z_i])\frac{1}{\sqrt{2\pi}} exp\Big\{ -\frac{1}{2}\Big(z_i - \sqrt{t\sum_{j=1}^{m}\sigma_{ij}^2}\Big)^2\Big\}dz_i$$

is getting larger then 1 for t large and hence $\rho(Y_i(t))$ is becoming negative for t large. Hence $\rho(Y(t))$ is negative as t goes to ∞. ■

Theorem 4 If

$$\lim_{t\to\infty}\Big(e^{(\mu_i - r)t} h'\Big(\Phi\Big(\sqrt{t\sum_{j=1}^{m}\sigma_{ij}^2}\Big)\Big)\Big) = +\infty$$

then $\rho(Y(t))$ is negative as t goes to ∞.

Proof. Indeed, similar to the above theorem, we have

$$e^{(\mu_i - r)t}\int_{-\infty}^{\infty} h'(\Phi[z_i])\frac{1}{\sqrt{2\pi}} exp\Big\{ -\frac{1}{2}\Big(z_i - \sqrt{t\sum_{j=1}^{m}\sigma_{ij}^2}\Big)^2\Big\}dz_i$$

$$\geq e^{(\mu_i - r)t} h'\Big(\Phi\Big(\sqrt{t\sum_{j=1}^{m}\sigma_{ij}^2}\Big)\Big)$$

Therefore,

$$e^{(\mu_i - r)t}\int_{-\infty}^{\infty} h'(\Phi[z_i])\frac{1}{\sqrt{2\pi}}exp\Big\{-\frac{1}{2}\Big(z_i - \sqrt{t\sum_{j=1}^{m}\sigma_{ij}^2}\Big)^2\Big\}dz_i$$

is getting larger then 1 for t large and therefore $\rho(Y_i(t))$ is becoming negative for t large. Hence $\rho(Y(t))$ is negative as t goes to ∞. ■

4. **Conclusions.** If $S_i(t)$, $i = 1, 2 \ldots, m$, are comonotonic, $VaR_\alpha(Y(t))$, $TVaR_\alpha(Y(t))$ and general case of strictly concave distortion function h for risks in Black-Scholes model of portfolio under actual probability are not monotone increasing with time.

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INFORMATION EFFICIENCY OF STOCK MARKETS

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ABSTRACT. *The efficiency of a stock market is principally measured by its information efficiency which is closely related to the information in stock markets. However, there is no uniform definition of information from the economy perspective since different researchers may have various opinions on the information of stock markets. In this research, a comparatively strict definition of information in Economics is presented. Based on this definition, the optimal conditions to reach the maximum information efficiency of stock markets are derived. The conclusion is: only when the market's operation and information transmission mechanisms are fully effective, and its information completeness degree is optimal, will the information efficiency of stock markets be optimal. Based on the conclusions, the information efficiency of reality stock markets is studied and the corresponding supervision countermeasures are suggested.*

Keywords: Information Definition; Stock Market; Information Efficiency

1. Introduction. The fundamental significance of the stock market lies in that it can efficiently allocate society's capital resource to promote the overall socio-economic development through its inherent market functions. The effectiveness of the basic capital resource allocation function of a stock market depends on the maturity degree of the market. "Market efficiency" is one of the metrics to evaluate the maturity degree of the market. The market efficiency can be differently understood based on different standing points: in macro sense, it can refer to functionality efficiency (Samuelson, 1965; Merton, 1992; Dow and Gorton, 1997), insurance efficiency (Arrow and Debreu, 1954), Tobin (1984)) or pricing efficiency (Samuelson, 1975); in micro sense, it may refer to operational efficiency (O`Hara, 1995) or the information efficiency (Fama, 1970).

The functionality efficiency of a stock market is defined as the efficiency of service provision of the stock market for the economic operation. The services include, providing direct financing to reduce corporate financing costs, creating premise for information gathering and outlet for the information spreading, aiding the macroeconomic control, guiding the flow of social capital to optimize the capital allocation, offering more effective corporate management structures, and promoting more rational use of assets and more effective redistribution of income. The insurance efficiency is: the stock market can provide insurance for the future delivery of goods and services for economic entities, the efficiency of which is referred to as insurance efficiency. If stock price is made based on "rational expectations" of future cash flows, then the stock market prices the company's securities unbiasly, the efficiency of which is referred to as pricing efficiency. Operational efficiency of stock markets refers to the efficiency a stock market executes the transactions for investors. Information efficiency, also known as the effectiveness of market information, that is how much stock price has sufficiently absorbed and reflected all available information. For high information efficiency, no investor can continuously gain excessive

Indeed, the above stock market efficiencies in various senses are organically correlated logically and functionally (Shi, 2001): the operational efficiency provides the micro-foundation for information efficiency; information efficiency is a prerequisite for markets to achieve pricing efficiency; pricing efficiency and insurance efficiency is a necessary condition for stock markets to realize functionality efficiency, which plays a key role for effectively allocating social resources and redistributing social income.

Through analysis above, essentially, the information efficiency of stock markets is the most important. So far, researches focusing on the information efficiency (Hua and Lu, 2001; He and Gao, 2001; Jin et al., 2000) have different understandings on information, which, however, are all extensions of information but not the intension. Moreover, few existing researches apply formal mathematical model to investigate the information efficiency. In this paper, we will derive a more strict definition of information in sense of economic with mathematical method. Within our information definition, we derive optimal conditions for maximizing information efficiency in the stock markets, based on the which, we suggest corresponding supervision strategies.

2. Definition of information in Economics. So far, there is no universally accepted definition on the information in sense of economic (Chen, 1998). Marsac (1959), Chen (1998) points out the posterior conditional distribution based on observed signals is generally different from the prior distribution and such probability difference is the consequence of information access. Arrow (1977), Chen (1998) believes that information is observation results based on which the probability changes according to the principle of conditional probability. The later scholars make great efforts to agree on one viewpoint (Chen, 1998): information in the Economics, in essence, is probabilistic knowledge difference caused by difference among market participants and event states in economic. Inspired by this viewpoint, we consider that the economic information should include three aspects: the observed signal, the degree of consistency between signal and the natural state and recognition of the natural state implied by this consistency degree. In the following the three aspects are separately discussed, based on which a strict definition of economic information is presented.

Assume the set of economic environment states is Ω, i.e. the set of all the natural states of factors and events which directly or indirectly influence the market. Market participants have a common objective prior probability with regard to the state of natural environment, it is represented by a given probability distribution P on Ω. When Ω is infinite, because $\sum_{k=1}^{\infty} P(\omega_k)$ =1, which is series convergence, $\lim\limits_{k\to\infty} P(\omega_k)=0$ holds, (here $P(\omega) \triangleq P(\{\omega\})$). For example

$$\{P(\omega_k)=\frac{1}{k(k+1)} \mid k=1,2,\cdots\}$$

meets the requirement. When Ω is finite, assume $\Omega=\{\omega_k \mid k=1,2,\cdots,m\}$, we can expand Ω into $\Omega=\{\omega_k \mid k=1,2,\cdots\}$ by defining $P(\omega_k)=0, k=m+1,m+2,\cdots$. By doing so, we only consider Ω as infinite in the following. In the economic sense, this assumption means that the market participants have known the objective probability distribution on natural states, and have "roughly" ordered the objective probabilities where less objective probability is "roughly" put in the back. It should be noted that such order is not necessarily monotonous.

Define signal mapping $\varphi: \Omega \to S$, $\varphi(\omega) = s$. s is signal participants observe when natural state is ω. Typical signals include price, cost, volume etc. S is the set of all possible values of φ, referred to as signal type set of participants. We assume that the participants assign each element of S with a subjective prior probability, i.e. $P(\varphi^{-1}(s)) > 0, \forall s \in S$, where $\varphi^{-1}(s) = \{\omega \mid \omega \in \Omega, \varphi(\omega) = s\}$. This assumption is reasonable as long as the participants are confident with their observed signal. Based on the property of probability, for $\omega \in \varphi^{-1}(s)$, $P(\omega) \le P(\varphi^{-1}(s))$ holds. Therefore if $\omega \in \varphi^{-1}(s)$ and $P(\omega) = 1$, $P(\varphi^{-1}(s)) = 1$ holds. Assume: (i) $P(\varphi^{-1}(s)) = 0$ when $P(\omega) = 0$, because $\{\omega\} = \phi$ implies $\varphi^{-1}(s) = \phi$; (ii) $P(\varphi^{-1}(s_1)) \le P(\varphi^{-1}(s_2))$ when $P(\omega_1) < P(\omega_2)$, where $\varphi(\omega_i) = s_i, i = 1,2$ ($s_1 = s_2$ is possible), namely, a signal corresponding to natural state with larger possibility is assigned with a larger subjective prior probability. These assumptions are relatively reasonable. From the economic perspective, these assumptions denote that market participants have subjective (priori) knowledge on the possibility of natural states based on the observed signal. These assumptions also mean participants set the subjective probability of natural state as positive, and such setting satisfies monotonicity and boundary conditions of the objective probability.

If participants receive signal $s \in S$, they infer whether each state ω belongs to $\phi^{-1}(s)$ and assign the state with a posterior probability:

$$P(\omega \mid s) = \begin{cases} P(\omega)/P(\varphi^{-1}(s)), & \omega \in \varphi^{-1}(s), P(\omega) > 0; \\ 0, & \omega \notin \varphi^{-1}(s), P(\omega) > 0; \\ 1, & P(\omega) = 0 \end{cases} \tag{1}$$

In (1), the first equation is derived from the definition of conditional probability. The second equation is because such conditional event is impossible. The third equation holds because $P(\omega)/P(\varphi^{-1}(s))$ is of $0/0$ type; then according to the monotonicity assumption (ii), $P(\varphi^{-1}(s))$ scales down as $P(\omega)$ decreases, so we can assign it with 1. From an economic sense, formula (1) denotes that market participants have a new subjective (a posterior) knowledge on the probability of natural states according to the observed signal, and determine the value of such probability according to the ratio of objective probability of natural state to subjective prior probability , meeting boundary conditions.

Define the degree of consistency of signal $\varphi(\omega) = s$ to natural state ω:

$$d: \ \Omega \times S \to R \ \text{(real set)}$$

$$d(\omega, s) = P(\omega \mid s) - P(\omega) = \begin{cases} [1 - P(\varphi^{-1}(s))]P(\omega)/P(\varphi^{-1}(s)), & \omega \in \varphi^{-1}(s), P(\omega) > 0; \\ -P(\omega), & \omega \notin \varphi^{-1}(s), P(\omega) > 0; \\ 1, & P(\omega) = 0 \end{cases} \tag{2}$$

Obviously, $-1 \le d(\omega, s) \le 1$.

When $d(\omega, s) = 0$, $P(\omega \mid s) = P(\omega)$. This means the signal s can hardly help participants to identify whether state $\{\omega\}$ appears.

When $-1 \le d(\omega,s) < 0$, it must hold that $P(\omega \mid s) = 0$ and $d(\omega,s) = -P(\omega)$. It indicates that participants observe the signal s but believe $\omega \notin \varphi^{-1}(s)$. If $\{\omega\}$ is a realized state (the probability $\{\omega\}$ appears is $P(\omega)$), such belief is an opposite recognition of observed signal on the realized state. The closer is $d(\omega,s)$ to -1, the stronger is the degree of the opposite recognition. Especially, when $d(\omega,s) = -1$, $P(\omega) = 1$, which means appearance of state $\{\omega\}$ is an inevitable event, while observed signal s result in an absolutely opposite recognition on the realized state $\{\omega\}$.

When $0 < d(\omega,s) \le 1$, $P(\omega \mid s) > P(\omega)$. This indicates that observed signal s can help recognition on the state $\{\omega\}$ to some extent. Notice that $0 \le P(\omega) \le 1$ and $0 \le P(\omega \mid s) \le 1$, hence the closer is $d(\omega,s)$ to 1, the more $P(\omega)$ reaches 0 and the more $P(\omega \mid s)$ reaches 1. This means the more state $\{\omega\}$ is a small probability event; the more correct of the recognition on the state $\{\omega\}$ based on the observed signal s. This conclusion is relied on the previous monotonicity assumption (ii): $P(\varphi^{-1}(s))$ decreases as $P(\omega)$ decreases. Especially, when $P(\omega) = 0$ as well as $P(\omega \mid s) = 1$, $d(\omega,s) = 1$ holds and vice versa.

In essence, the market participants recognize the real situation of natural states based on the difference between subjective posterior probability (based on the observed signal) and objective natural state's probability. Such recognition may be consistent with or contrary to the real situation.

Based on the above analysis, we give a formal definition of information as follows:

Definition of Information. for given space (Ω, S, P, φ, d), when $d(\omega,s) > 0$, the increased recognition degree on the state $\{\omega\}$ appearance caused by observed signal s is known as information (positive information); when $d(\omega,s) < 0$, the opposite recognition degree on the state $\{\omega\}$ appearance induced by observed signal s is known as noise (negative information).

With terms in information theory, the significance of $d(\omega,s)$ can be re-explained as follows: $d(\omega,s) = 0$ denotes observed signal s does not convey any information of natural state $\{\omega\}$; $d(\omega,s) > 0$ means observed signal s represents information of natural state $\{\omega\}$ to some extent; $d(\omega,s) < 0$ indicates observed signal s reflects negative information of natural state $\{\omega\}$ to some extent. The closer $d(\omega,s)$ is to 1, the stronger information of natural state $\{\omega\}$ observed signal s conveys. The closer $d(\omega,s)$ is to -1, the stronger noise of natural state $\{\omega\}$ observed signal s conveys.

In sense of information theory, above assumptions on (Ω, P) denotes that the information source of stock markets is open for all market participants (information users). The process of market participants' observing signal $\varphi(\omega) = s \in S$ is an information transmission and reception process. The process of market participants' assigning state ω with a posteriori probability $P(\omega \mid s)$ is an information judging process.

3. Information Efficiency and Practical Study of Stock Markets.

3.1. Information Efficiency of Stock Markets. To improve the information efficiency of stock markets, we should let the prices of stock fully reflect all information relate to pricing and guide investors to reasonably anticipate relevant information, so that stocks' prices can dynamically approach to their intrinsic values. Here the stock's price is one of the observed signals and the stock's intrinsic value is determined by the natural state. If the observed stock price accurately reflects information of the natural state, it faithfully reflects the intrinsic value of the stock. Based on this idea, we redefine information efficiency of stock market based on our definition of information in section 2.

Assume the set of stock market participants is N, s.t.$|N|=n$. For participant $i\in N$, let S_i, ϕ_i and d_i separately denote its signal type set, signal mapping and coincidence degree. Define $S=\prod_{i=1}^{n}S_i$ with its member $s=(s_1,s_2,\cdots,s_n)\in S$, where $s_i\in S_i, i=1,2,\cdots,n$. Hence for $(\omega,s)\in\Omega\times S$, $d(\omega,s)=$ $(d_1(\omega,s_1),d_2(\omega,s_2),\cdots,d_n(\omega,s_n))$.

Assume $B=\prod_{i=1}^{n}[-1,1]\subset R^n$ and f is a strictly monotonically increasing continuous function determined by *information transmission mechanism* of market on B:

$$f: \ B\to R, \ y=f(x_1,x_2,\cdots,x_n) \ \text{s.t.}|f(x)|\le 1, \ \forall x\in B \tag{3}$$

Let D denote completeness degree of information in the stock market. D can be determined by following mapping:

$$F: \Omega\times S\to R \ \ D=F(\omega,s)=f(d(\omega,s))=f(d_1(\omega,s_1),d_2(\omega,s_2),\cdots,d_n(\omega,s_n)) \tag{4}$$

Because of the strict monotone of f, the stronger information on natural state $\{\omega\}$ signal s conveys, i.e. the better consistency between signal $\varphi(\omega)=s$ and natural state $\{\omega\}$), the greater is the completeness degree of information in the stock market.

Proposition 2.1. Assume $\forall s_i\in S_i$, $\lim\limits_{P(\omega)\to 0}d_i(\omega,s_i)$, $i=1,2,\cdots,n$ are all finite. For specified f, the necessary and sufficient condition for maximizing the information completeness degree D is: for all $s\in S$, it holds

$$\lim_{P(\omega)\to 0}d_i(\omega,s_i)=1, i=1,2,\cdots,n \tag{5}$$

Proof: Define $D_{\max}=\max\limits_{d(\omega,s)\in B}\{D\}$, $f_{\max}=\max\limits_{x\in B}f(x)=f(1,1,\cdots,1)$.

Sufficient condition. Assume formula (5) holds. Because $-1\le d_i(\omega,s_i)\le 1$, $i=1,2,\cdots,n$ and f is a strictly increasing function, it holds that

$$D=f(d_1(\omega,s_1),d_2(\omega,s_2),\cdots,d_n(\omega,s_n))\le f_{\max}, \ \forall d(\omega,s)\in B$$

and therein $D_{\max}\le f_{\max}$. On the other hand, $D=f(d_1(\omega,s_1),d_2(\omega,s_2),\cdots,d_n(\omega,s_n))\le D_{\max}$, and because of (5) and f being continuous, it holds that

$$f_{\max}=\lim_{P(\omega)\to 0}f(d_1(\omega,s_1),d_2(\omega,s_2),\cdots,d_n(\omega,s_n))\le D_{\max}$$

Therefore $D_{\max}=f_{\max}$, i.e. the information completeness degree D achieves maximum.

Necessary condition. Assume D achieves maximum, i.e. $D_{\max}=f_{\max}$.

Proof by contradiction: If for a certain i, $\lim\limits_{P(\omega)\to 0}d_i(\omega,s_i)=a<1$ holds. Notice that when $k\to\infty$, $P(\omega_k)\to 0$ holds, so for $\varepsilon=(1-a)/2>0$, $\exists K_0>0$, when $k>K_0$, it holds that: $d_i(\omega_k, s_i) < a + \varepsilon = (1+a)/2 < 1$.

Define $b = \max\{(1+a)/2, d_i(\omega_1, s_i), d_i(\omega_2, s_i), \cdots, d_i(\omega_{K_0}, s_i) < 1$. It holds that

$$d_i(\omega_k, s_i) \le b < 1, \quad k = 1,2,\cdots$$

Then $\forall d(\omega, s) \in B$, $D = f(d_1(\omega, s_1), d_2(\omega, s_2), \cdots, d_n(\omega, s_n)) \le f(1, \cdots 1, b, 1, \cdots, 1)$

holds.

Thereby $$D_{\max} \le f(1, \cdots, 1, b, 1, \cdots, 1) < f(1, \cdots 1, 1, 1, \cdots, 1) = f_{\max}$$

which is contrary to the condition. Hence $\lim\limits_{P(\omega)\to 0} d_i(\omega, s_i) = 1, i = 1,2,\cdots,n$. Proof completed.

Note 2.1. Proposition 2.1 illustrates the information completeness D achieves maximum when the information on natural state $\{\omega\}$ observed signal s transmits reaches maximum.

Further, we assume that the mapping f is f^* when the market information transmission mechanism is fully effective, (i.e. $\forall f, f_{\max} \le f^*_{\max}$). If the information completeness degree D achieves maximum for f^*, then for any f, the information completeness degree D achieves maximum.

Note 2.2. When $\Omega = \{\omega_k \mid k = 1,2,\cdots,m\}$, according to the previous prescription : $P(\omega_k) = 0$, $k = m+1, m+2, \cdots$, condition of proposition 2.1 is automatically satisfied and therein the information completeness degree D achieves maximum. Define

$$D_r = \max_{d(\omega_k, s)\in B} \{f(d(\omega_1, s)), f(d(\omega_2, s)), \cdots, f(d(\omega_m, s))\}$$

and generally we have $P(\omega_k) > 0$, $k = 1,2,\cdots,m$. Therefore $d(\omega_k, s) < 1$, $k = 1,2,\cdots,m$, $\forall s \in S$. Hence $D_r < f_{\max} = D_{\max}$. This means that the practical maximum of information completeness degree D is less than the theoretical one when the number of considered state of nature is inadequate.

Assume value range of f is R_f and g is a strictly increasing continuous function determined by *operation mechanism* of market on R_f

$$g: R_f \to R, \quad z = g(y), \text{ s.t. } |g(y)| \le 1, \forall y \in R_f \tag{6}$$

Let E_I denote information efficiency of the stock market. E_I can be determined by the following mapping:

$$G: \Omega \times S \to R, \quad E_I = G(\omega, s) = g(D) = g(f(d_1(\omega, s_1), d_2(\omega, s_2), \cdots, d_n(\omega, s_n))) \tag{7}$$

So the information efficiency of the stock market is determined by the completeness degree of market information, transmission mechanism of market information and operation mechanism of markets.

Proposition 2.2. When information transmission and operation mechanisms of a market are fully effective, as well as the information completeness D achieves maximum, information efficiency E_I of the stock markets will achieve maximum. Proof of proposition 2.2 is similar to proposition 2.1.

3.2. Study of Information Efficiency in Practical Stock Markets. According to the above analysis, within our information framework, the condition for maximizing information efficiency E_I of a stock market is: 1) the relevant information are fully disclosed and uniformly distributed to participants, i.e. there is no information asymmetry; 2) information transmission and operation mechanisms of the market are sufficiently effective; 3) market participants make rational judgments on the information; 4) the information completeness degree D achieves maximum.

However, in the practical stock market, the information contains noise, the information collection const money and time, and different participants may possess different capabilities in information collection and analysis, therefore the information owned by market participants is incomplete and asymmetrical, i.e. $d(\omega, s_i) < 0$ for some $i \in N, \omega \in \Omega$. Hence information efficiency E_I of practical stock markets cannot achieve maximum.

In practical stock markets, information asymmetry among different stakeholders is ubiquitous. For instance, institutional investors possess more information than individual investors; investors close to information sources possess more information than those far away from sources of information. Moreover the information is time sensitive. Investors who first receive bullish information can mobilize capital in time to preemptively buy cheap stock, while participants who later receive information only follow the trend and purchase stock with prices already raised. On the other hand investors who receive bearish information earlier can sell stocks earlier to avoid loss, while participants receiving information later can only close positions with loss or get hooked. There is significant difference between investors asynchronously receiving information, therefore speculative gains by making use of information may far exceed the normal investment return. If the market is flooded with such opportunities, imbalance between supply and demand can never be eliminated and prices continuously rise or drop and the market is unstable.

A more severe problem is, by taking advantage of their considerable capitals and superiority to access information, market manipulators purposely generate noise in the stock market and therein change the investors' expectations. They can further generate irrational market bubble by using of the herd behavior, excessive reaction and self-reinforcing mechanism of the market. By doing so, they impair the market's overall information completeness degree, and thus result in information inefficiency. When manipulators exist, the model of information efficiency in stock markets is:

$$E'_I = \alpha w E_I + (1 - w) E_I$$

where w denotes the capital weight of market manipulators, s.t. $0 < w < 1$; α denotes reduction coefficient of information efficiency caused by the noise of market manipulation s.t. α <1 (α <0 is possible), which means $1-\alpha$ (>0) is the expanded coefficient of information inefficiency caused by noise. Let $\Delta E_I = E_I - E'_I = (1-\alpha) w E_I$ denote the loss of market information caused by noise. Obviously, the larger the capital weight w of market manipulators is, the larger is the expanded coefficient $1-\alpha > 0$ creating inefficient of information, then the greater is the loss of information efficiency in market. Especially, when $1-\alpha > 1/w$, $E'_I < 0$ holds, i.e. information efficiency in market is of negative

Particularly, in China's stock markets, because information asymmetry and incompleteness is more severe, and irrational investment and manipulating behavior floods the market. Moreover, because securities are generally of low intrinsic value, pursuit of short-term speculative gains becomes the main drive of security transactions, which increase the stock market's risk and degree of non-rational bubbles. Hence in China's stock market, abnormal fluctuations in security price is more frequent and the market is harder to achieve stable dynamic equilibrium.

4. Supervision Methods for Improving Information Efficiency. According to discussions in section 3, the information efficiency of a stock market is positively correlated to its operation mechanism, its information transmission mechanism and the information on natural state $\{w\}$ observed signal s transmits. The improvement of operational efficiency has been investigated by a lot of literatures and thus not discussed here. The second condition involves the information disclosure. Here the information disclosure does not only refer to disclosure of financial information of listed companies, but also should include disclosure of natural states of all factors and events directly or indirectly impacting the market. Also the information disclosure is required to be reflected by observed signal (such as stock price, trading volume, etc). To fulfill such information disclosure, first, the listed company should disclose not only its complete financial information, but also its business status, investment status, competitive status, capital and dividend status and status of the industry it belongs to. Secondly, the relevant state departments and the media should fully disclose the macroeconomic information related to stock markets, and increase new indicators to clearly illustrate these information if necessary. Finally, both institutional investors and capable individual investors should be willing to pay the cost for mining and judging information related to the stock markets; also they should transmit these information to the stock markets through the medium of stock price. By doing so, managers and ordinary market participants can have more rational understanding on the intrinsic link between the information and stock price, and thus are more enthusiastic on investment.

In addition, we should establish a good formation mechanism of stock price to avoid price manipulation, so that stock price can more accurately reflect the intrinsic value of stock. Moreover, we should strictly supervise the market and strengthen punishment on information distortion and market manipulation.

5. Conclusion. In this research, we formally define the information in sense of economy. Based on the information modeling, a stock market's information efficiency E_I is optimal when its transmission and operation mechanisms are sufficiently effective and its information completeness degree D reaches maximum. Optimal information efficiency of a stock market can ensure high effectiveness of the stock market and form a long-term stable dynamic equilibrium on the stock price.

In real stock markets, the real information efficiency values vary for the degrees of the information completeness and symmetry, as well as the rationality degree of market participants. When degrees of information asymmetry and incompetence and participant irrationality are pretty high, the information efficiency will be greatly impaired. The consequence is abnormal volatility in security price are more frequent and the market is very difficult to achieve stable dynamic equilibrium. In this research, from the perspectives of listed companies, state departments, media and investors, we discuss feasible supervision countermeasures for real stock market to make information efficiency approach the optimal value.

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EVOLUTION ROUTES OF ENTERPRISE BRAND NETWORK WITHIN INDUSTRIAL CLUSTERS BASED ON THE PERSPECTIVE OF SYMBIOSIS

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ABSTRACT. *It has great significance to give academic attention on the brand romotion from the perspective of network and symbiosis. This paper discusses the concept of symbiosis in the enterprise brand network within industrial clusters (EBNIC), and revealed three types of symbiotic relations in EBNIC：mutualism, competitive symbiosis and paras-itism symbiosis. The evolution routes of EBNIC were divided into four phases: forming phase, mature phase of mutualism symbiosis dominant, mature phase of competitive symbiosis dominant and recession phase, which were described by logistic equations and its evolution characters were decomposed.*

Keywords: Evolution Route; Brand Network; Industrial Clusters; Symbiosis

1. Introduction. Brands conglomeration can appears when the industrial clusters develop to certain level, in which there are numerous bright brands produced with high growing rate, such as: low voltage electric apparatus clusters of LIUSHI, textile industrial clusters of CHANGSHU, SHISHI, and others. Brands conglomeration is not only the simply accumulations of individual brands, but also complicated connections exist. So it has great significance to give researches on the brand promotion from the perspective of network. Enterprise brand network within industrial clusters (EBNIC) is referred to the network structure linked by the intricate relations among the brands within industrial clusters. As present, EBNIC has received scant attention from academics. Only some literatures' discussion involved. Huang and Yang (2006) argued the idea of brand ecologic network. Wang and Han (2008) analyzed the evolution laws of brands populations about the roles of interactions among the brands from the perspective of ecological niche. Yao wk and Zhou (2009) proposed the concept of EBNIC, and analyzed the relational characters and meanings of enterprise brand network in clusters, This paper aims to discuss the concept of symbiosis in the environment of EBNIC, reveal types of symbiotic relations in EBNIC, describe its evolution routes by logistic equations, and shed lights on its evolution characters.

2. Symbiotic Relationship of Brands in Ebnic. Symbiosis is a concept from biology, which original meaning is referred to the phenomena that different Species with different beneficial relations live together to form a survival mean benefiting mutually. There are three kinds of symbiosis relationship existing in the enterprise brand network within industrial clusters (EBNIC): mutualism and competitive symbiosis.

(1) brands relation of Mutualism. Mutualism brand can be classified three forms in EBNIC: brand mutualism base on the supply chain, mutualism based on the externality, and mutualism base on the clusters brand effects. Brand Mutualism based on the supply chain referred to the mutual-benefited states in sales and raw materials buying which the brand can acquire in EBNIC. Enormous brands conglomerated in an area could attract more human resources, raw material providers, and other resources providers entering the industrial clusters, and improved the resource supply conditions of brand growth, which can form the brand mutualism based on the externality. In addition, enormous brand conglom- erating can magnify the overall awareness of the industrial clusters, and midwifery the clusters brand, which can boost the brand promoting subsequently.
(2) brand relations of competitive symbiosis. In EBNIC, it is not always exiting mutual benefit among the brands. Under some situations, the brands development can be restricted mutually, which were caused by the exiguity of land, market, financing, and infrastructure. When the brand expanded to some level in EBNIC, brands have to contest in resource acquiring, leaded to form the competitive symbiosis among the brands, which limited the brand growth. For example, more and more resource acquiring costs in low voltage electric apparatus clusters of LIUSHI, caused by the shortage of water, electricity, and infrastructure supply, have limited the brand development seriously.
(3) brand relations of parasitism symbiosis. with the exception of two typical symbiosis relations, the relations of parasitism symbiosis also existed in EBNIC, formed between the vigoroso brands and puny brands. In EBNIC, the vigoroso brands have strong driving on the puny brand. The puny brands can improve by using the vigoroso brands' market place, imitating the vigoroso brands' product, or building the supply chain with the vigoroso brands. In the relation of parasitism symbiosis, but the puny brands was is of no great consequence for the vigoroso brands.

The symbiosis relations was not invariable in the development stages of EBNIC, which will have different characters in different stages (table 1). During the primary stage of EBNIC, the mutualism relations are dominant, and during the recession stages of EBNIC, the relations of mutualism symbiosis can convert into relations of competitive symbiosis with the resource competitively intensifying more and more, which could lead to the recession of brands in EBNIC. Due to the disequilibrium characters of brand development, parasitism symbiosis could evolutes into the mutualism symbiosis and competitive symbiosis with certain conditions, too.

3. The Characters Analysis of Development Stages of Ebnic. Assuming that there are two brands population in EBNIC, which were represented by A and B, $N_1(t)$ and $N_2(t)$ represent A brands population, B brands population respectively. and K1and K2represent the utmost environment capacity of A, B brands population respectively(Yuan&Bi, 2006). and $r_1(t)$ and $r_2(t)$ represent the quantitative rate of growth of A, B brand population in time t respectively. δ represent the influence coefficient of one brands population on the other. positive coefficient represent the relations of mutualism symbiosis, and negative coefficient represent the relations of competitive symbiosis. $[K-N(t)]/K$ called logistic coefficient (Kincaid&Overcash, 2001), too, is the restriction term, and represent the relative distance of a brands population to utmost environment capacity.

TABLE 1. Symbiosis types of enterprise brand network within industrial clusters in different phases

Evolution stages of EBNIC	Characters of EBNIC	Character of symbiosis Relations	Situation of EBNIC
Forming stages of EBNIC	①No core enterprise and vigoroso brands，the influence and awareness of brands in EBNIC； ②The demand from the external market are high，and the competition among the brand in EBNIC are low； ③market strategy are poor, and the level of product difference low	1	Network Without centre
The mature stages of mutualism symbiosis domanint of EBNIC	①product begin to differentiate； ②the supply chain pefect，the labor division begin to segmentate; ③ the networks of production, sales and R&D become perfect, the forming conditions of brand are gradually mature. ④Cooperation and competition enjoined coexistence； ⑤cluster brand effects are prominent	1，2，3，4，5	Network without centre or single-centre network
The mature stages of competitive symbiosis domanint of EBNIC	①the product differentiate more； ③ the vigoroso bands begin to come forth to integrate the supply chain in EBNIC. ④Connection are close among the brands in EBNIC, and information and knowledge flowed smoothly. ④competitions are intensively among the brands, and crowd effects are high.	1，2，3，4，5	single- centre network or mutual-centre network
recession stages of of EBNIC	①the enterprise compete intensively among the materials ②market shrinked, and unhealthy competition are seriously. ③some brands exits from EBNIC, and the brands links breakout	4	Network decomposed

1-brand mutualism base on the supply chain, 2- mutualism based on the externality, 3- mutualism base on the clusters brand effects, 4-competitive symbiosis, 5- parasitism symbiosis

3.1. Forming Stages of EBNIC. In this stage, when $N_1(t)+N_2(t)<G$, the characters are δ_1〉0，δ_2〉0, the material of the brands growth demanding are ample, and no material competition among the brands in EBNIC, and only the relations of mutualism symbiosis based on the supply chain exist, the synergistic effect on the marketing development, external resource using and others can be acquired. In this stage, the mutual interaction among brands demonstrated learning and imitation effect, and the enterprises can promote their brands by cooperating with other brand on the technology, management marketing.

The logistic equation can be described as follows.

$$\begin{cases} \frac{dN_2(t)}{dt} = r_2(t)N_2(t)[\frac{K_2 - N_2(t)}{K_2} + \delta_1 N_1(t)] \\ \frac{dN_1(t)}{dt} = r_1(t)N_1(t)[\frac{K_1 - N_1(t)}{K_1} + \delta_2 N_2(t)] \end{cases} \tag{1}$$

The conditions of stable solution as follows:

$$d_{N1(t)} / dt = 0, d_{N2(t)} / dt = 0$$

In this stage, because A can't get the number of stability, $d_{N1(t)} / dt > 0$ and $d_{N2(t)} / dt > 0$ will always come into existence. Consequently, the number of brands in EBNIC can't get stability. As shown in figure 1.

3.2. The Mature Stages of Mutualism Symbiosis Dominant of EBNIC. When brands number in EBNIC get a high level, $N_1(t) + N_2(t) \geq G$, the limited of nature capacity will be breakthrough, Graedel and Allenby (2004), with the number of brands in EBNIC gradually growing. In this stage, the crowed effect will be prominent, and the market will gradually saturate, leading to the intensive competition among the brands. but in this stage, the mutualism symbiosis will be always dominants in EBNIC. The influence coeffcience brands population are δ_3 and δ_4, $\delta_3 < \delta_1$, $\delta_4 < \delta_2$, due to the crowding effect.

When $N_1(t) + N_2(t) \geq G$

$$\begin{cases} \frac{dN_2(t)}{dt} = r_2(t)N_2(t)[\frac{K_2 - N_2(t)}{K_2} + \delta_3 N_1(t)] \\ \frac{dN_1(t)}{dt} = r_1(t)N_1(t)[\frac{K_1 - N_1(t)}{K_1} + \delta_4 N_2(t)] \end{cases} \tag{2}$$

There are two groups of solutions for equations

Q=(0，0) and $P = [\frac{K_1(1+\delta_3 K_2)}{1-\delta_3\delta_4 K_1 K_2}; \frac{K_2(1+\delta_4 K_1)}{1-\delta_3\delta_4 K_1 K_2}]$

The Q solution was taken out because of his insignificance for the symbiosis in EBNIC. the necessary and sufficient conditions above can be global asymptotic stability of solution are as follows:

$1-\delta_3\delta_4 K_1 K_2 > 0$ and

$$\frac{r_1(t)(1+\delta_3 K_2)}{1-\delta_3\delta_4 K_1 K_2} + \frac{r_2(t)(1+\delta_4 K_1)}{1-\delta_3\delta_4 K_1 K_2} < 0 \tag{3}$$

when $1-\delta_3\delta_4 K_1 K_2 > 0$, and $\delta_3 K_1 < 1$, and $\delta_4 K_2 < 1$, p match the condition of global asymptotic stability of solution. The two brands populations can be symbiosis steadily. In this situation, the mutual-interactions of the brands in EBNIC are not strong, the strength of brands are counterbalance. The traits of EBNIC in this situation are Network Without centre.

When $1-\delta_3\delta_4 K_1 K_2 > 0$, if $\delta_3 K_1 > 1$, and $\delta_4 K_2 < 1$, or $\delta_3 K_1 < 1$, and $\delta_4 K_2 > 1$, p match the condition of global asymptotic stability of solution, too. In this situation, some brands have great influences on other brands in EBNIC, which are vigoroso brands in industrial clusters, and can provide supports for other brands in R&D, management, marketing and others aspect. the puny brands, parasitizing and valueless for the vigoroso brands, will be threaten by the vigoroso. If the acts of disrupting the marketing come true, the integration among brands will happen. In this phase, the brand number in EBNIC will be steady in point D(as figure1).

3.2. Mature Stages of Competitive Symbiosis Domanint of EBNIC. When the situation of resources and the market environment changed, and the brands competition intensively, and the crowding effect preponderated over the mutualism effect, the growth function of brand numbers in EBNIC will changed, which the influence coefficient of δ_5 δ_6 will turn to be negative, which represent the symbiosis relations turning from mutualism relations to the relations of competitive symbiosis. Some brands will integrate other brands, simultaneous some brands withdraw from the EBNIC with the driving of competitive symbiosis. The number of brands in EBNIC will reduce to B(as figure 1), and evolutes from B. The equation in this stage as follows.

$$\begin{cases} \dfrac{dN_2(t)}{dt} = r_2(t)N_2(t)[\dfrac{K_2 - N_2(t)}{K_2} - \delta_5 N_1(t)] \\ \quad (5) \\ \dfrac{dN_1(t)}{dt} = r_1(t)N_1(t)[\dfrac{K_1 - N_1(t)}{K_1} - \delta_6 N_2(t)] \end{cases} \tag{4}$$

St: $1-\delta_5\delta_6K_1K_2>0$

The stability of solution is as follows:

$$P = [\frac{K_1(1-\delta_5 K_2)}{1-\delta_5\delta_6 K_1 K_2}; \frac{K_2(1-\delta_6 K_1)}{1-\delta_5\delta_6 K_1 K_2}] \tag{5}$$

When $1-\delta_5\delta_6K_1K_2>0$,and $\delta_5K_1<1$, $\delta_6K_2<1$, p match the condition of global asymptotic stability of solution. The two brands populations, between which the interaction was not great, are counterbalance, and can be symbiotic steadily. The characters of EBNIC in this situation are network without centre. In this phase, the number of brands will be steady in point C (as figure1)

3.4. Recession Stages of EBNIC. ENBIC will enter into the recession phase if the disrupting to the stability comes true in EBNIC, such as vicious price competition caused by certain enterprise, the situation of market destroyed, market shrink, and abrupt recession or withdrawing of certain core brands causing the breakthrough of brands value chains. The equation in this phase are as follows.

$$\begin{cases} \dfrac{dN_2(t)}{dt} = r_2(t)N_2(t)[\dfrac{K_2 - N_2(t)}{K_2} - \delta_7 N_1(t)] \\ \quad (7) \\ \dfrac{dN_1(t)}{dt} = r_1(t)N_1(t)[\dfrac{K_1 - N_1(t)}{K_1} - \delta_8 N_2(t)] \end{cases} \tag{6}$$

The equation above subject to $1-\delta_7\delta_8K_1K_2<0$, $\delta_7K_1>1$, $\delta_8K_2>1$, and can't match the condition of global asymptotic stability of solution. Evolution states is as figure1

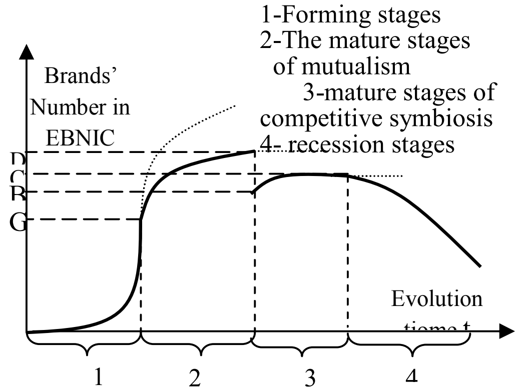

FIGURE 1. Dynamic evolution of enterprise brand network within industrial clusters

4. Conclusions and Future Direction. From the perspective of symbiosis, this paper tidied up the symbiosis relations in EBNIC, which were classified into three types: brands relation of Mutualism, brand relations of competitive symbiosis, and brand relations of parasitism symbiosis. the evolution routes of EBNIC were divided into four phase: Forming stages, The mature stages of mutualism symbiosis dominant of EBNIC, mature stages of competitive symbiosis domanint of EBNIC, and recession stages of of EBNIC. Every phase was described by logistic ,by which, the character of symbiosis relations were analyzed.

This paper only proposed some cute ideas about the evolution routes of EBNIC by ecological methods. In the future research, empirical date should be collected and to confirm proposes above.

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APPLICATION OF SERVICE BLUEPRINT AND FMEA IN SECURITY MANAGEMENT

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ABSTRACT. *Due to the increase in the diversity and complexity of the society and since most social activities are participated by large groups of people, the needs of people for security services increased over the years and the demand for the quality of the security services increased along with it. Traditional security management emphasized on using bodyguards because of their strong physique and quick reactions, but it does not have deep evaluation and control on the entire service process of security management. To overcome the shortcomings of the traditional security management, the two purposes of this study are: 1) to establish a service blueprint of the security management to display the service process through graphic visual; 2) using the service blueprint of security management as basis, compute the risk priority number (RPN) based on the occurrence rating (O), severity rating (S) and detection rating (D) of each potential failure modes through failure mode and effect analysis (FMEA) to evaluate high potential failure modes of RPN and maintain it at a lowest risk.*

Keywords: Security Management; Service Blueprinting; Failure Mode and Effects Analysis (FMEA)

1. Introduction. Due to the diversity of the society and internationalization brought by convenience in transportation and communication, different security problems arise. Thus, the thoughts and implementation of security management change continuously. For example, because of the 911 incident in 2001 that shocked the whole world, the USA government approved the Homeland Security Act of 2002 in 2002 where the Department of Homeland Security was established to be in charge of the national security of the USA. The vast scope of security management includes personal safety, property safety and even national security. Traditional security management emphasized on using bodyguards because of their strong physique and quick reactions but it does not have deep evaluation and control on the entire service process of security management. To overcome the shortcomings of the traditional security management, the two purposes of this study are: 1. to establish a service blueprint of the security management to display the service process through graphic visual. 2. Using the service blueprint of security management as basis, compute the risk priority number (RPN) based on the occurrence rating (O), severity rating (S) and detection rating (D) of each potential failure modes through failure mode and effect analysis (FMEA) to evaluate high potential failure modes of RPN and maintain it at a lowest risk.

2. Literature Review.

2.1. Security Management. The scope of security management is vast and it includes personal safety, property safety and even national security. This study focused on personal safety where the subjects provided with this service are people. This study provided timely, fixed or complete sets of security maintenance to the specific subjects according to their needs. Traditionally, the people who need personal safety are mostly politicians and people who have the public power and the resources to complete a task. Security management is needed due to the increase in the diversity and complexities of the society and since most social activities are participated by large groups of people. For example, when local or international actors, actresses, singers or athletes are in any public activities or any indoor and outdoor concerts and performances, there will surely have large groups of people who will attend. Therefore, these public figures have great needs for personal safety and their demand for the quality of the security service will also increase. Traditional security management emphasized on using bodyguards because of their strong physique and quick reactions but it does not have deep evaluation and control on the entire service process of security management. Besides that the situation can’t be fully controlled, lacking the ability to predict risk, lack of responsiveness, lack of monitoring and incomplete contingency planning can cause life-threatening situations, property damages, restrictions of freedom and even damage and delay of the project activities or affect the peace order.

2.2. Service Blueprinting. Blueprinting is often applied in construction where the architect or designer shows their design concept through architectural drawing. In the early days, the architectural drawing was recopied in a special type of paper which produces blue lines, thus are called blueprints. The whole process of the blueprint is displayed through graphic visual. Basically, blueprint is a two-dimensional picture where the horizontal axis represents the chronological order of the whole process and the vertical axis represents the actions in the different stages. The application of blueprinting is not limited to the industrial manufacturing process. Moreover, Shostack (1984, 1992) believed that the delivery process of services can also be expressed through blueprinting. Using blueprinting to design the service process is called service blueprinting.

Shostack (1984) suggested using service blueprinting to display the visual figure of the service to assist the process designer confirm the chronological order of the task of service, content of policy decision, flow of resources, customer interaction and service in the service process to let the participating service providers further understand the details of the content and process of the service. More importantly, adding client into the service blueprints to separate the contacts of the service and the client using the line of visibility can assist process designers set out from the client’s point of view. The designers can then strengthen the service quality of the clients’ contact points by thoroughly understanding the service process clients have experienced.

Kingman-Brundage (1989) suggested that aside from the line of visibility, the line of interaction can also be used to separate the interactions between the clients and the onstage employees and the line of internal interaction can be used to separate the actions of the internal support employees and onstage and backstage employees. Therefore, the actions of the clients, onstage employees, backstage employees and internal support employees can be separated using the line of interaction, line of visibility and line of internal interaction.

Fitzsimmons and Fitzsimmons (2008) suggested adding potential failure modes in the service blueprint. Finding potential failure modes in advance can add the recognition points in the process and using checklists to prevent failures in the recognition points can guarantee that the service provided in the service process is flawless.

2.3. Failure Mode and Effects Analysis. Failure mode and effects analysis (FMEA) was proposed in 1960 mainly to satisfy the high reliability and safety requirements of the aerospace industry. In 1960, the United States Department of Defense introduced FMEA to ensure high quality and established the army standard ‘‘MIL-STD-1629” and revised it to MIL-STD-1629A (Shostack, 1992) in 1980. Teoh and Case (2005) pointed out that the international organization for standardization (ISO) suggested the adoption of FMEA in 1990 and incorporated it in the standard of ISO9000 series. Revised FMEA has been widely applied in different fields. For example, aerospace, weapon manufacturing, machineries, automobiles, electronic industry, semiconductor and medical service, etc. FMEA plays an important role in the improvement of the reliability of industries on the overall system and the quality of the product and service.

Failure mode and effects analysis (FMEA) is an engineering technique used to ensure and eliminate known and potential failures and errors before all products or services are delivered to the client. It also evaluates the risk produced and adopts the appropriate actions. According to Teoh and Case (2005), there are two types of FMEA; one type of FMEA is at a designing stage where it handles and designs the related activities and the other type of FMEA is used to solve the manufacturing process. All FMEA analysis results are organized in a FMEA Table. Traditional FMEA separately consider a ten point system according to the characteristics of the product or service and calculate risk priority number (RPN) based on occurrence (O), detection difficulty (D), and severity (S). Traditional RPN can only provide the chronological order of the evaluated results. Rhee and Ishii (2003) considered cost of failures as one of the evaluation standard. Tarum (2001) conduct the evaluation based on the impact of failure on the financial status and proposed FMERA (Failure Modes, Effects, and Financial Risk Analysis) based from maximizing the financial benefits where a column with cost related information is added in the original FMEA Table.

3. Main Results. To improve the quality of their service, security firms integrate the security works of the workflow into standardized and systematic professional body security but clients will require security companies to provide more integrated and diversified quality service. Therefore, aside from the original basic security work of protecting the safety of the clients, security companies transform the emphasis of their role into security service and will certainly enhance the complexity of the security service process.

This study first applied service blueprinting to conduct a detailed research and analysis on the workflow of the security industry and draw a complete and detailed blueprint to describe the security service. Linking every process can provide security managers a more comprehensive and thorough understanding of the overall security service process and can accurately provide quality security service.

In general, security companies all possess a complete set of service process and control system and all participants can follow operating procedure and standard to provide quality security services and improve customer satisfaction. Scholars of service management believed that service blueprinting can help clearly identify the potential failure modes and weak links in the process of the provided service and thereby, improving the service quality. In other words, after the service blueprinting is complete, the manager can use the complete blueprint to view the steps or process of the possible failures and use this method to identify and improve the failure.

Although service blueprinting can identify the steps, process or points of potential failures, it can't provide further evaluation of the failure's steps or points. Thus, the service blueprinting of the whole process is used as the foundation in the context of security management. Besides that it can detect the link, scope and responsibility of failure, adding FMEA can evaluate, predict and control points of failures and can compute RPN through occurrence (O), detection difficulty (D) and severity (S). Service blueprinting can control the whole security service process to ensure that the quality of the security reached the controllable goal. In addition, adding the evaluation and prediction of FMEA on failures, it can reduce the risk further or even achieve the goal of zero risk.

4. Case Study. This study used the visit of two NBA teams, Denver Nuggets and Indiana Pacers, to Taiwan on October 6, 2009 as example. The players are the team's most important asset as well as the teams' soul. Especially for professional basketball teams, the worth of every player on the team is not cheap and there's certainly no need to stress on the importance of the players.

The process of the Denver Nuggets and Indiana Pacers' visit to Taiwan is divided into three parts: 1. arrival at Taiwan Taoyuan International Airport to check-in into the hotel, 2. hotel to the venue of the game and back to the hotel and 3. departing from Taiwan Taoyuan International Airport after the game. Figure 1 shows the service blueprint of the teams from their arrival to departure from Taiwan. As shown in Figure 1, the focuses of the security service are the in and out at the hotel, to and from the venue of the game, during the game and the running of the vehicles between the two locations is the focus of security services. Thus, the physical evidences of this study are "hotel security operation" and "court security operation" and are shown within the dash line in Figure 1.

The actions of the players shown within the dash line in Figure 1 are separated into three areas namely, "hotel check-in", "vehicle operation" and "game venue". This study described the structure of the security service through in the vertical axis. According to the hierarchical structure, the line of interaction, line of visibility and line of internal interaction of the security service separates the action of players, bodyguard staff, staff personnel and support into four parts. In the security service blueprint, the line of interaction mainly divides the interaction of the players and the bodyguard staff where as long as a vertical line passes through the line of interaction, it represents that the players and the staff have interactions. The line of visibility mainly divides the bodyguard staff that are seen by the players and the staffs that are not seen by the players. The function of the line of internal interaction is to divide the interactions of the contact staff and the internal support staff. Aside from showing the service blueprint through visual flowchart, FMEA is applied to these three areas and the Risk Priority Number (RPN) of these three areas are shown in Table 1~Table 3. FMEA first consider the “potential failure mode” and then considered the “potential failure”, “cause for failure”, “potential effect”, “control method” and “suggested measures for improvement”. The risk evaluation of the degree of severity (S), frequency of occurrence (O) and chance of detection (D) are separately obtained according to the effect, cause and current detection method of FMEA. Risk Priority Number (RPN) is obtained after multiplying the degree of severity (S), frequency of occurrence (O) and chance of detection (D) and is represented as RPN=S×O×D. The evaluation criteria of the degree of severity (S), frequency of occurrence (O) and chance of detection (D) are shown in Table 4~Table 6.

The obtained RPN is arranged from the highest to lowest where the highest threshold is prioritized. After evaluation, RPN=18 is used as the threshold. Ranks lower than 18 are considered low and are within the reasonable and safe boundary. RPN greater than or equal to 18 are RPN with high potential failure. Thus, it is required to separate the RPN according to failure mode, effects and causes to find protective measures and strengthen it. This study furthered explored the cause of failure of high potential failures, analyze the potential effects and proposed suggestions for improvement which are all shown in Table 1~Table 3.

With regards to the points of failure of “hotel check-in” shown in Table 1, the potential failures higher than the thresholds include: 1. surrounding with RPN=18; 3. hijack with RPN=18; 4. murder with RPN=24; 5. sniper with RPN=32. It is necessary to provide measure for improvement for these four high risk potential failures.

With regards to the points of failure of “vehicle operation” shown in Table 2, the potential failures higher than the thresholds include: 1. car crash with RPN=24; 2. explosion with RPN=32; 4. ambush with RPN=24; 5. sniper with RPN=32. It is necessary to provide measure for improvement for these four high risk potential failures. With regards to the points of failure of “game venue” shown in Table 3, the potential failures higher than the thresholds include: 7. sniper with RPN=32; 8. explosion with RPN=32. It is necessary to provide measure for improvement for these two high risk potential failures.

5. Conclusion. For a long time, people often engage themselves in a number of routine operations in the security management system but some details are often overlooked causing threats to the life of the person being protected or affecting the program operation of the activities. This study used the promoted risk management and security as demands and applied FMEA to identify the characteristics of the danger and develop relevant actions to establish high preventive measures. This study showed a visual flowchart using service blueprint. Firstly, based from the past experiences and the scope of the failure mode based on domestic and international dangerous cases, this study finds the potential failure mode operation in the process through the numerous coordination and discussion of the experts and provide rankings for each potential failures. After ranking, the items with high risk are sorted using failure mode and provide actions to each suggested potential failures to be used as future references.

Moreover, the results of the classification showed that different processes have different results. Therefore, the suggestions provided to strengthen the actions in each process can be used as references. Aside from focusing on the intensive guidance on human factors, the strengthening actions typically adopted should emphasize on the strength and improvement of the security management to serve as the preventive measures of risk. After the analysis, this study explored and described the following according to the results of the classification:

(1) High risks factors identified through failure mode. The FMEA is used to identify the high risks. Table1~Table 3 shows that the RPN of each failure of the areas, “hotel check-in”, “vehicle operation” and “game venue” are predicted. Through the ranking of the RPN, RPN=18 is used as the threshold where the highest threshold is prioritized. After evaluation, RPN lower than 18 are considered low and are within the reasonable and safe boundary. The ranks of RPN with high potential failure are from 18 to 32. Thus, it is required to separate the RPN according to failure mode, effects and causes to find protective measures and strengthen it. This study furthered explored the cause of failure of high potential failures, analyze the potential effects and proposed suggestions for improvement which are all shown in Table 1~Table 3.

(2) Strengthening of educational training. Personal safety is a human’s main service operation process. Individual variation exists regardless of the professional security officers or the person being protected (security subject). However, “intensive training for security personnel” is the only way to strengthen the coping ability of an individual. In the security operation, unexpected accidents can happen at any time and condition which can also be said that it varies from time to time. At this point, training proficiency is a completely good example of it. Therefore, regular or irregular training, dynamic simulation of the occurrence of various conditions and constant renewal of the correct concept and approach are also the most effective way to reduce man-made problem and negligence.

(3) Grasp the chance of eliminating threats. “Chance is an inevitable factor for success”. FMEA is the analysis before a task and not the remedial measures after a task is done. It is the best method used to achieve preventive effects. We should grab the chances to obtain the opportunity and the speed of completing the action in the implementation of the safety operation process especially in the security maintenance behavior, to grasp the situation before the occurrence of prime time is a very important factor. The concept of the SWAT "sudden change of systems and disasters are invisible" can be applied to identify the risk points during the operation to obtain the goal of process quality and efficient security and to shorten the time to discover a crisis and control the situation at its best defense system.

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Appendix.

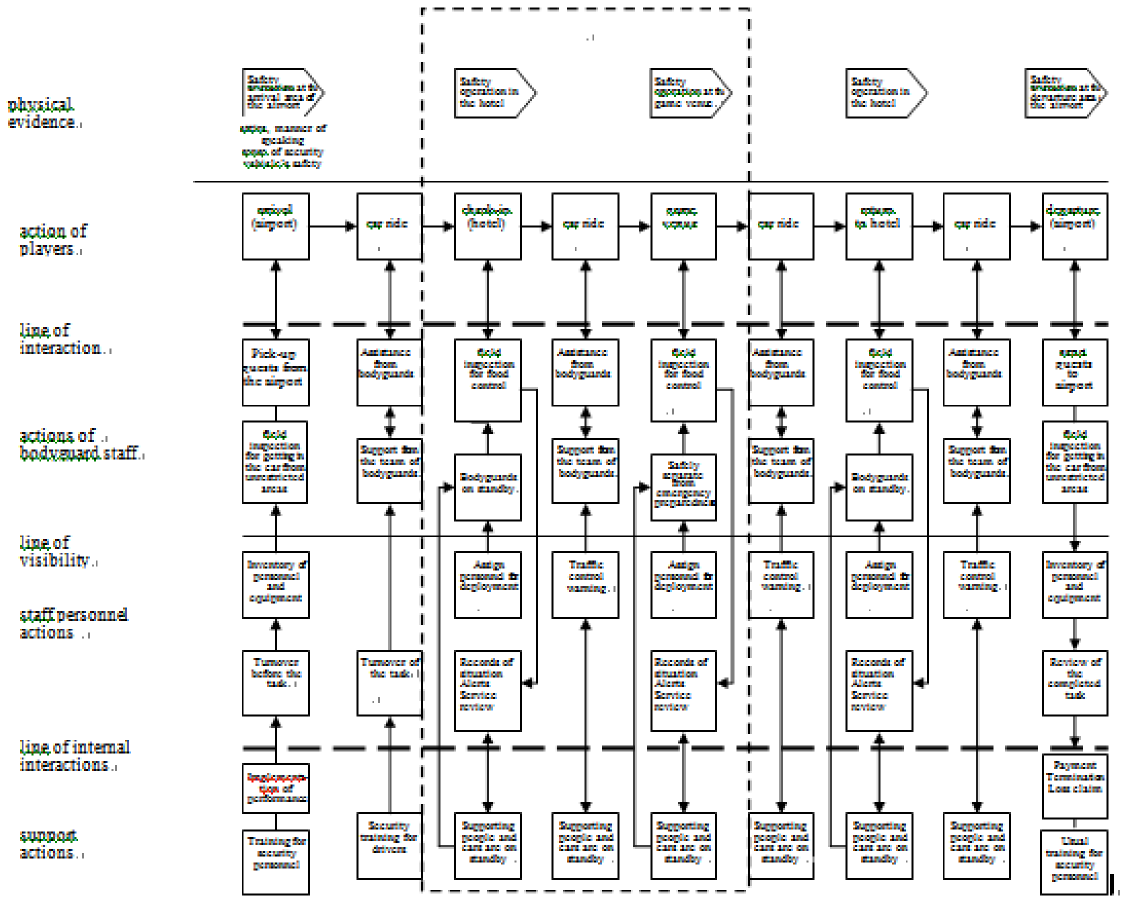

FIGURE 1. Service blueprint of the safety operation

TABLE 1-1. FMEA's risk priority number (rpn) of "hotel check-in"

Potential failure modes	Potential failure	Cause of failure	Potential effect	Control method	D	O	S	RPN	Suggested measures for improvement
∆ Hotel Check-In	1.surrounding	1. Unable to control the anti-American and anti-team public opinion and neglect the public sentiments and reactions. 2. Failed to strengthen the monitor of the hotel and pay attention for suspicious behaviors around the hotel. 3. The police are unable to coordinate with the special police to control the order of the scene, break-outs and the arrest criminals.	D: Request immediately for reinforcement. Take the player away from the scene or shield the player to as safe place and request the police to go to the scene of the crime and collect the necessary evidence. E: The player is surrounded and is unable to attend or forced to cancel the game.	Yes	2	3	3	18	1. Control and analyze the anti-American and anti-team public opinions to monitor suspicious people and things. 2. Assign a staff to monitor the surrounding of the hotel beforehand and pay attention for any suspicious behaviors. 3. Coordinate with special police to control the order of the scene, break-outs and arrest the criminals.
	2. sabotage			Yes	2	2	2	8	
	3. hijack	1. Unable to control the anti-American and anti-team public opinion and neglect the public sentiments and reactions. 2. Failed to strengthen the monitor of the hotel and pay attention for suspicious behaviors around the hotel. 3. The police are unable to coordinate with the special police to control the order of the scene, break-outs and the arrest criminals.	D: Request immediately for reinforcement. Take the player away from the scene or shield the player to as safe place and request the police to go to the scene of the crime and collect the necessary evidence. E: The player is hijacked and hurt and is unable to attend or be forced to cancel the game.	Yes	2	3	3	18	1. Control and analyze the anti-American and anti-team public opinions to monitor suspicious people and things. 2. Assign a staff to monitor the surrounding of the hotel beforehand and pay attention for any suspicious behaviors. 3. Coordinate with special police to control the order of the scene, break-outs and arrest the criminals.
	4. murder	1. Unable to control the anti-American and anti-team public opinion and neglect the public sentiments and reactions. 2. Failed to strengthen the monitor of the hotel doors and monitor suspicious characters to enter the kitchen. 3. Did not assign experts to monitor the kitchen, taste their meals and pay attention on the safety of the intake of foods and drinks.	D: Contact the doctor traveling with the team immediately for initial inspection. Immediately contact the police to collect evidence from the scene of the crime and take the player to the emergency room using the ambulance. E: Cause injuries on players that forced them to suspend or cancel the game.	Yes	3	2	4	24	1. Control and analyze the anti-American and anti-team public opinions and ensure that no suspicious character enters the kitchen. 2. Coordinate with the police and investigate related personnel to arrest criminals and request the ambulance to assist in sending players to the hospital.

TABLE 1-2. FMEA's risk priority number (rpn) of "hotel check-in"

Potential failure modes	Potential failure	Cause of failure	Potential effect	Control method	D	O	S	RPN	Suggested measures for improvement
∆ Hotel Check-In	5.sniper	1. The organizers will not pay attention on the surroundings of the public place, the exits, car stops, and inside the premises that criminals might attack the premises, space or things. 2. Staff can't effectively and immediately check, control and monitor suspicious people and things.	D: Form a wall covering the player and immediately leave the scene. Confirmed the direction of the attack and immediately contact the police to go to the scene of the crime, collect evidence and forensics and provide the position of the criminal to facilitate the arrest. Take the injured player to the hospital by ambulance. E: Cause injuries on players that forced them to suspend or cancel the game.	Yes	4	2	4	32	1. The organizers should pay attention on the surroundings of the public place, the exits, car stops, and inside the premises that criminals might attack the premises, space or things. This should be one of the priorities of the staff. 2. Make rounds on the important locations to monitor and control suspicious people and things. 3. Take the players out from the line of the premises; coordinate with the police and the ambulance to standby on the scene for rapid control of the scene and the ambulance for medical treatment.

TABLE 2-1. FMEA's risk priority number (RPN) of "vehicle operation"

Potential failure modes	Potential failure	Cause of failure	Potential effect	Control method	D	O	S	RPN	Suggested measures for improvement
* Vehicle Operation	1. car crash	1. When the driver can't pay attention to the road in front, the traffic and vehicles acting suspiciously around the vehicle. 2. Staff can't effectively and immediately check, control and monitor suspicious people and vehicles.	D1: Immediately take the player out of the scene of the crash or move to a safe place for cover; at the same time inform the police disperse and arrest suspected criminals or seize the vehicle. D2: Request for reinforcements and deployed to prepare the replacement for the damaged vehicles. E: Cause injuries on players and spectators that forced them to suspend or cancel the game.	Yes	2	3	4	24	1. The driver should pay attention on the traffic and monitoring the road in front for suspicious vehicles 2. Effectively coordinate with the police can instantly controls and monitor suspicious people and vehicles. 3. Select a good vehicle with good driving performance and condition. 4. Prepare back-up vehicles in case of damage or failure.
	2. explosion	1. Failed to note that the surrounding of the route might be a cover for the criminals to stash their explosives. 2. Staff can't effectively and immediately control and monitor suspicious people and things.	D1: Immediately remove the explosive from the player or move to a safe place for cover; also alert staff immediately to evacuate the spectators and guide them away from the direction of the explosion. D2: Immediately report to the police, eliminating the scene control, collect evidence, forensic and rescue casualties to avoid the situation from getting worse. E: Cause injuries on players and spectators that forced them to suspend or cancel the game.	Yes	4	2	4	32	1. Take note of the surrounding of the route that might serve as a cover for the criminals to stash their explosives. 2. Drivers should provide special monitoring and attention on the key premises on the surrounding for suspicious actions. 3. Take the players out from the explosion premise; if needed, coordinate with the bomb squad, police and the ambulance to standby on the scene for rapid get the explosives from the scene and the ambulance for medical treatment.

TABLE 2-2. FMEA's risk priority number (RPN) of "vehicle operation"

Potential failure modes	Potential failure	Cause of failure	Potential effect	Control method	D	O	S	RPN	Suggested measures for improvement
＊ Vehicle Operation	3. hijack			Yes	2	2	3	12	
	4. ambush	1. Failed to note that the route might be a cover for the criminals to attack the premises. 2. Bodyguard staff can't effectively and immediately control and monitor suspicious people and things.	D: Immediately take the vehicle of the team and leave the scene of the crime. Immediately contact the vehicle of the police to go to the scene of the crime to facilitate the arrest. Take the injured player to the hospital by ambulance. E: Cause injuries on players that forced them to suspend or cancel the game.	Yes	4	2	3	24	1. Take note of the surrounding of the route that might serve as a cover for the criminals to attack the premises. 2. Drivers should provide special monitoring and attention on the key premises on the surrounding for suspicious actions. 3. Take the players out from the line of the premises; coordinate with the police and the ambulance to standby on the scene for rapid control of the scene and the ambulance for medical treatment.
	5. sniper	1. Failed to note that the route might be a cover for the criminals to attack the premises. 2. Bodyguard staff can't effectively and immediately control and monitor suspicious people and things.	D: Immediately take the vehicle of the team and leave the scene of the crime. Confirmed the direction of the attack and immediately contact the police to go to the scene of the crime, collect evidence and forensics and provide the position of the criminal to facilitate the arrest. Take the injured player to the hospital by ambulance. E: Cause injuries on players that forced them to suspend or cancel the game.	Yes	4	2	4	32	1. Take note of the surrounding of the route that might serve as a cover for the criminals to ambush the people. 2. Drivers can use the binoculars to provide special monitoring and attention on the key premises on the surrounding for suspicious actions. 3. Take the players out from the line of the premises; coordinate with the police and the ambulance to standby on the scene for rapid control of the scene and the ambulance for medical treatment.

TABLE 3. FMEA's risk priority number (RPN) of "game venue"

Potential failure modes	Potential failure	Cause of failure	Potential effect	Control method	D	O	S	RPN	Suggested measures for improvement
◎ Game Venue	1. stampede			Yes	1	4	2	8	
	2. disturbance			Yes	1	4	2	6	
	3. surrounding			Yes	2	2	3	12	
	4. stand collapse			Yes	3	1	4	12	
	5. sabotage (car)			Yes	2	2	3	12	
	6.hijack			Yes	3	1	4	12	
	7. murder (food and beverages)			Yes	3	1	4	12	
	8. sniper	1. The organizers will not pay attention on the surroundings of the arena, the exits, car stops, and inside the premises that criminals might attack the premises, space or things. 2. Staff can't effectively and immediately check, control and monitor suspicious people and things.	D: Form a wall covering the player and immediately leave the scene of the crime. Confirmed the direction of the attack and immediately contact the police to go to the scene of the crime, collect evidence and forensics and provide the position of the criminal to facilitate the arrest. Take the injured player to the hospital by ambulance. E: Cause injuries on players that forced them to suspend or cancel the game.	Yes	4	2	4	32	1. The organizers should pay attention on the surroundings of the arena, the exits, car stops, and inside the premises that criminals might attack the premises, space or things. This should be one of the priorities of the staff. 2. Make rounds on the important locations to monitor and control suspicious people and things. 3. Take the players out from the line of the premises; coordinate with the police and the ambulance to standby on the scene for rapid control of the scene and the ambulance for medical treatment.
	9. explosion	1. The organizers will not pay attention on the surroundings of the arena, the exits, car stops, and inside the premises that criminals might attack the premises, space or things. 2. Staff can't effectively and immediately check, control and monitor suspicious people and things.	D1: Immediately remove the explosive from the player or move to a safe place for cover; also alert staff immediately to evacuate the spectators and guide them away from the direction of the explosion. D2: Immediately report to the police, eliminating the scene control, collect evidence, forensic and rescue casualties to avoid the situation from getting worse. E: Cause injuries on players and spectators that forced them to suspend or cancel the game.	Yes	4	2	4	32	1. The organizers should pay attention on the surroundings of the arena, the exits, car stops, and inside the premises that criminals might attack the premises, space or things. This should be one of the priorities of the staff. 2. Make rounds on the important locations to monitor and control suspicious people and things. 3. Take the players out from the line of the premises; coordinate with the police, fire brigade and the ambulance to standby on the scene for rapid control of the scene and the ambulance for medical treatment.

TABLE 4. Evaluation criteria of the frequency of occurrence (O)

Level	Rating	Definition
Frequent	4	An incident will immediately occur
Occasional	3	An incident most possibly will occur
Uncommon	2	An incident will probably occur
Remote	1	Almost no incident will occur

TABLE 5. Evaluation criteria of the degree of severity (S)

Level	Rating	Definition
Catastrophic	4	The incident will cause death
Major	3	The incident will suspend the game or the itinerary
Moderate	2	The incident will attract the spectators
Minor	1	The incident might attract the spectators with a sidelong glance

TABLE 6. Evaluation criteria of the chance of detection (D)

Level	Rating	Definition
Very high	1	It's easy to identify the causes or sources of the incident
High	2	It's rather easy to identify the causes or sources of the incident
Medium	3	It's not that easy to identify the causes or sources of the incident
Low	4	It's very difficult to identify the causes or sources of the incident

AN ANALYSIS TO THE RELATIONSHIP OF THE CORPORATION'S CHARITABLE GIVING AND TAX POLICY IN CHINA

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ABSTRACT. *This article notes the problem of the level of contributions affected by taxes, and examinees the relationship of the corporation's charitable giving and tax policy in China. Suggestions for improvement is also discussed in this paper.*
Keywords: Charitable Giving; Tax Price; Deductible Rate; Tax Price Elasticity

1. Introduction. With the growing economic power, corporations are bringing great influences to the global economy, politics and society. Charitable giving is an important social phenomenon. Compared with the corporate philanthropy in the western countries, the level of donation in China is lower and the corporations are lack of initiative and plan. This paper performs an empirical study on corporate charitable giving in China and draws some interesting conclusions.

2. The Relationship of the Corporation's Charitable Giving and Tax Policy. Adam Smith writes in his book (The Wealth of Nations): "Whoever offer to another a bargain of any kind, proposes to do this. It is not from the benevolence of the butcher, the brewer, or the baker that we expect our dinner, but from their regard to their own interest." John Stuart Mill has putted forward the thought of Adam Smith and Nassau William Senior and has putted forward the hypothesis of Economic Man. However, their theory also has got a great many criticize, the market experiments of Arizona School, the individual decision-making experiments, game experiment, the theory of heuristics put forward by Daniel Kahneman and Amos Tversky and the rules of thumb theory, all these pointed out that the behavior of individual may brought out by habit or by incomplete information which lead to non-economic action, and they thought the hypothesis of Economic Man had confined limit. The hypothesis of Economic Man can not explain the altruistic behavior that is wide exist in our daily life, though many of this altruistic behavior can be derived from the selfish behavior and because of the invisibility of the people's motive, we still can not demonstrate this behavior is brought out by selfish incentive.

Because of the fail in explanation of the altruistic behavior of the classical hypothesis of Economic Man, it comes out the hypothesis of new economic man, that believes an economic man not only compare the economic revenue and the cost but also think over the utility of mental utility such as honorable reputation and morality so as to get a utility-maximize choice.

A lot of researches had discovered that the corporation's charitable giving has a close relationship with tax policy. Schwart(1968), Nelson(1970), Levy and Shatto (1978), Clotfelter (1985) pointed out that the charitable giving would decline when the tax price of this charitable giving was increasing. These results coincide with the positive analysis research work of Carroll and Joulfaian (2005). But when we consider this problem in different countries, there are different legal systems of tax revenue in different country and the corporation's action may become quit different and this leads to the result that the tax policy has a distinct different influence between countries. In this paper, we try to set up a model of relationship between the corporation's charitable giving and tax policy.

The corporation's utility curve can display the relation of the corporation's charitable donation and the after-tax profits. The corporation's iso-utility curve is convex just as been showed in the follow chart:

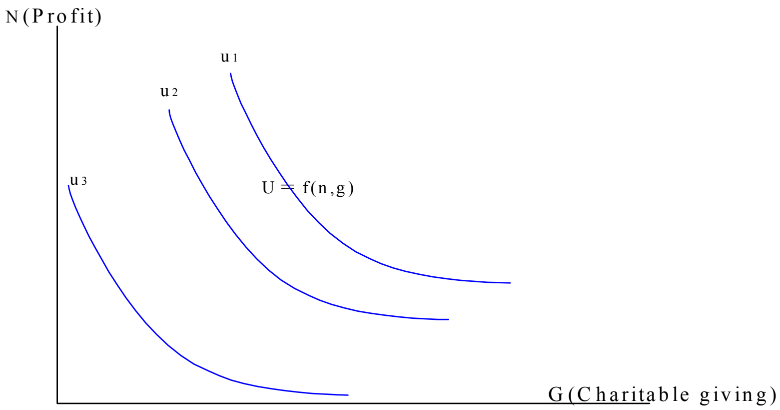

FIGURE 1.

Navarro (1988) had sum up the four different theoretic models for corporation's charitable giving.

Case 1: *Demand considerations*. By the hypothesis of profit maximum behavior and the tax influence is ignored and the charitable giving may not lower production cost. The corporation's profit maximum function can be wrote as: $\Pi=P*Q(P,G)-C[Q(P,G)]-G$. Where Π equals profits; Q is a function of G and the price, P; and production cost, C is a function of Q

Case 2: Cost considerations. By the hypothesis of profit maximum behavior and the tax influence is ignored and the charitable giving may lower production cost. The corporation's profit maximum function can be wrote as: $\Pi=P*Q(P,G)-C[Q(P,G);E]-G$, where $C=C[Q(P,G);E]$, and E represent the corporation's reputation that has relation with the charitable giving.

Case 3: Tax considerations. By the hypothesis of profit maximum behavior and the tax influence is considered. The corporation's profit maximum function can be written as: $\Pi=(1-t)*(R-C-G)$ (R.: total revenues)

Case 4: Utility Maximization and managerial discretion. By the hypothesis of utility maximum behavior and the tax influence is considered. Denote: G, managers choose a level of giving; X, a level of other preferred expenditures; and Q: output.

Max U [G, X]

s.t. $\Pi_D=\Pi_R-\Pi_0$

$\Pi_R=(1-t)*[R(Q,G)- C[Q(P,G);E]-G-X]$

This constraint may be written such that discretionary profits Π_D, must equal reported after-tax profits Π_R, minus the minimum level of earnings Π_0, necessary to prevents either a change in management by shareholders or a corporate takeover by outside buyers in the market for corporate control.

Navarro also used the cross section data (1976 -1982) of 249 companies to analysis the relationship of the corporation's charitable giving and tax policy. Boatsman and Gupta had used the data of 212 companies (1984 —1988) and because it spanned two American tax reform actions, the inspection of the variation of charitable giving of the same corporation can be studied when facing different tax rate. They had used hybrid model, random effect model, fixed effect model to deal with the cross section data and time series data. Their research work had indicated that the income effect of the tax price of corporation's charitable giving exceed the substitution effect, there are negative correlation between corporation's charitable giving and margin tax rate. Svitkova[1](2007) investigate 577 large and middle corporations from 2001 to 2003 in Czekh and used the data of 152 corporations from 2001 to 2004 in Slovakia.

3. Empirical Research of the Corporate Charitable Giving and Tax Policy in China. As one of the emerging market economics, the company in China is quit different compared with other countries. In the paper, we focus to the problem of sensitive of the Chinese corporation to the change of tax policy.

Corporate charitable giving can be both looked as expenditure (consume) and a kind of demand. The tax price of corporation's charitable giving is been defined as the amount of payment when corporate donates one yuan, and when the corporation's income tax rate is t, it equals $1-\mu*t$ (here μ represents the deductible rate). In China, there are many preferential policies in the income tax law of corporation, the actual tax rate is quite different from nominal tax rate so we should use the expression of tax price=1-μ*the actual income tax rate of corporation, where the actual income tax rate equals the income tax divides the profit of corporation.

We use the declared information in tax department which include index of the sales income, total profit, assets, liabilities, charitable giving of 811 corporate and the time period is from 2003 to 2009(partial data is missing but do not influences the regression). Through the compare of different regression model, we choose the best that is charitable giving=C+β_1*income+β_2* profit ratio+β_3*tax price+β_4*debt ratio. To show clearly the difference in different corporation's action, we use the reasonably complete data of 39 corporations and use fix effect model to deal with this problem. The result of different data simulation had been compared accordingly.

[1] Essays on Philanthropy Katarina Svitkova, Dissertation, Prague, January 2007

3.1. Regression Analysis (Model 1). We use the weighted least-squares method to process data. The independent variable is income (INC), profit rate (PRO_RATIO), tax price (TAXPRI), assets-liabilities ratio(DEB_RATIO) and the dependent variable is charitable giving(GIV).

The fundamental regression equation is been written as followings:

Model 1: $GIV=C+\beta_1*INC+\beta_2*PRO\_RATIO+\beta_3*TAXPRI+\beta_4*DEB\_RATIO+\varepsilon$

C is constant, β1, β2, β3 and β4 are regression coefficients, ε is random error. The result of weighted least square method (WLS) is as table 1:

TABLE 1.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	284075.3	5266.573	53.93930	0.0000
INC	0.000112	2.83E-06	39.65505	0.0000
PRO_RATIO	193812.3	13315.40	14.55550	0.0000
TAXPRI	-231882.6	5064.028	-45.79014	0.0000
DEB_RATIO	-64579.10	2234.089	-28.90624	0.0000
R-squared	0.913520	Mean dependent var		897516.8
Adjusted R-squared	0.913232	S.D. dependent var		4836551.
S.E. of regression	482107.0	Sum squared resid		2.79E+14
F-statistic	3169.020	Durbin-Watson stat		1.064656
Prob(F-statistic)	0.000000			

The coefficient of determination: R=0.91352, the Statistical Hypothesis model passed t test and the parameters are: C=284075，β1=0.000112,β2= 193812.3,β3= -231882.6, β4=－64579.10

We can find that the corporation's charitable giving is significantly negative correlated with the tax price. The decline of the tax price may leads to the increase of the corporation's charitable giving. β1,β2>0 and β4<0 means the corporations charitable giving was positively correlated with sale income, profit and negative correlated with assets-liabilities ratio what means when assets-liabilities ratio decline the charitable will increase and this is consistent with the research work of Navarro(1988),Adams and Hardwick(1998). The explanation is that managers like to cut down financial leverage to avoid the risk of bankrupt or the lost of position and earnings. The lower the assets-liabilities ratio the higher the agency cost will be and the stronger the control of the manager to the company and the more the charitable giving made by the manager for maximum his utility.

3.2. The Analysis of Panel Data (Model 2). We also used the integral data of 39 corporations from 2003 to 2009 to test the result. The comparing of random effect model and the fix effect model illustrate that the fix effect model is more suitable and the result of computed parameters are listed as table 2.

R^2=0.805931, β_1= 0.000189, β_2= 824649.2, β_3= -459035.9, β_4= 79510.89. β_3<0, It also illustrates that the corporate charitable giving is positively correlated with tax price.

TABLE 2.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
INC	0.000189	3.14E-05	6.007967	0.0000
PRO_RATIO	824649.2	115371.3	7.147785	0.0000
TAXPRI	-459035.9	52133.82	-8.804955	0.0000
DEB_RATIO	79510.89	43335.16	1.834789	0.0695
R-squared	0.805931	Mean dependent var		464665.6
Adjusted R-squared	0.724422	S.D. dependent var		546290.5
S.E. of regression	286777.8	Sum squared resid		8.22E+12
F-statistic	138.4272	Durbin-Watson stat		2.068705
Prob(F-statistic)	0.000000			

Cao (2006) had calculated that the tax price elasticity of charitable giving in China (concerning 278 samplings) was between -1.12 and -3.72 and was -2.08 by average. But the calculation used the nominal tax rate and not the actual tax rate. In China, the actual tax rate is quite different from the nominal tax rate because there are many tax preferential policies so their conclusion is not quit reliable. From 2008, the rule of income tax had been adjusted and the nominal income tax rate had been changed from 0.33 to 0.25 and this change gave us more convenient to calculate the tax price elasticity of corporate charitable giving.

The highest tax price of the sampling data is 0.9485 and the lower is 0.4589, we have got 1229 data of corporate charitable giving and total amount of charitable is 166.69 million yuans, so the tax price elasticity of charitable giving:

$$\eta=(\Delta GIV/GIV)/(\Delta TAXPRI/TAXPRI)=(\Delta GIV/\Delta TAXPRI)*(TAXPRI/GIV)$$

From model 1 we get to know: $\Delta GIV/\Delta TAXPRI=-23.1882$, the average of TAXPRI= 964/1229=0.78437, the average of GIV =16669/1229=13.56， the tax price elasticity of charitable giving in China is $\eta=-23.1882*0.78437/13.56=-1.3413$，this result is lower compare with the calculation of Xin Zhang and Hongbin Cao’s -2.08，and also lower compared to the Carroll and Joulfaian (2005)’s result[2], It means that the Chinese corporate charitable giving is not so sensitive as in some foreign countries.

4. Conclusions. The corporate charitable giving has some relationship to tax policy in China, but comparing with advanced countries, it is relatively lower. The tax policy should give more incentive to the corporate charitable giving in China for two reasons: Firstly, China was vast in territory and the social and economic development is quit unbalanced in these areas and the government can not solve all the problem of the society, the corporation can deal with their familiar area to save social cost and to get efficient disposal of resources. Secondly, the corporation’s ability is quiet limited in China and their charitable activities should be encouraged by policy support. From the government point of view, we should also pointed out that the tax preferential policy should be regulated to avoid of the use of the preferential item for the evasion of tax by some companies.

[2] Their calculation is between 1.51and 2.08. Day and Devlin 2004

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ENTERPRISE VALUE CREATION AND VALUE SHARING BASED ON SUSTAINABLE GROWTH

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ABSTRACT. *With the transformation of economic form from industrial economy into economy based on knowledge and the transformation of enterprise's nature from "economic man" into "social-ecological-economic man", enterprise's sustainable growth becomes a more complex task. The objectives of the company should be derived by balancing the conflicting claims of the various 'stakeholders' in the firm, and maximizing the profit of stakeholders. In this paper, we analyze on how to rationally and effectively create value and share from the levels of enterprise, value chain and value network for stakeholders, and eventually realize the sustainable development of enterprises through implementation of business strategy.*
Keywords: Sustainable Growth; Stakeholders; Value Creation; Value Sharing

1. Introduction. With the transformation of economic form from industrial economy into economy based on knowledge and the transformation of enterprise's nature from "economic man" into "social-ecological-economic man", corporate sustainable growth becomes a more complex task. A sustainable organization is one that while pursuing profit, enlightened companies should take care to protect the environment and uphold the rights of workers and other stakeholders as well. Maximization of shareholders' value is not necessarily the right objective. The theoretical justification for this objective was derived from the "nexus of contracts" view of the firm. According to Fama and Jensen (1983), each party belonging to the nexus has contractual claims on the surplus with pre-determined payoffs. Stout (2002) forcefully argues that: "the residual claimants argument for shareholder primacy is a naked assertion, and an empirically incorrect one at that". The objectives of the company should be derived by balancing the conflicting claims of the various 'stakeholders' in the firm, managers, workers, stockholders, suppliers, vendors (Ansoff, 1965). "Companies that set profits as their No 1 goal are actually less profitable in the long run than people-centered companies (Waterman, 1994)."

The "new" business organization is becoming increasingly networked. The boundaries of the organization are becoming more blurry, permeable, and interactions with stakeholders become more thoroughly knit into the fabric of firms. Which stakeholders are internal and which are external to the organization is becoming an increasingly importance. Zingales (2000) defined modern enterprise as a kind of net of specialized investments from stakeholders and the stakeholders relation net develops into a value creation system of open enterprises network. Max Clarkson (1994) offered the following definition, "The firm is a system of stakeholders operating within the larger system of the host society that provides the necessary legal and market infrastructure for the firms' activities. The purpose of the firm is to create wealth or value for its stakeholders by converting their stakes into goods and services." Generalizing stakeholders commonly create enterprise's value, and have the rights of sharing the enterprise's equity. Therefore, it is necessary that should research enterprise's sustainable development issues from angle of stakeholders' value creation and sharing.

The rest of this paper is organized as follows. Section 2 provides a brief discussion of the meaning of stakeholders' value. Description and analysis of value creation are given in Section 3. Section 4 presents measures and methods of value sharing. Section 5 concludes the paper.

2. Stakeholders and Stakeholder Value.

2.1. Categories of Stakeholder. A stakeholder perspective indicates that it is no longer tenable to regard the shareholders as the only residual claimants, where residual claimants are defined as persons or collectives whose relationship to the firm gives rise to a significant residual interest in the firms' success or failure. Stout (2002) points out that the argument that shareholders are the sole residual claimants in corporations not only does not hold as a practical matter, but also as a matter of law. The idea that the law views shareholders as the sole residual claimants is a common misconception among many economists. Such a view is not legally accurate. There is widespread agreement that the stakeholder framework has proved useful in the analysis of the strategic and normative challenges organizations face, and that good stakeholder relationships are key to organizational viability and business success (Freeman, 1984; Donaldson, 1995; Wheeler, 1997; Svendsen, 1998; Post et al., 2002). Madu (1996) pointed out that "being environmentally correct is not only a business strategy that stands to yield huge profits for companies, but also a social responsibility function for companies". At the broadest definitions sustainability is concerned with the effect which action taken in the present has upon the options available in the future.

To succeed in a stakeholder-driven business environment, business must think and operate in new ways, shaping strategies and actions with full awareness of their impacts on and implications for stakeholders (Chris et al.2007). Organizations and their leaders face the challenge of weaving a web of sustainable relationships, complex as it may be, navigating in it, and engaging a multitude of stakeholders in a dialog (across differences) to create resonance (Boyatzis and McKee, 2005), trust (Nooteboom, 2002), and ultimately stakeholder social capital.

However, enterprises have all forms of stakeholders, in order to serve the different types of stakeholders effectively; it must classify stakeholders reasonable. According to relevance of corporate Interests, stakeholders can be divided into two types: one is internal stakeholders; Business activities have a direct impact on the interests of these type stakeholders, they are common interests and goals-makers of enterprise, and sought their cooperation to achieve this common interests and goals. The common interests and objectives of internal stakeholders is a reflection of the enterprise value, internal stakeholders share these enterprise value. The other is external stakeholders, Business activities have an indirect impact on the interests of stakeholders, and such stakeholders can be further divided into: value chain stakeholders and value network stakeholders. The former refers to enterprises of value chain; the latter refers to stakeholders of value network. Categories of stakeholder, type of value and key stakeholders are summarized in the following table 1.

TABLE 1. Overall category of stakeholders

Categories	Type of value	Key stakeholders
Internal stakeholder	Enterprise value	employees, shareholders, creditors, managers, etc.
External stakeholder	Value of value chain	suppliers, distributors, the target enterprise customers etc.
	Society value	consumers, community, pressure groups, environment etc.

2.2. Stakeholder Value. A major purpose of stakeholder theory is to help corporate understand their stakeholder environments and manage more effectively within the nexus of relationships that exists for their companies. However, a larger purpose of stakeholder theory is to help corporate improve the value of the outcomes of their actions, and minimize the harms to stakeholders. This article adopt the method of stakeholder value analysis proposed by Chris Laszlo et al. (2005), we build a sustainable value framework, which is shown in figure 1.

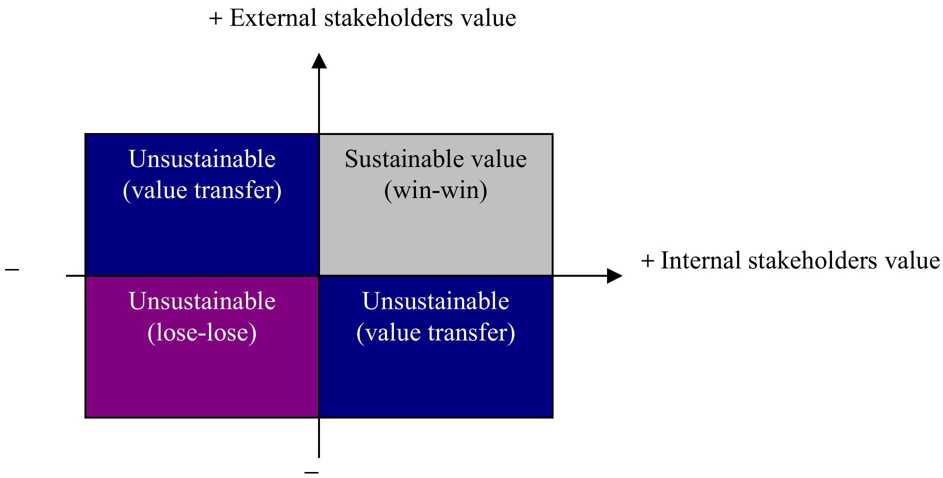

FIGURE 1. Sustainable value framework

Figure1 describes company performance along two axes: internal stakeholder and external stakeholder. In this framework, sustainable value occurs only when a company creates value that is positive for its internal stakeholders and its external stakeholders. Companies that deliver value to internal stakeholders while destroying value for external stakeholders have a fundamentally flawed business model.

Starting in the upper left of figure 1 and moving anti-clockwise, consider the following four cases of value creation and destruction.

2.2.1. Unsustainable (Value Transfer). When value transferred from internal stakeholders to external stakeholders, the internal stakeholders represent a risk to the future of the business. External stakeholders' value in those cases is created at the cost of one or more internal stakeholders, thereby representing a value transfer rather than true value creation.

2.2.2. Unsustainable (Lose-Lose). When value is destroyed for both internal stakeholders and external stakeholders, this represents a 'lose-lose' situation of little interest to either.

2.2.3. Unsustainable (Value Transfer). When value transferred from external stakeholders to internal stakeholders, the external stakeholders represent a risk to the future of the business. Internal stakeholders' value in those cases is created 'on the backs' of one or more external stakeholders, thereby representing a value transfer rather than true value creation.

2.2.4. Sustainable (Win-Win). When value is created for both internal stakeholders and external stakeholders, this represents a 'win-win' situation of much interest to either.

Enterprise's sustainable growth is to achieve a win-win situation of internal stakeholders and external stakeholders, to avoid value transfer value destruction. Furthermore, the realization of sustainable growth depends on two fundamental questions to a large extent: value creation and the distribution of this value (Schumpeter, 1954; Weintraub, 1977). These two persistently challenging questions are also or, arguably should be the two fundamental questions concerning the so-called "stakeholder theory". Next, this article will focus on value creation and sharing from three different levels of enterprise, value chain and value network for stakeholders, and eventually realize the sustainable development of enterprises.

3. Value Creating of Stakeholder. Whatever approach to stakeholding is adopted by business the first question must be 'who your stakeholders are and how to create value for them?' The route to durable competitive success was by focusing less exclusively on internal stakeholders and financial measures of success, and including all stakeholder relationships within a broader range of measures, and in thinking and talking about business purpose, performance and actions. Accounting to a stakeholder agency theory, managers are seen as the agents for all stakeholders, not simply shareholders.

We defines success in terms of sustainable development, and arguing that outstanding businesses derive their strength from a distinctive structure of relationships with employees, customers and suppliers – which explains why continuity and stability in these relationships are essential for a flexible and co-operative response to change. In order to achieve the sustainability of value creation, Enterprises need to implement stakeholder value management effectively form levels of enterprise, value chain and value network.

3.1. Creating Enterprise Value. The size of business value-added value depends on value-added of process as well as the size of value-added of activities that compose the processes. In order to improve value-added ability of processes and activities, it is necessary to implement business process management. Business process management is an important and effective enterprise management way, which is based on processes and process operations for control object, through streamlining, deleting, merging of processes or operations, it can such as measures to rationalize unreasonable business processes, delete non-value-added activities and optimize enterprise business processes, thereby creating greater value added.

The stakeholder view holds that firm performance is best measured by the value added. Computationally, the value-added amount can be determined by adding pre-tax profit to payroll costs plus interest charges. An alternate approach to computing value-added is to deduct “bought-in” costs from sales revenues, where “bought-in” costs represent all costs and expenses incurred in buying goods and services from other firms.

Functionally, the value-added statement may be conceived as a modified version of income statement. Consequently, it can be derived from the income statement, ie the value-added equation can be obtained by rearranging the profit equation (1) as follows:

$$S - B - DP = W + I + DD + T + R \tag{1}$$

Where:
S = Sales Revenues
B = Bought-in materials and services
DP = Depreciation
W = Wages
I = Interest
DD = Dividends
T = Taxes
R = Changes in Retained earnings

Equation expresses the net value added method. In both cases, the left side of the equation shows the value added created by the groups involved in or impacting the managerial production team (the workers, the shareholders, the bondholders and the government); the right side illustrates the distribution of the wealth to the same members of the team. The right-hand side is also known as the additive method and the left-handed side the subtractive method.

3.2. Creating Value of Value Chain. Through the implementation of value chain management, it helps to improve relationship among enterprises of value chain, promote cooperation among enterprises of value chain, often allows every party to benefit. Therefore, it is possible to establish partnership based on common interest through implementation of enterprise value chain management, joint efforts to make “cake” bigger, that is, through joint efforts of enterprises of value chain to increase value of the entire value chain. Under normal circumstances, value-added of the entire value chain increases, every enterprise of value chain is also likely to share more value of the value chain. Of course, the numbers of value-added of each enterprise of value chain can share are subject to the binding contract of value-added share, and value-added share is an important element of value chain management either.

Enterprises have to cooperate with other upstream and downstream enterprises to make the advantages complementary with each other so as to strengthen their competitiveness together, and therefore adapt to the competitive environment of the contemporary market. Enterprises have gradually abandoned the old management mode, in which they take charge of their own design, manufacture, and sales. While sparing no effort to gain the demands of end customers, they also pay attention to set up the cooperation relationship and firm the community interest with the suppliers and sellers, and create the efficient value chain.

3.3. Social Value Creation. Changing societal expectations are placing new challenges before enterprise, and are shifting the nature of the business and society relationship. Business firms are placing increasing emphasis on their ongoing "sustainability," which implies a simultaneous focus on economic, social, and environmental performance. This has vitalized a new generation of civil society groups, who, along with other business stakeholders－consumers, communities, employees, and governments－are reshaping the set of demands facing contemporary business. Contemporary business need to adopt new stakeholder view to create value for organization and broad global society and re-orient business growth by broadening conceptions of context and capabilities. Sustainable business should provide quality products to meet consumer demands, establish good contacts with local communities and control adverse impacts on environmental out of business activities etc, in order to better create value for society.

4. Value Sharing of Stakeholders. When enterprise Value-added is given, the economic interests of various stakeholders constraints mutually, so each stakeholder is bound to conflict with other stakeholders in the process of maximizing his own interests, in order to ensure stakeholders cooperation fairly and efficiently, it is necessary to establish a system to coordinate their contradictions and confliction of economic interests among stakeholders, the core of such a system is enterprise value share system. (Wang, 2006).

Content and the form of value sharing in enterprise, there is a growing trend of diversification. In general, internal stakeholders share business value, that is, the value-added of enterprises, and external stakeholders will share the value of the value chain and society value.

4.1. Value Sharing of Enterprise Value. Nowadays shareholders and creditors invest monetary capital in enterprises, managers and employees also invest intellectual capital. Moreover, the intellectual capital has gradually become the main source of competition. Such changes in the structure of property rights, it is bound to require innovate companies' distribution system. Sharing of enterprise value consists of three parts: the first part distribute according to a fixed share; the second part, value-added is shared between the owners of monetary capital and the owners t of intellectual capital, it can distribute according to contribution, satisfaction or combination of input and contribution and so on; the third part is retained to meet the needs for enterprise accumulation and development. When enterprise is carrying out innovation of distribution, it should take full account of the input or contribute of internal stakeholders; so as to promote innovation of sharing smoothly.

4.2. Value Sharing of Value Chain. The formation of value chain is to enhance competitive advantage of business alliances through using complementary resources, in order to achieve win-(multi-) win purpose, and finally realize operation of value chain stably. First of all, sharing of value chain must abide by the principle of mutual benefits. Co-operation of the enterprises in value chain is based on the participating companies who share the fruits of cooperation, and should obtain more interests than it operate solely, and this is a win-win basic value orientation, otherwise, it would lose the material basis of survival and development. This principle also fully reflects demands of the stakeholder theory. Secondly, it must comply with the balance principle of risk, cost and benefits. This principle does mean operating in accordance with risk, cost and size of contribution of the participating enterprises in the allocation process, embody the idea of efficiency. In practice, it commonly use value chain analysis, extension of Kolomogoro's complexity analysis and profit pools analysis to distribute value of value chain.

4.3. Value Sharing of Social Value. The sharing of enterprises' social values is different from the sharing of enterprise value and the sharing of the value chain, it is not based on relationship of interests, more or moral obligation is legally binding. There are many forms of enterprises' social values, for example, enterprise reduce product costs, increase customer value and better meet customer needs; enterprise concern about the production environment, reduce pollution, product safely and reduce social problems; enterprise active co-operation with the community, create a good environment for the development of the community and win recognition and so on.

5. Conclusions. Whether financial shareholder wealth approach or the strategic management stakeholder approach is justified depends on what theory of the firm we hold. Thus, the theory of enterprise value creation and value sharing based on sustainable growth has important consequences for the theory of economic valuation, which is one of the two fundamental questions of the strategic management discipline, and is of enormous relevance to financial management practice. The theory of sustainable growth has fundamental economic implications for understanding economic value creation and distribution. Forward thinking business leaders in sustainability-focused organizations can use the framework offered here to bring clarity to the strategic management in their companies, and can help build the alignment capacity to convert strategies into actions.

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EXPLORATORY STUDY ON LABOUR-SHORTAGE PHENOMENA OF SMALL AND MEDIUM-SIZED ENTERPRISES IN ZHEJIANG PROVINCE

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ABSTRACT. *A new round of "labour shortage" emerged as a result of the economic recovery. The investigation on the enterprises and labour market reveals that 29.7% of the Small and Medium-sized Enterprises (SMEs) are confronted with the dilemma of "labour-shortage". These SMEs' total labour gap ratio amounts to 28.5% and small enterprises are particularly short of labours. The "labour-shortage" is actually the mechanic-shortage, especially the lack of junior and middle-level technicians. The "labour-shortage" is rooted in the labour flow which resulted from the decrease of relative gains, indicating that the Lewis turning point of China's labour supply is coming. The solutions for the "labour-shortage" issue lie in the increase of the wages and welfare benefits of the workers, the improvement of working conditions, as well as the cultivation of a favourable employment and service environment by the local governments.*
Keywords: Small and Medium-sized Enterprises (SMEs); Labour Shortage; Survey

1. Literature Review and Research Questions. The structural labour flow which was formed in the process of economic development, according to Lewis's (1954) Dual Economic Model, could be divided into two phases: Phase 1, Unlimited Labour Supply, when there is a surfeit of cheap labour and the wages rest with means of livelihood; and Phase 2, Labour Shortage, the moment when the surplus rural labours in the traditional agriculture departments have been absorbed completely by the modern industrial sections, and the wages depend greatly on the marginal productivity. Along with the transformation from Phase 1 to Phase 2, the surplus labour became scarce; therefore the corresponding labour supply curve goes upward bending while the labours' wages are increasing as well. The conversion from unlimited labour supply to labour shortage, in other words, the dual economic structure transformation, is called "Lewis Turning point." Lewis (1954), M. P. Todaro (1969), who puts forward "the rural-to-urban migration model", reckons that the labour dissociated from the agriculture should be employed in the process of urbanization, that is to say, the issue of rural surplus labour should be taken into account in the analysis of the urbanization, Todaro (1969).

Scholars in China, the country which is deemed to be always in the Phase of Unlimited Labour Supply (as described in the Lewis's (1954) Dual Economic Model), made their multi-dimensional research on the rural-urban labour flows. Studies at the macroscopic level analysed issues on the rural labour supply, the flow direction, the velocity of flow, and the flow capacity (Lin et al. 1998; Cai and Wang, 1999; Hu, 1986).

On the basis of the comparison and analysis of the disparities between migrant and local workers in terms of occupation, skills and wages, the investigations from the microcosmic point of view focused on the farmers' migration desires and motivation of labour flow. (Wei, 2003; Hu, 1996; Zou and Zhang, 2006; Zhong, 2006)

Since the emergence of the "Labour Shortage" Phenomenon in 2004, the issue of supply and demand of rural labours has aroused extensive concern from the people of various circles. Cai Fang (2007), after analysing the gross supply and demand of rural labours, made the conclusion that the amount of rural labour in China was changing from the unlimited supply to the finite surplus, predicting the emerging trend of structural and local labour shortage, Cai (2007). The low income level was the deep-seated cause for the "Labour Shortage" as a result of the rural labour flow (Ding,2006; Wang, 2006; Xie and Yao,2006).

Besides, the change of labor flow modes is also caused by the non-standard employment, the non-guaranteed rights and interests of working people, which resulted in the farmers' "vote with feet", Liang et al. (2007).

The catastrophic fall in orders which was due to the influence of the financial crisis in 2008, drastically reduced the need for labour and temporarily alleviated the phenomenon of "Labour Shortage". However, a large number of labours are needed because of the increase of orders since the second half of 2009. To their surprise, some enterprises discovered that they failed to recruit the number of labours needed. The gradual economic recovery was confronted with a new round of "labour shortage". The authors of this essay, based on the questionnaire survey of the SMEs in Zhejiang Province, attempt not only to evaluate the degree of the current "labour shortage", the characteristics and reasons, but also to verdict whether the "Lewis Turning Point" of labour supply is coming in China.

2. Questionnaire Design and Survey.

2.1. Questionnaire Design. The respondents of the "Labour-shortage" Phenomenon Questionnaire consist of the HR (Human Resources) Managers of the enterprises, the employees and the administrators of the labour market (hereafter referred to as "labour agencies"). The questionnaire includes three parts, i.e., subjects' demographic data, causes of "labour shortage" and countermeasures. For the demographic data, the HR Managers are requested to fill out the following information: industry, scale of the enterprise, number of employees currently available, number of employees needed, posts available and so on; whereas "the employees" are invited to fill in information like age, academic degrees, etc.

The five-level Likert Scale was designed to measure the causes of “labour shortage” and the countermeasures. For the items on causes, the questionnaire listed all the potential factors from three points of view, i.e., employees, enterprises and the local government. The three types of respondents − HR Managers, Employees and Labour Agencies − were invited to check five options (1-5) of the potential factors according to the current situation, herein, 1 = entirely disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = agree absolutely. As to the countermeasures, the questionnaire listed various possible measures for the improvement of the “labour shortage” phenomenon from the perspectives of both the enterprises and the local governments, and the three kinds of respondents judged the effects on the measures, hereinto, 1 = Ineffectual, 2 = Less Effective, 3 = Somewhat Effective, 4 = Quite Effective and 5 = Pretty Effective.

2.2. Questionnaire Survey. Through the anonymous survey of the SMEs and the Labour Market in Zhejiang Province in 2009, 1,536 questionnaires from 345 enterprises and 11 labour agencies were collected. After eliminating the uncompleted ones, there were 1,061 valid questionnaires in total, the validity ratio being 69.1%; thereinto, 303 (28.6%) questionnaires were collected from the HR Managers, 725 (68.3%) from the employees and 33 (3.1%) from the labour agencies.

3. Analysis of the “Labour Shortage” Phenomenon. The gap ratio, the nature and the structural differences of the “labour shortage” were evaluated on the basis of the questionnaires from the HR Managers.

3.1. Evaluation of Number of Employees Needed. For the convenience of the respondents, two questions were designed to evaluate the degree of “labour shortage”. One is the number of employees currently available in the enterprises, with the following options “□ less than 100 workers □ 100-500 workers □ 500-1000 workers □ more than 1000 workers”; the other is the number of employees needed, including items “□ less than 50 workers □ 50-100 workers □100-300 workers □more than 300 workers”.

3.1.1. Evaluation Hypothesis. In order to evaluate the real situation of “labour shortage”, the author made the following hypotheses:

Hypothesis 1: It is the normal personnel turnover, if less than 50 additional workers are needed.

Hypothesis 2: If less than additional 10% of the current number of workers is wanted, there is no “labour shortage” phenomenon.

3.1.2. Evaluation of the Gap between the Number of Employees Currently Available and the Number of Employees Needed.

(1) Evaluation of the enterprises involved in the labour shortage. According to the questionnaires filled out by the HR Managers, there are 101 enterprises, among the 303 enterprises investigated, which demand more than 50 new employees. The numerical interpolation method was adopted to evaluate the number of current employees and the number of employees needed in an enterprise. We evaluated the current crew of an enterprise with “80, 300, 750 and 1500” whereas “75, 200 and 400” are used to evaluate the

number of employees needed. There were 90 enterprises, each with a gap ratio of 10% or over, that is to say, 29.7% of the enterprises were confronting with the “labour shortage”.

(2) Degree of the Labour Shortage. Questionnaires from the above-mentioned 90 enterprises were reviewed and analysed, yielding that the average number of employees currently available in the enterprises was 516 (95% confidence intervals: 410-622) whereas the number of employees needed was 147 (95% confidence intervals: 125-169). Therefore, it was found that the employees’ gap ratio was 28.5% (95% confidence intervals: 20.1%-41.3%). (3) Artisans are most needed in the enterprises. The analysis of the types of workers needed in the enterprises (see Table 1) revealed that, the most prevalent vacancies were those for elementary artisans (41.9%) and intermediate artisans (28.8%), whose cumulative recipient reached 70.7%. Thus it can be seen that the essence of “the labour shortage” is the lack of artisans.

TABLE 1. Ratios of employees needed in the enterprises

Position Requirements		Percentages
Artificers	Elementary	41.9%
	Intermediate	28.8%
	Advanced	15.0%
Technicians	Elementary	7.7%
	Intermediate	8.6%
	Advanced	11.5%
Others		26.5%

Hence, the following conclusions could be made: 29.7% enterprises were confronted with the difficulty of the “labour shortage”, and the number of employees needed occupied 28.5% of the total number of employees in the enterprises. The current “labour shortage” is, in fact, “the lack of artisans”, and the major deficiencies are the elementary mechanic and intermediate artificers.

3.2. Difference Analysis of the “Labour Shortage” Phenomenon. After the classification of the enterprises in terms of scales (see Table 2), it follows that the smaller the scale of an enterprise is, the higher its labour gap ratio is. The enterprises, whose sales revenue was less than 10,000 RMB Yuan and whose gap ratio was as high as 76.15%, could hardly operate in gear, because the “labour shortage” had severe impact on their production and management. However, the gap ratio of the enterprises with sales income over 100 million RMB Yuan, was lower than 20%, indicating that they were also influenced by the “labour shortage”, but the shortage could be made up by the workers’ extra hours in the short term.

It was discovered that small enterprises, in terms of employment patterns, tended to employ temporary and short-term workers. Although such a pattern − recruiting temporary employees according to the orders − does reduce the operational cost, the enterprises may blunder away great opportunities for development when the orders multiply suddenly.

TABLE 2. Labor shortage percentages for enterprises of various scales

Scale of Enterprises（Sales Revenue）(Unit: RMB Yuan)	Samples	Number of Employees available	Number of Employees needed	Gap Ratio
＜10 million	15	153	117	76.1%
10-50 million	29	277	109	39.5%
50-100 million	20	454	149	32.8%
＞100 million	22	1064	209	19.7%

Note: The numbers of employees currently available and needed were all the evaluated averages.

4. Analysis of Causes for the "Labour Shortage". The causes for the "labour shortage" were explored from the following three perspectives: the enterprises, the local governments and the employees.

4.1. Causes of the Enterprises. Factors regarding the causes of the labor shortage in the viewpoint of the enterprises, as the options we set in the investigation, include no guarantee for the labours' rights and interests, poor working conditions, low wages and benefits, little welfare, temporary employment and uncertain future of the enterprise. Factor analysis revealed that KMO was 0.83, and factor loadings of all the factors are over 0.5 (If the factor loading is less than 0.5, the factor will be removed), indicating that all the factors could be used to explain the "labour shortage" phenomenon (see Table 3).

TABLE 3. Factors influencing the "labor shortage" from the enterprises' perspective

Factors	Factor Loadings
no guarantee for the rights and interests of the labours	0.81
poor working conditions	0.80
low wages and benefits	0.79
low welfare	0.79
temporary employment	0.70
uncertain future of the enterprise	0.67
KMO=0.83	

In view of the enterprises, the two major factors influencing "labour shortage" are low wages and benefits, and low welfare, whose means are 3.22 and 3.11 respectively (see Table 4).

It is further discovered that obvious discrepancy exist between the understanding of these factors by the enterprises' human resources department (HR Dept.) and the cognition of the employees and the labour agencies, as illustrated by the multiple comparisons between different types of respondents (see Table 4). Reasons for the discrepancy are two-folded. One is the sharp conflict between labour and management. The enterprises' human resources department stands for the bosses, who pay little attention to the employee's welfare and working conditions, thus the strong divergence between the employer and the employee came into being. On the other hand, the labour agencies can do nothing to help the employees, though they sympathize with the labour and are in agreement with the employees. The enterprises refuse to improve the wages and working conditions in that the cost for management would be increasing so that the enterprises' competitiveness might be weakened. The rural labours, as the weak group, have no choice but to "vote with their feet" passively if labour and management don't reach an accommodation on the wages and benefits, etc.

TABLE 4. Multiple comparisons of factors influencing "labour shortage" in view of the enterprises

Factors	Overall Samples N=1061		(1) HR Dept. N1=303	(2)Labour Agencies N2=33		(3)Employees N3=725	
	Mean	Std. Dev.	Mean	Mean	(1)-(2)	Mean	(1)-(3)
Low welfare	3.22	1.08	2.95	3.48	-0.53**	3.32	-0.37**
Low wages & benefits	3.11	1.11	2.83	3.33	-0.50*	3.21	-0.38**
No guarantee for rights & interests	3.00	1.09	2.70	3.18	-0.48*	3.11	-0.41**
Poor working conditions	2.93	1.05	2.68	3.12	-0.44*	3.02	-0.34**
Seasonal employment	2.74	1.07	2.63	2.76	-0.13	2.78	-0.15*
Uncertain future	2.60	1.13	2.40	2.82	-0.42*	2.68	-0.28**

Notes: 1. For the multiple comparisons with the homogeneity test of variance, LSD module is selected while T2 moduleis observed with the non-homogeneity test of variance; hereinafter the same. 2. Symbol * indicates the level of significance at the point of 0.05, and symbol ** means the significance level at the point of 0.01.

4.2. Factors in Respect of the Employees. Factor analysis (see Table 5) showed that the following indexes could all be used to interpret the "labour shortage" phenomenon: the unwillingness to leave the hometown as the Spring Festival was coming, unstable employment, more opportunities to develop in the rural area, rising living costs, the unavailable job information, and low wages.

TABLE 5. Factors of the "labor shortage" phenomenon from the employees' perspective

Factors	Factor Loadings
unwillingness to leave the hometown before the Spring Festival	0.65
unstable employment	0.65
more opportunities for development in the rural area	0.64
rising living costs	0.60
the unavailable job information	0.60
low wages	0.57
KMO=0.72	

From the employees' perspective, the major factors resulting in the "labor shortage" phenomenon are the rising living costs, unwillingness to leave the hometown before the Spring Festival, low wages, and more opportunities for development in the rural area, and their means are 3.62, 3.26, 3.21 and 3.21 in sequence (see Table 6). It can be seen that the "labour shortage" phenomenon owes a lot to the following three facts. Firstly, yearly progressive decrease of relative gains – the living costs have been kept rising by a fairly large scale whereas the wages of the rural labors failed to rise simultaneously – dampens the farmers' enthusiasm to work in the cities

Secondly, with the implementation of "New Rural Policies" put forward by the China Central Government, there are more and more opportunities for the farmers to carve out in the hometown, and agricultural products yield more profits which further cut down the supply of rural labors. Thirdly, the increasing order forms during the second half of 2009 provided more posts, but the demand was contrary to the normal practice of rural labors, that is, they usually migrate to look for a job at the beginning of a year. Therefore, the "Lewis Turning Point" of labor supply is coming in China, which brings forward new challenges for the SMEs in terms of the institutional innovation and their adjustment of development strategies.

TABLE 6. Multiple comparisons of factors influencing the "labor shortage" from the employees' viewpoint

Factors	Overall Samples N=1061		(1) HR Dept. N1=303	(2)Labor Agencies N2=33		(3)Employees N3=725	
	Mean	Std. Dev.	Mean	Mean	(1)-(2)	Mean	(1)-(3)
rising living costs	3.62	1.01	3.60	3.18	0.42*	3.65	-0.05
unwillingness to leave the hometown	3.26	1.17	3.46	3.09	0.37	3.19	0.27**
low wages	3.21	0.99	2.96	3.33	-0.37*	3.31	-0.35**
more opportunities in the countryside	3.21	1.01	3.33	3.39	-0.06	3.15	0.18**
unstable employment	2.93	1.09	2.82	2.76	0.06	2.99	-0.17*
the unavailable job information	2.92	1.06	2.88	2.85	0.03	2.94	-0.06

By way of the multiple comparisons (see Table 6), it is further discovered that significant difference lies in the perception of some factors by the human resources department (HR Dept.) and that of the employees. Respondents from the human resources department exaggerated the causes in view of the rural labors, yet they evaded factors such as "low wages" and unstable employment.

4.3. Causes in Terms of the Local Governments. As indicated by the factor analysis in Table 7, factors contributing to the explanation of the "labor shortage" phenomenon include the following indexes: imperfect social insurance system, insufficient pre-job training, lax implementation of labor laws, and deficient education service for the rural labors' children, weak function of the labor unions, descending regional attraction and industrial transfer to the inland provinces.

TABLE 7. Factors influencing the "labor shortage"phenomenon from the angle of local governments

Factors	Factor loadings
imperfect social insurance system	0.77
insufficient pre-job training	0.72
lax implementation of labour laws	0.72
deficient education service for the rural labours' children	0.72
weak function of the labour unions	0.72
descending regional attraction	0.68
industrial transfer to the inland provinces.	0.58
KMO=0.85	

TABLE 8. Multiple comparisons of indexes influencing the "labour shortage" phenomenon in respect of the local governments

Factors	Overall Samples N=1061		(1)HR Dept. N1=303	(2)Labour Agencies N2=33		(3)Employees N3=725	
	Mean	Std. Dev.	Mean	Mean	(1)-(2)	Mean	(1)-(3)
insufficient pre-job training	3.32	1.03	3.17	3.27	-0.1	3.38	-0.21 **
weak function of the labour unions	3.28	1.09	3.29	3.15	0.14	3.28	0.01
deficient education service for the rural labours' children	3.26	1.02	3.23	3.21	0.02	3.27	-0.04
imperfect social insurance system	3.22	1.10	3.10	3.24	-0.14	3.26	-0.16 *
lax implementation of labour laws	3.13	1.08	3.07	3.09	-0.02	3.15	-0.08
industrial transfer to the inland provinces	3.02	0.95	3.12	2.94	0.18	2.98	0.14*
descending regional attraction	3.01	1.00	3.03	3.15	-0.12	2.99	0.04

Judging from the local governments, the main factors on the "labour shortage" phenomenon consist of five items, i.e., insufficient pre-job training, weak function of the labour unions, deficient education service for the rural labours' children, imperfect social insurance system, and lax implementation of labour laws, whose means are 3.32, 3.28, 3.26, 3.22 and 3.13 in sequence (see Table 8). It demonstrated that the local government should improve the administration on how to create the sound and fair social environment.

The multiple comparisons demonstrate that there is a difference between the perception of the factors of local governments by the HR Dept. and the employees' perception, though no prominent distinction is found between the perception of the HR Dept. and those of the labour agencies. The cognitive discrepancy is mainly embodied in three factors, that is, insufficient pre-job training, imperfect social insurance system and the industrial transfer to the inland provinces.

5. Countermeasures of Dealing with the "Labor Shortage" Phenomenon. For the sake of solving the issue of "labour shortage" effectively, the tasks the enterprises and the local governments should fulfill are analyzed in the light of the employees.

5.1. Solutions of the SMEs. The results of the investigation show that, if the enterprises wish to enhance their attraction, the employees agree with the necessity of the following measures, that is, the promotion of income and welfare, the improvement of working environment, standardization of employment and employee training. The mean sequencing of the above-mentioned measures is 3.82, 3.66, 3.57 and 3.53 (see Table 9). Hereinto, to increase the wages and benefits is of great importance, only through which the recruitment difficulties could be overcome ultimately.

TABLE 9. Analysis of measures for the solution of "labour shortage" from the perspective of SMEs

Means / Options	Overall Sample	Age Difference					Academic Degree Diversity				
		≤20	21-30	31-40	41-50	>51	≤Elementary school	Junior high school	Senior high school	Junior college	≥Bachelor
increasing wages and welfare	3.82	3.41	3.89	3.73	3.79	4.08#	3.87	3.73	3.86	3.78	4.05#
improving working environment	3.66	3.46	3.71	3.56	3.74#	3.69	3.49	3.52	3.73	3.79#	3.76
Standardizing employment	3.57	3.44	3.62	3.51	3.50	3.85#	3.21	3.47	3.61	3.71#	3.71#
Employee training	3.53	3.72	3.57	3.40	3.56	3.69#	3.34	3.46	3.59	3.54	3.71#
Job ads campaign	3.44	3.33	3.49#	3.37	3.46	3.23	3.28	3.22	3.57	3.59#	3.58
humanistic care	3.36	3.33	3.44#	3.31	3.17	2.85	3.02	3.19	3.45	3.51	3.53#
Number of Samples	725	39	396	199	78	13	47	237	219	160	62

Note: Values indicated by the symbol "#" are the maximum means of the inter-group comparisons, and hereafter the same.

The analysis of the age difference indicates that workers over 41 years old, whose corresponding group was mainly the skilled workers or technicians, were more concerned about the wages and welfare, working conditions and the employment system. The young employees (the age ranging from 21 to 30) paid more attention to the job information and

TABLE 10. Factor analysis of solutions for the "labour shortage" from the perspective of local governments

Means / Options	Overall Samples	Age Difference					Academic Degree Difference				
		≤20	21-30	31-40	41-50	>51	≤element-ary school	Junior high school	Senior high school	Junior college	≥Bachelor
optimizing the social surroundings	3.59	3.38	3.62	3.55	**3.68**#	3.54	3.40	3.43	3.74	3.63	**3.76**#
providing the educational opportunities for the rural labours' children	3.56	3.28	3.55	3.49	**3.95**#	3.46	3.55	3.42	3.60	3.62	**3.77**#
intensifying the labour supervision	3.49	3.36	**3.54**#	3.45	3.49	3.00	2.98	3.38	**3.63**#	3.57	3.60
perfecting the social insurance system	3.48	2.97	3.57	3.35	**3.62**#	3.46	3.19	3.37	3.53	3.54	**3.82**#
Inputting more training outlay	3.43	2.92	3.45	3.38	3.64	**3.69**#	3.36	3.30	3.48	3.46	**3.68**#
Enhancing employment service	3.42	3.05	3.48	3.35	**3.51**#	3.23	2.94	3.27	3.53	**3.61**#	3.55
Transforming and upgrading the industries	3.31	3.26	**3.41**#	3.23	3.09	2.85	2.74	3.09	3.44	3.50	**3.58**#
Strengthening the functions of labour unions	3.28	3.15	**3.38**#	3.18	3.13	3.23	2.66	2.99	3.50	3.46	**3.63**#
Number of Samples	725	39	396	199	78	13	47	237	219	160	62

the corporate humanistic care. As revealed by the analysis of the academic degree difference, employees with degrees of junior college and bachelor were eager to see the promotion of benefits and welfare, working conditions and standard employment. Thus it can be seen that, if they want to attract high-quality employees, the SMEs should attach greater importance to the increase of wages and welfare, the improvement of working conditions and employment systems, but these measures will naturally boost up the management costs of the SMEs. It prefigures that the SMEs in China have to face the rising of employment cost, that is to say, their competitive advantages of “low labour cost” could hardly remain, and therefore it is an impending battle for the industries to transform and upgrade themselves.

5.2. Adjustment by the Local Governments. It is found in the survey that the local government should meliorate the employment environment by optimizing the social surroundings, providing the educational opportunities for the rural labours’ children, intensifying the labour supervision and perfecting the social insurance system. The means of the above four measures are 3.59, 3.56, 3.49 and 3.48 in sequence (see Table 10).

In terms of age difference, employees at the age of 41 to 50, in comparison with those of other ages, lay more emphasis on the possibility of attracting more rural labours to work in the cities if the local governments make an effort to optimize the social surroundings, provide the educational opportunities for the rural labours’ children, perfect the social insurance system and boost up employment service, etc. Judging by difference in the academic degree, employees with bachelor degrees are looking forward with great expectation to the government’s melioration of the surroundings and services in the hope of relieving the tension of “labour shortage”.

6. Conclusions. By means of the survey on the “labour shortage” phenomenon of the SMEs , it has been observed that:

Firstly, 29.7% of the SMEs, especially the small enterprises, were confronted with the “labour shortage” (the average gap ratio 28.5%) as a result of the economic recovery.

Secondly, the essence of “labour shortage” is “technician shortage”, mainly elementary and intermediate artisans, whose accumulative gap amounts to 70.7%.

Thirdly, the comparative benefit decrease of the rural labour is the essential cause for the “labour shortage”, indicating that the Lewis Turning Point of labour supply is coming in China.

Fourthly, in order to solve the problem of “labour shortage”, the SMEs should lay weight on promoting the wages and welfare as well as the working environment, while the local governments should concentrate on the cultivation of favorable surroundings for employment service. The employees aspire to the rising wages and welfare. The previous advantage of the SMEs - “low cost” - is gradually disappearing.

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KNOWLEDGE AND ONTOLOGICAL SUPPORTS OF KNOWLEDGE

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ABSTRACT. *The purpose of this article is to examine, from the perspective of different theoretical approaches, the relationship that exists between different ontological supports of knowledge and knowledge itself (the way it is created and its characteristics). The results of the article consist of (1) making explicit the ontological support-knowledge creation, characteristics or types of knowledge relationship in different approaches; and (2) enabling understanding of the fact that the ideas we have about knowledge (how it is created or what its characteristics are come from our beliefs about the supports in which, or in interaction with, it is created).*

Keywords: Knowledge; Knowledge Creation; Ontological Support of Knowledge; Abstract Knowledge

1. Introduction. The underlying purpose of this study is to examine the relationship between knowledge and reality in the field of management. All forms of our actions upon reality (know-how, technology, organizational routines and differing practices) or of our understanding of the world (systematic organization of ideas and concepts) are forms of knowledge; and all the ways in which physical, technical or social reality manifests itself as a consequence of nature or human action, are the supports on which knowledge is founded. The structure of this present study is as follows: section two (theoretical framework), presents a preliminary discussion on the ontological and epistemological dimensions of knowledge, and includes a classification of different names and types of knowledge. Section three highlights and discusses the importance of the ontological supports of knowledge, and shows different proposals. Finally, section four shows the conclusions of this study.

2. Theoretical Framework. The supports for knowledge and knowledge itself should be separated to carry out the analysis and conceptually order its different components and dimensions. The supports on which and /or in which knowledge is produced form the basis for the ontological dimension, and the identification and analysis of the knowledge produced will pave the way for the epistemological dimension. The first of these, in a cognitive analysis of knowledge in organizations, refers to individual members of the organization, its groups and the organization as a whole (Crossan et al.,1999; Nonaka and

Takeuchi, 1995). The second refers to different types of knowledge, and in this sense, contributions that refer to the organization and the economy propose a wide range of names and descriptions.

Some of these correspond to particular circumstances of time and place (Hayek,1945), knowledge linked to information (Arrow,1973; Williamson,1985), specific knowledge (Fama and Jensen,1983b; Fama and Jensen,1983a), tacit and explicit knowledge (Nonaka,1991; Polanyi,1962), analyzable or non-analyzable knowledge (Boisot and Child,1999; Perrow,1967; Perrow,1970), human capital (Becker, 1993), organizational routines (Nelson and Winter,1982), core competences (Prahalad and G. Hamel,1990), and knowledge linked to the organizational context and to practice (Spender,1996; Spender, 2007; Spender, 2008; Tsoukas, 1969; Weick, 1969) .

The distinction between knowledge of concrete situations and abstract or conceptual knowledge, along with the differences between constructivist and cognitive view, can help to come up with a general classification of the different ways in which knowledge is labeled. Table 1 shows this classification but adds the column other approaches in order to include the labels for knowledge that exclude the concepts of the cognitive view or constructivist view; and excludes the concept of intersubjectivity from abstract or conceptual knowledge as, in organizations, explicit knowledge depends upon its particular idiosyncratic environment. Some forms of knowledge have two dimensions and are classified into two different boxes.

TABLE 1. A classification of different labels and types of knowledge

	Constructivist view	Cognitive view	Other approaches
Knowledge of concrete situations	• Organizational routines • Core competences • Knowledge linked to concept and practice	• Tacit knowledge • Non-analyzable knowledge	• Knowledge of particular circumstances of time and place • Specific knowledge
Abstract, conceptual knowledge	• Organizational routines • Core competences	• Explicit knowledge • Analyzable knowledge	• Knowledge linked to information • Human capital

3. Ontology and Epistemology in Knowledge and Knowledge Creation. The models described by Nonaka and Takeuchi (1995) and Crossan et al. (1999) are important contributions to knowledge theory from a fundamentally cognitive viewpoint. However, looking further than the richness of the ideas and the abundance of fine points to be made on both approaches, their proposals include an excessive separation between ontological support and knowledge creation, in such a way that there is a greater emphasis on the epistemological process in itself (the interaction between the different types of knowledge) than on the dynamic between ontology and epistemology (the relationships between reality and knowledge through practice).

The differences inherent in explaining the formation of knowledge by underlining the interaction between different types of knowledge, or highlighting the relationships between reality (physical, technological and organizational context) and knowledge are subtle but profound. If knowledge is created via the interaction between tacit and explicit knowledge, it is true to say that tacit knowledge is a consequence of practice (therein lies the practice), but the reality or context become secondary, whilst the tacit-explicit dynamic prevails and the focus is on the process in the mind instead of on the interaction between mind-context and mind-reality.

From a constructivist view, Tsoukas (1969) highlighted the "the unarticulated background related to human understanding". This unarticulated background is "a set of subsidiary particulars which are tacitly integrated by individuals", in a way where there is "a focal target, and the person who links the two". In other words, through their objectives, people integrate and give sense to their practices and their experience, building the world and organizations; and there is a group of secondary details which remain in the shadows of consciousness (sensations, intuition, knowledge linked to practice), a result of the interaction with ontological support which, when integrated by force of will and the personal objectives of the individual, lead to the articulation (formalization, conceptualization) of knowledge.

Therefore, unarticulated background is an indispensable part of articulated knowledge, or "tacit knowledge is the necessary component of all knowledge" (Ibid.: 14), which rather differs from the clearer separation we can find in Nonaka and Takeuchi, and in Crossan, Lane and White. At the same time, ontological support (on and in which practice is carried out) and knowledge creation are closely linked here.

Taking a more radical approach, and fascinated by the importance he attributes to practice and the knowledge linked to it, Spender (2008) tells us that "practice is richer and more complex than the mere execution of cognition, and cannot be theorized within a framework of rationality and goal-seeking", in such a way that knowledge management, contrary to the other types of management, "begins precisely and only with the uncertainties and knowledge-failures that arrest rational decision-making and force us outside rationality's box. (…) Knowledge management is really about managing knowledge-absences rather than knowledge-assets. In this sense, what Spender considers to be the core of their argument, is the need to manage knowledge linked to practice which is tacit and non-structured and absent as conceptual and formal knowledge; he thus proposes that "knowledge management is ultimately about managing both imagination and reason as actors confront and resolve uncertainty". Or, in other words, in order to manage non-structured knowledge linked to practice, we need intuition as well as reasoning.

In this contribution by Spender, as in that of Tsoukas, ontological support and knowledge creation are closely linked, and as in Tsoukas this paves the way for a particular epistemological conception: the possibility of a clear separation between tacit and explicit knowledge simply does not exist.

The way in which ontological support is conceived (ontological support per se and/or relationships to it) explains the epistemological conception. Or, put differently, the way in which reality is conceived, and the relationships with it explain the conception of existing types of knowledge. From an overall perspective, if in the ontological support of knowledge we can distinguish between components of the physical, technical and social dimensions of reality (material and social contexts), and the individual and cognitive dimension (the person and their mind), the different conceptions of knowledge correspond to a greater or lesser degree to the relationship between knowledge and one or other ontological components (or supports).

For the focus of Crossan et al.(1999), the relationship with reality and obtaining tacit knowledge is resolved in the individual minds of members of the organization (intuiting, through practice), and the identification and analysis of tacit knowledge, externalizing it via the interpretation (interpreting) of knowledge, a strictly cognitive concept. Organizational context is important (as is patently obvious during the stages of integrating and institutionalizing knowledge), but more as a framework for the diffusion and embedding of knowledge than as a necessary context for its creation. On the other hand, the physical and technological world exists and forms a part of the tasks and the acquisition of experience, but can only figure implicitly and indirectly in a strictly cognitive approach.

As a result, a conception of ontological support, in which the mind of the individual (intuiting and interpreting) is the fundamental support, leads to conceiving knowledge, in its creation stage, in strictly individual and cognitive terms. Later on, when the organization gains in importance as an ontological support, the stages of integrating and institutionalizing extend the cognitive conception to the organization as a whole.

In the proposal by Nonaka (1991) and by Nonaka and Takeuchi (1995), the emphasis on the social context is much greater. In the first stage of knowledge creation (socialization), ontological support is not the individual per se but experience and shared mental models. The ontological supports on which knowledge creation is based in Nonaka and Takeuchi, regardless of the fact that the authors attribute it specifically to individuals, groups, organization and interorganizational relationships, correspond fundamentally to the individual-group support and to the organization as a whole. The importance of organizational support as a context that enables personal disposition and the necessary behaviour is underlined in the studies by Nonaka and Konno (1998) and Nonaka et al.(2001). In addition, although the relationship with the physical and technical world is also implicit and indirect here, the emphasis the authors lay on practice and the way in which these relationships should be organized (hypertext organization) brings them closer to the material, physical and technical context.

Consequently, the different conception of ontological support in which the organizational context (as a generator of knowledge) carries greater weight than in the previous approach, and the greater emphasis on practice (as an approximation to the physical and technical world), lead to a more complex conception of knowledge and its creation process. Here, tacit knowledge is formed as a consequence of practice within a collective or work group, and the transformation of tacit knowledge into explicit knowledge is also the result of collective work in the organization.

With regard to Tsoukas (1969) and Spender (2008), whose essential ideas we attempted to synthesize at the start of this section, important differences exist between them. However, in both cases, their conception, which belongs to the constructivist view, is still a cognitive one, and the emphasis they lay on practice, which is even greater than in the proposal of Nonaka and Takeuchi (1995), puts them in touch with physical and technological supports, apart from the organizational context. This contact is implicit and is not mentioned by the authors, but is inevitable because there is no type of practice that does not include technological and/or material elements.

4. Conclusions. Some conclusions that can be derived from the authors reviewed in this study are, firstly, that knowledge creativity (how knowledge is created, based on its material or human support) and/or the conception of its nature, are linked to its ontological support. It is also linked to the physical, technological and social nature of this support (the material and organizational contexts) and to the behaviour and individual cognitive capacity (the knowledge in the mind) as the human part of ontological support.

In the review of knowledge theories, there is no perfectly established mechanical relationship between the conception of ontological support and the way in which knowledge creation or its nature is perceived, but it does show in different ways, and with relevance, the influence of the ontological conception of how knowledge is conceived.

Secondly, it appears to be appropriate to separate the stage of knowledge creation from the stage of the analysis and conceptualization of knowledge creation. In the creation process, as we have previously mentioned, the material and social supports (concrete reality and the social contexts with which we interact) and the human supports of knowledge (behaviour and the mind) interact, accumulating experience and forming the background (the "secondary" details) of new knowledge. In the process of analysis and conceptualization, however, the only support that can reasonably come into play is the cognitive one (knowledge in the mind), giving sense to knowledge per se and its relationship–partial and analytical-with reality. These two planes of knowledge, its creation and its analysis are not always clearly distinguished in the literature, but our conclusion is that this distinction is appropriate.

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THE MODEL DESIGN OF ECOLOGICAL COMPENSATION RESPONSIBILITY IN WATERSHED MANAGEMENT

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ABSTRACT. *Ecological compensation mechanism of watershed is recognized as an effective way to resolve economic development and environmental protection problems of districts in the watershed. However, the determination of criteria for watershed ecological compensation is very complicated and not yet well-solved. One crucial problem in this determination of criteria is that the responsibility among districts of the watershed is not well-established. The responsibility can be categorized into responsibility of water quality and definition of water quantity. Then, we take Huaihe watershed as the sample for empirical study; the results show that our definition method of environmental responsibility of watershed is fair and efficient.*

Keywords: Watershed Management; Model Design; Ecological Compensation Responsibility

1. Introduction. This thesis establishes water quality responsibility model and water quantity responsibility model respectively, and use Huaihe watershed as study case, define the responsibility of water quality and water quantity for four provinces of Huaihe watershed, and analyze the results in detail. The results of this research provides the basis for the more scientific calculation of the eco-compensation quantity, this research can be also used as reference for defining compensation standard of transboundary pollution. The allocation of emission permits in the status quo mainly happens in between enterprises of one region. This research employs the Gini coefficient method which used widely in evaluating the equity of income allocation to allocate the emission permit of each district in the watershed, which accordingly define the water quality responsibility, this method not only enrich the options for free allocation of emission permits, but also provide reference for allocation of emission permits between different regions.

The paper can be organized as following sections: section 1 deals with the model of water quality responsibility, then we introduce water quantity responsibility model in section 2; then we use Huaihe watershed as a study case for responsibility in section 4; The conclusions and prospects are included in the last section.

2. Model Design of Responsibility of Ecological Compensation in Watershed. Many scholars (Liu et al., 2006; Qin and Qiu, 2005; Liu and Yu, 2007) has conducted several researches associated with the compensation criteria of ecological compensation of watershed. These scholars generally followed this basic route: eco-compensation of watershed can be divided into water quantity compensation and water quality compensation. Water quantity compensation is represented by the product of water quantity obtained by the downstream and the market price of water resource, while surface water quality criteria type III is deemed as the standard for the water quality compensation. Then three scenarios occur: (i) if upstream sustained the type III water quality transferred to downstream, there will be no compensation. (ii) If upstream "over-protected" the water resource and the water quality shifted to downstream is better than type III, downstream has to pay for the marginal water quality which is valued as the product of the overall cost of upstream environmental protection (includes direct investment and opportunity cost) and certain coefficients. (iii) If the water quality can not reach the standard, upstream must compensate downstream for the poor water quality.

Above researches all implied that maintaining the uniform type III water quality was the environmental responsibility of up stream. As long as this definition of environmental responsibility is distinct and reasonable, the compensation standard should be basically sound. However, "is this definition really reasonable?" by reasonable, we mean fairness, efficiency and enforceability. Accounting for these factors, we calibrate an environmental responsibility model to address this problem.

2.1. Modeling Thought. It is very complicate to define environmental responsibility among each district of watershed, since attaining reasonable definition has to take account of fairness, efficiency, as well as legal rule and historical factors. Zhao et al. (2005) has demonstrated that the mechanism of macroscopically regulation by means of emission trading (MMRET) is significantly preferable to the mechanism of appointed quota of pollution reduction in China. In the frame of MMRET, the definition of environmental responsibility can be actually transformed into the initial allocation of pollution permits among districts in the watershed. Therefore, the problem left to us is how to allocate the pollution permits efficiently and fairly. This paper involves two phases to define the environmental responsibility of each district in the watershed. The first phase is to determine the optimal allocation strategy of emission permits for districts in the watershed by establishing an emission permits allocation model. Then, we employ the formulation of emission permits and water quality to define the final environmental responsibility of each district. To model the allocation of emission permits, we develop a non-linear programming model seeking for least abatement cost based on the reasonable fairness among the individual district, by which the initial emission permits of each district could be calculated.

2.2. Allocation of Initial Emission Permits. We assume that watershed covers ***N*** districts and each district can take measures to restrain their pollutants to their own area or transfer the pollutants to downstream. They can decide the amount of pollutants remained in their own area or transferred to downstream as well. The main variables and symbols are as follows:

AC_i *(i=1, 2, 3, ... N)* is the industry emission abatement cost function of district *i*, it can be estimated using econometric model: $AC = \xi W^{\alpha}\eta^{\beta}$, $\eta = (I - E)/S$ (Cao and Wang, 1999), where W represents annual discharge of sewage, I, E represents the average pollutants concentration of inlet and outlet of pollution treatment equipment respectively. S is the type III discharge standard of pollutants concentration.

P_i (i=1, 2, 3, … N) is the initial emission permits allocated to district *i*.

P_{imax} is the river water environmental capacity of the watershed attached to district i.
P_{0i}' is the present emission of district i.
$\overline{P}_i$ is the mean historical emission of district i.
e_i is the "equity emission index" of district i.
The standard formulation of the policy-maker's optimization problem is to minimize the emission abatement cost, defined here as:

$$Min\pi = \sum_{i=1}^{i=N} AC_i \tag{1}$$

Subjects to two restraints: the aggregate emission restraint and "equity restraint".
In this paper ， the initial allocation of emission permits is carried out in the overall watershed. Considering the fairness of each district, upstream do not necessarily enjoy all the river water environmental capacity of watershed attached to their geographical areas, in other case, they can even occupy downstream's water environmental capacity, which means downstream must reduce their emission in order to compensate the increment of pollution that upstream bring on.
(1) Aggregate emission restraint: the total emission permits allocated are equal to the overall water environmental capacity of watershed.

$$\sum_{i=1}^{i=N} P_i = \sum_{i=1}^{i=N} P_{i\max} \tag{2}$$

(2) "Equity restraint": According to the conception of Gini coefficient which is an index to estimate equity of income, a specific method is established to evaluate the scenario of allocation of water emission permits among districts in the watershed. Correlative factors of the Gini coefficient for emission permits allocation are population, future development planning, and level of pollution control and mean historical emission. Among them, population-initial emission permits Gini coefficient accounts for the difference of the permits allocation per capita among each district. Kvemdokk (1999) regards the allocation of emission permits in terms of population as politically and ethically acceptable. Thus, it may be unfair that more pollution permits are allocated to the region with smaller population.
In addition, we verge future development planning factor and level of pollution control factor into "equity emission index"-initial emission permits Gini coefficient, which reflect that watershed regulator should take into account the synthesized impact of economic development level, level of pollution control, level of production and technology, and future development planning. The result of allocation should not limit the development of backward areas, and provide incentive for conducting cleaner production technology or the transform of traditional high-contamination industrial structure. "Equity emission index" can be described as:

$$e_i = \frac{(1+a_i)^k / (1+\overline{a})^k}{(P_{0i} / GDP_i) / \overline{(P_0 / GDP)}}$$

Where a_i represents the expected economic growth rate of district i in the future development planning, $\overline{a_i}$ is the average expected economic growth rate of all the districts in the watershed, k is the duration of the planning. P_{0i} / GDP_i indicates the emission per *GDP* of district *i*, $\overline{(P_0 / GDP)}$ is the average emission per GDP of all the districts. In the case that the pollution units of a district adopt cleaner technology or transform into the industry with light pollution, and the expected economic growth rate of this district is high, hence, the district will be granted more discharge permits.

Considering that most of upstream areas are undeveloped region, their capability of technical innovation is restricted, therefore the allocated emission permits will be relatively few according to the allocation indicator of level of pollution control, this will results in "the Matthew effect". In order to reduce the influence of this effect bring to the principle of fairness, considering the discrepancy of different regions, we employ " compensation ability" indicator which can be expressed by GDP per capita. The weaker the "compensation ability" is, the more emission permits are allocated.

In order to guarantee the equity in the time scale, the initial allocation of emission permits needs to be stable among years, which denotes that there should be no significant difference between initial emission permits and mean historical emission, therefore, mean historical emission- initial emission permits Gini coefficient is developed to measure this equity. We introduce $\overline{P_i}$ to describe the mean historical emission. For reasons that the closer the year is, the more demand information of emission included in the historical emission, we employ exponential smoothing method to estimate $\overline{P_i}$:

$$\overline{P_i} = \alpha P_i^{T-1} + \alpha(1-\alpha) P_i^{T-2} + \alpha(1-\alpha)^2 P_i^{T-3} + \ldots \quad i = 1, 2, \ldots, N$$

Where T represents the year for initial allocation, P_i^{T-1} describe the emission of year *T-1* and so on, α (0< α <1) is a weighted coefficient, which specifies the reliance of initial emission permits on the demand information of emission in the year *T-1*. The larger value of α will lead to the shorter data sequence.

The smaller above Gini coefficients are, the fairer initial allocation is. In the evaluation of the allocation of income, due to the limitation of social development, it is impossible to distribute income perfectly equal, so there is little possibility that Gini coefficient is less than 0.2. The reasonable range of Gini coefficient should be 0.2-0.4. However, in the sphere of environmental problem, if there is no conflict of natural resource among regions, the Gini coefficient could approximate to 0, Wu et al. (2002) define the reasonable scope of Gini efficient as 0-0.2 in evaluation of the total pollutant load allocation among seven river basins of China. On the other hand, if there are frequently transboundary pollution events among regions, and there is no well-established coordination mechanism for environmental conflict, Gini coefficient may be magnified. In the study of the equity evaluation of total load allocation for atmosphere pollutants, Liu et al. (2002) specified 0-0.3 as the reasonable scope of Gina coefficient. In our study, based on the fact that coordination mechanism for environmental conflict among districts of watershed is not yet mature, and the problem of transboundary pollution is overwhelming, we define the reasonable scope of Gini coefficient as 0-0.3.

According to the calculation of the cumulative percentages of initial emission permits, "equity emission index", mean historical emission and population, we further adopt trapezoid planimetry to compute the Gini coefficients based on the factors of population, "equity emission index" and mean historical emission respectively. These are described in following manner:

$$G_j = 1 - \sum_{i=1}^{N} (X_{j(i)} - X_{j(i-1)})(Y_i + Y_{i-1})$$

$$X_{j(i)} = X_{j(i-1)} + M_{j(i)} / \sum_{i=1}^{N} M_{j(i)}$$

$$Y_i = Y_{i-1} + P_i / \sum_{i=1}^{N} P_i$$

Where $X_{j(i)}$ is the cumulative percent of factor j; $M_{j(i)}$ is the value of factor j in district i; Y_i is the cumulative percent of initial emission permits; P_i specifies the initial emission permits of district i; when $i=1$, $(X_{j(i-1)}, Y_{i-1})$ is treated as $(0,0)$. Because all the Gini coefficients range from 0 to 0.3, the constraint conditions are:

$$G_j < 0.3 \qquad (3)$$

2.3. Environmental Responsibility. Subjecting to (2), (3), with the objective of (1), a non-linear programming model is described in last chapter; we solve the allocation of initial emission permits using software Matlab.

The optimum solution of this non-linear programming model P_i^* is the optimal initial emission permits allocated to each district of watershed. Incorporating the principle of efficiency and fairness, this allocation strategy should be the accepted method by all the districts of watershed. Water quality of cross-section (Ci) is the function of river flow (W), emission of human activities (P_i) and background concentration of pollutants (B_i), which can be denoted as $C_i = f(W, P_i, B_i)$.

In this equation, river flow and background concentration are exogenous variables. Provided by emission allocation obtained by the optimum allocation model discussed in last chapter, we can compute the water quality of the cross-section to define the final environmental responsibility of each district in the watershed.

3. Case Study of Huaihe Watershed.

3.1. Definition of Water Quality Responsibility in the Huaihe Watershed. For a long time, Huaihe watershed management department determine the emission permit quota according to the water environmental quality requirement, and regions must fulfill their task by themselves, which means that the environmental responsibility is class III water quality in the cross-section between each region and they compensate each other according to this responsibility. This definition of water quality responsibility does not consider the equity and efficiency factors.

Huaihe watershed includes four provinces: Anhui, Henan, Shandong, Jiangsu. We use subscript a, h, s, j to represent those provinces, Huaihe watershed can be graphed as figure 1. According to the 《Water pollution control plan of Huaihe watershed and "the ninth five-year plan"》, Total emission permits of 1997 for COD is 890.2 thousand tons, among those provinces, Henan is allocated 247.2 thousand tons; Anhui, 207.7 thousand tons;

Shandong, 263.8 thousand tons; Jiangsu, 171.5 thousand tons. According to the objective of reduction of at least 600 thousand tons COD by 1997, till 1995 COD should be reduced by 10%, 1996 should be reduced by 15%, 1994 should be reduced by 5%. Then the COD emission of provinces in Huaihe watershed from 1993 to1996 are showed as Table 1.

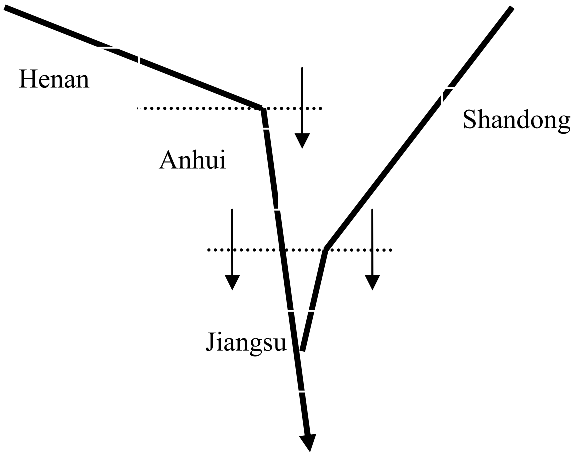

FIGURE 1. Diagram of Provinces in Huaihe River Watershed

TABLE 1. COD Load of Four Provinces in Huaihe Watershed from 1993 to 1996

Province	1996 load	1995 load	1994 load	1993 load
Henan	28.53	34.236	36.138	38.04
Anhui	28.32	33.984	35.872	37.76
Shandong	35.97	43.164	45.562	47.96
Jiangsu	19.79	23.742	25.061	26.38

According to 《China statistic yearbook》, we can get the data for the population, GDP of each province in Huaihe watershed in 1996. Acccrding to the ninth five-year planning, we can get the development speed of each province. Those data are as Table 2:

TABLE 2. Development Speed of the Ninth Five Year Planning and Population and GDP of Each Province in 1996

Province	GDP（10^9 yuan）	Population（10^3）	Population in Huaihe watershed（10^3）	Planning development speed
Henan	368.341	91720	5894.60	10%
Anhui	233.925	60700	3540.00	12.50%
Shandong	596.042 8	7380	3179.06	10%
Jiangsu	600.421	71100	3827.08	12%

Organized from the data above, we can get the COD emission per billion yuan GDP and GDP per capita showed as Table 3:

TABLE 3. COD Emission Per Billion GDP and GDP Per Capita of Each Province in 1996

Province	COD emission per billion（$t/10^9$ yuan）	GDP per capita（10^3 yuan/ people）
Henan 1	632 .793	4.0159289
Anhui 1	289.1393	3.8537891
Shandong	1975.7215 6.82	12634
Jiangsu 7	25.90432	8.4447398

Because it is hard to determine the COD emission per billion yuan GDP of the area of provinces which belongs to Huaihe watershed, considering that the area which belongs to Huaihe watershed of one province is economically, socially and culturally same as the whole area of that province, so we suppose that the COD emission per billion yuan GDP of the area of one province which belongs to Huaihe watershed is the same as the COD emission per billion yuan GDP of the total province. COD emission data can be attained from 《China environment yearbook》, Henan：601423.6t；Anhui：301561.9t；Shandong：1177613t；Jiangsu：435848.2t. Population indicator of Gini coefficient is population of area of provinces which belongs to Huiahe watershed, Compensation capacity indicator is expressed by GDP per capita of each province.

The sum of abatement cost function of each province in 1997 is (Zhao, 2007)

$$\pi = 1490 P_{ha}^{0.507} + 690 P_{aa}^{0.807} + 214 P_{sa}^{0.407} + 283 P_{ja}^{1.219}$$

P_{ja} represents the COD abatement of Jiangsu province in 1997, others are deduced by analogy. Suppose that the COD load of next year is the same as the emission of COD at last year, we can change our COD abatement cost function as:

$$\pi = 1490(28.53 - P_h)\left|28.53 - P_h\right|^{-0.493} + 690(28.32 - P_a)\left|28.32 - P_a\right|^{-0.193}$$

$$+214(35.97 - P_s)(\left|35.97 - P_s\right|)^{-0.593} + 283(19.79 - P_j)\left|19.79 - P_j\right|^{0.219}$$

P_h，P_a，P_s，P_j represent the allocated emission permit of Henan, Anhui, Shandong and Jiangsu respectively. We set smoothing coefficient as 0.8[14], back 3 years.

Applying Matlab software to calculate the model, the optimized result is as follows:

TABLE 4. Result of Cost Optimization

Province	Allocated COD emission permit using our model（10^4t）	Allocated COD emission permit in the status quo （10^4t）
Henan 21	.1438	24.72
Anhui 21	.9895	20.77
Shandong 2	0.1379	26.38
Jiangsu 25	.7488	17.15
Total COD abatement cost	5331.4* 104 yuan	7923.4* 10^4 yuan

Optimized Gini coefficients are as follows:

TABLE 5. Optimized Gini coefficients

Indicator	Average emission qua ntity	Level of pollution control	Population	Compensation capacity
Initial Gini coefficient	0.052	0.315	0.116	0.173
Optimized Gini coefficient	0.165	0.125	0.067	0.193

The results sho w that the o riginal allo cation m ethod does not consid er the le vel of pollution con trol, which ca n not prov ide in centive for emission redu ction, while a dopting our a llocation method, Gini co efficients a ll are in th e reasonable range, and cost reduction is abo ut 2592*10^4yuan. Th erefore, ou r m ethod can gu arantee th e optimized e fficiency under the reasonable equity range.

Because the quantity of domestic wastewater and non-point source water is under 30% of all the waste water before 19 98, the abatement co st function in our empirical study on ly include the ind ustrial po llution. Howev er, aft er 2000, th ere is more a nd m ore non -point source po llution a nd dom estic wastewater. However, there is no well-establ ished m ethod for dealing with the abate cost function o f non -point sou rce. With the establishment of coordination mechanism for conflict, Gini coefficient should be limited under 0.2. In China, there will be huge transaction cost which will offset efficiency at some extent, so using my model t o a llocate emission perm it to make the whole watershed m ost efficient is still valuable.

With the asymmetrical information problem in the abatement cost and emission data, we should minimize t he Gin i coe fficient and attain th e optimized efficiency of watersh ed through tradable emission permit mechanism.

3.2. C alculating the A llocated W ater Quan tity of F our Pr ovinces. Consider th at basic water use for resid ents' li fe should b e fi rstly guaranteed, so in the water ri ghts allocation process, re sidents' l ife use water s hould be given priority f or satisfying. T herefore, the water qu antity for allocation is the t otal water resource qu antity minus b asic water u se for residents' life of all the regions minus ecological water use of the river course.

As to e cological water use of river co urse, the ut ilization ratio of riv ers wit h a bundant runoff should not surpass 40%, poor runoff rivers should not exceed 60%.Huaihe watershed is abundant runoff river, 40% is the utilization ratio.

Due to th e d ata o f domestic water u se qu ota of each prov ince: Shandong: 102 .5L/d, Henan: 100L/d, Jiangsu: 165L/d, Anhui: 185L/d. (Data is from 《water use quota》of each province), water qu antity t hat can be u sed for allocat ion i s 482.96-82.83-482.96×60%=11.0354 billion m^3. Then allocated wa ter righ ts of each province is：Henan, 3.298095 billion m^3，Anhui, 2.585053 billion m^3，Jiangsu, 2.860652 billion $m^{3,}$ Shandong 2.2916 billion m^3.

If we allocate wa ter righ ts according to th e multi-year wa ter u se of each p rovince, th en the result of water al location ra tio should be: 0.1969，0.2012，0.44，0.1619. Ra nge of variation is: +51.67%, +10.8%，-39.1%, +29.96%.

4. Conclusions and Prospects. This paper firstly proposes to solve the responsibility problem in the calculation of eco-compensation quantity. It adopts Gini coefficient method to allocate emission permit according to the principle of equity and efficiency. And establish nine indicators mainly equity indicators to allocate the water rights. This paper firstly tries to allocate water rights in the Huaihe watershed.

Another indicator “negotiation ability” should be added in the allocation model, because upstream has the priority in water quality control as well as water quantity control. So the quantification of negotiation ability should be the research direction in the future. Water quality and water quantity is the properties of water, these two properties are undetectable. So the method for integrating these two properties should be highly emphasized.

Because the allocation of emission permit and water rights happens between the provinces in this thesis, if it happens between the smaller districts in one province, or even smaller than that, the efficiency indicators should be put more weight in a river basin.

Ecological compensation mechanism of watershed is recognized as an effective way to resolve economic development and environmental protection problems of districts in the watershed. Based on these in the public policy design of watershed management, we study and design a systematic process using a set of indicators to measure and compare an organization's operation, working practices and performance against other organizations operating under similar conditions or recognized as having the best possible performance.

Used to establish performance targets and improve management and working methods. And then, proposed the desirable condition of water resources and water quantities and qualitative use in watershed management.

Future research might consider the following issues that are not addressed in this study. First, the principle and indicator system of AHP should be improved，in addition, weight determination process should let water user participate for the sake of convenient implementation. Second, as equity is a concept hard to measure, the indicator system for Gini coefficient method should be further studied. How to certify the reasonable range for the Gini coefficient, and there are many methods for calculate Gini coefficient. Third, applied in watershed planning to help formulate action plans. In terms of an evaluation of total benefits to total costs of an actual or proposed water program or project, used to compare and rank alternative investment strategies or project designs.

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 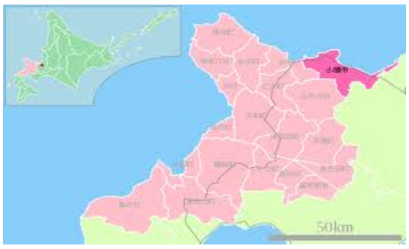

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