IMIP 2015

Multimedia University

29 – 31 October Melaka *Malaysia*



Proceeding of

The International Symposium on

Innovative Management, Information & Production 2015

ISSN 2185-5463

Initiated by

International Society of Management Engineers, Waseda University, Japan

Organized by

Multimedia University, Malaysia National Chengchi University, Taiwan Zhejiang Gongshang University, China

Sponsored by

International Journal of Innovative Management, Information & Production

International Journal of Intelligent Technologies and Applied Statistics

Journal of Advanced Computational Intelligence and Intelligent Informatics

Preface

It is a great pleasure that we announce, on Oct 29, 2015, the opening of the international symposium of Innovative Management, Information and Production 2015 (IMIP2015) at Multimedia University, Melaka Campus, Malaysia.

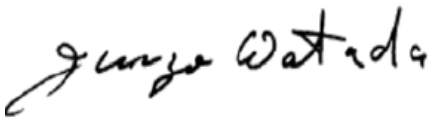
Melaka is the starting point of modernizing Malaysia when Portuguese arrived here in 1511. Even though Malaysia was found various people previously, the meeting with Portuguese is one of the most epoch making in the Malaysian history. It was to meet Europe. In the sense, Multimedia University also plays a pivotal role in modernizing the Malaysia industries. As well as intelligent technology and modern production, multimedia technologies are quite important. The university plays such a key role in Malaysia.

We are very much pleased to provide concepts of and discuss about Innovative Management, Information and Production for modern industries and economics in Malaysia.

We announce that we have been starting the World Collaborative Innovation Center of Management Engineering www.wcicme.com in parallel to IMIP and ISME. The collaborative innovation has an important concept in pushing global industries and economy. This center will play a key role globally. One is to provide various research projects as well as collaborative symposiums.

We hope this symposium can enable us to start our modernization in the central manufacturing country, Malaysia, in all over the world.

Junzo WATADA, Waseda University, Japan
Siong Hoe LAU, Multimedia University, Malaysia



International Symposium on Innovative Management, Information & Production 2015

Symposium Committee

General Chairs

Co-Chair	Watada, Junzo	Japan
Co-Chair	Lau, Siong Hoe	Malaysia

Advisory Committee

	Nguyen, Hung T	USA

International Progam Committee

Chair	Huarng, Kun-Huang	Taiwan
	Agarawal, Aman	India
	Bouchon-Meunier,	France
	Choi, Jaeseok	Korea
	Chung, Chan Sup	Korea
	Denoeux, Thierry	France
	Dhompongsa, Sompong	Thailand
	Ding, Liya	Macau
	Gil, Maria Angeles	Spain
	Grzegorzewski,	Poland
	Gupta, K. Arjun	India
	Ishii, Hiroaki	Japan
	Jirousek, Radim	Czech
	Khalid, Marzuki	Malaysia
	Koczy, Laszlo T	Hungary
	Kumar, Kuldeep	Australia
	Langrand, Claude	France
	Lee, Oesook	Korea
	Leung, Kwongsak	Hong Kong
	Li, Jinhua	China
	Li, Ronald	China
	Li, Shoumei	China
	Lin , Yuan Horng	Taiwan
	Moutinho, Luiz	UK
	Novak , Vilem	Czech
	Santiprabhob, Pratit	Thailand
	Shary, P. Sergey	Russia
	Shiizuka, Hisao	Japan
	Sriboonchitta, Songsak	Thailand
	Sugeno, Michio	Japan
	Takeda, Fumiaki	Japan
	Tan, Choo Jun	Malaysia
	Tay, Kai Meng	Malaysia
	Tran, Lanh	USA
	Wang, Qingshi	China
	Wang, Shaoping	China
	Yager, Ronald	USA
	Yap, Hwa Jen	Malaysia
	Yap, Keem Siah	Malaysia
	Zhao, Guoqing	China

Publicity Committee

Co-Chair	Xu, Bing	China
Co-Chair	Lim, Chee Peng	Australia

Organizing Committee

Co-Chair	Wu, Berlin	Taiwan
Co-Chair	Tan, Shing Chiang	Malaysia
	Azman, Afizan	Malaysia
	Chong, Siew Chin	Malaysia
	Goh, Pey Yun	Malaysia
	Kannan,	Malaysia
	Lee, Chin Poo	Malaysia
	Lew, Sook Ling	Malaysia
	Ong, Lee Yeng	Malaysia
	Ooi, Shih Yin	Malaysia
	Pang, Ying Han	Malaysia
	Razak, Siti Fatimah	Malaysia
	Tan, Choo Kim	Malaysia
	Wee, Kuok Kwee	Malaysia

Content

Does CSR influence the corporate value? Evidence from Chinese manufacturing enterprise

Explored Causality of Financial Investment in Sports Level and Health Care Expenditure

Building a Type-2 Linguistic Regression Model and its Application on Technique of Company Valuation

A Multiple Regression Analysis Approach for Mathematical Model Development in Dynamic Manufacturing System: A Case Study

Comparison of International Differences in the Volatility of Economic Growth and Non-Performing Loan Ratio: A Statistical Study Based on the Quantile Regression Model[1]

Qin Song[1,2] , Wang zhenLei[3]

(1.TaiZhou University, TaiZhou, P.R.China, 318000

2.HuaZhou University of Science and Technology, WuHan, P.R.China, 430074

3.HangZhou DianZi University, HangZhou, P.R.China, 315000)

Abstract: The relationship of economic growth and non-performance loan ratio of 13 different countries from 2005~2014 were analyzed based on the quantile regression models with panel data. The difference characters between 13 countries were also got. The results showed the relationship of economic growth and non-performance loan ratio was positive before Financial Crisis in 2008, while the relationship of them was negative after 2008. America countries were in low level of non-performance loan ration before 2008, while they were in high level after2008. The impact of economic growth and non-performance loan ratio of countries which were in high level non- performance loan ratio was more significant than countries which were in low level of non- performance loan ratio.

Keywords: Quantile Regression; Economic Growth; Non-Performing Loan Ratio

1.Introduction

The banks play a vital role in the whole economic development and social progress. The operation of the bank is also directly or indirectly influenced by the national economy. However, in June 7, 2013, the People's Bank of China released the report pointed out that the balance of non-performing loans of Chinese banking financial institutions rebounded for the first time after the year of 2005. Credit risk has emerged. As of the end of 2012, the balance of non-performing loans was 1070 billion yuan and it was 23.4 billion yuan more than the beginning of the year. Non- performing loan rate was 1.56% in 2012. In 2015 China banking survey report, KPMG pointed out that pains of the economic structural adjustment were reflected, pressure of economic downward increases and non-performing loans and overdue loans scale were a rising trend. Data showed that the total of the first quarter of the domestic commercial banks' non-performing loans was 982.5 billion yuan at the end of March in 2015. The total was an increase of 336.4 billion yuan over the same period in 2014 and increased 139.9 billion yuan comparing with the end of 2014. The latest non-performing loan ratio reached 1.39% and it was up 0.35% over the same period in 2014. Since the first quarter of 2014, the total non-performing loans increased by 0.0875% per quarter with the upward trend of the phenomenon of acceleration. The report further pointed out that in the absence of the corresponding stimulus, non-performing loans would further rise and the expected rate of non-performing loans in 2015 may exceed 1.5%. Although the size of the banking assets and liabilities are further expanded, the growth rate has slowed down. In addition, the size of non-performing loans and non-performing loan ratio is on the rise. The expansion of the size of loans and non-performing loan rate rising has not been effectively resolved. In the larger environment of economic structure adjustment, the economic downward pressure increases leading to the bank falling into a "loan scale expansion - the rate of non-performing loans increased - reduce the size of the loan –

[1] Grant from: Chinese Postdoctoral Science Foundation(No.2013M542029); ZheJiang Philosophy and Social Science Planning Project(14NDJC026YB); ZheJiang Philosophy and Social Science Key Research Base: The Research Center of Information Technology & Economic and Social Development Project(14XXHJD08YB); The Research Base of ZheJiang Statistics Science Project(2015); TaiZhou Philosophy and Social Science Planning Project(12GHY01)

the decline in profits- to expand the size of the loan". It is necessary to strengthen the understanding of economic growth from the theoretical and empirical aspects of the impact of bank' non-performing loan ratio in the new normal economy of China. What is the level of non-performing loans in China's banking sector in different countries? Is the relationship between economic growth and non-performing loan rate changed? Is there a difference in the effect of economic growth of different economies on the rate of non-performing loans of banks? In the "new normal" situation, the answers to these questions can be more clearly in order to grasp the relationship between China's economic growth and non-performing loan rate and the difference of the bank's non-performing loan ratio during the economic structure adjustment.

Based on the above analysis, this paper studies the comparison of international differences in the volatility of economic growth and non-performing loan ratio using 13 countries' data by quantile regression model. Exploration and innovation are as follows. (1) There is a new research perspective. The past researches more focused on the impact of different bank' non-performing loan ratio, but this paper is concerned about the impact of different countries' economic growth for non-performing loan ratio; (2) There is much wider study period than before. The sample period of this paper is from the year of 2005 to the year of 2014 which covers the special period of the international financial crisis and provides a strong support for the changing of non-performing loan ratio during the economic structural adjustment; (3) There is a new method. Most of the previous research methods are time series, for example VAR model. The quantile regression model is based on the weighted average absolute error as the objective function to estimate the regression coefficient which can be used to investigate the difference of different countries' economic growth to non- performing loan ratio. The organization of this paper is as follows. In section 2 we introduce the literature review and research ideas. In section 3, we present the construction of the quantile regression model. In section 4 we introduce variable selection and descriptive statistics. In section 5 we present empirical results and analysis. In section 6 we leave some concluding remarks.

2.literature review and research ideas

2.1Summary of research contents and ideas

Through the comparison of the research literature of domestic and foreign scholars on the economic growth and non-performing loan ratio, the main focuses of the research are as follow. First, the relationship between economic growth and non-performing loan ratio is not the same. The developed countries tend to negative correlation and the developing countries tend to be irrelevant. Second, the impact and the characteristics of economic growth on non-performing loan ratio are not the same. Third, the impact of economic downturn on the rate of non-performing loans is in the financial, asset value and the bank's 'Pro cyclical behavior' and so on.

Firstly, the empirical research conclusions about the relationship between economic growth and bank non-performing rate are not consistent. In general, the research on the developed economies is significantly negatively correlated (Fama, 1986; Wilson, 1997; Saurina and Jimenez, 2006; Das and Ghosh, 2007; Gunsel, 2012; Vouldis, Metaxas and Louzis, 2012; Boujelbene and Zribi, 2011; Castro, 2013; and the developing countries tend to be irrelevant (Fofack, 2005; Aver, 2008; Poudel, 2013; Dragomirescu and Bucu, 2014). On the relationship between economic growth and the rate of non-performing also has two parties in China. One party considered there was a negative relationship (Zhang Miao, 2002; Li Hongjin, 2008; Li Lin and Yan Feng Suo, 2009; Wang Xiaofeng, 2014), the other is that there is no clear relationship (Ling Chao Xu and Wu Guangwei, 2011; Yue Peipei and Zhen Xungang, 2011).

Secondly, the relevant research conclusions about the impact and characteristics of economic growth on the bank's non-performing loan ratio are not unified. Salas and Saurina (2002), Jakubik (2007) pointed out that economic growth and interest rates are the most important macroeconomicfactors affecting bank credit risk through the study of the banking sector in Spain and Czech. But this conclusion has changed because of the differences in the sample selection from other foreign studies. Crouhy, Galai and Mark (2000) showed that the impact of economic growth on the bank's non-performing rate is asymmetric. That is to say, the rate of non-performing loan has increased significantly during the economic recession and the rate of non-performing loan will not be significantly decreased during the economic expansion. Li Lin and Suo Yanfeng (2009) studied that 70% of China's non-performing loans are caused by changes in economic growth at least. Xu Lingchao and Wu Guangwei (2011) believed that the impact of inflation on the bank's non- performing loans rate is the biggest factor in China's macroeconomic factors (more than 40%). Zhang Tingting et al. (2010) using data from 2004 to 2010 in the first quarter of Jiangxi Province, obtained that when benchmark interest rate dropped 1%, the 4 lag of non-performing loans reduced 1.051 billion yuan. Lu Panpan (2012) showed that the effect of the benchmark interest rate to bank non-performing rate was maximum in macroeconomic factors. Li Junfeng (2010) pointed out that because the economic cycle was ahead of the credit cycle, the rise in non- performing loan ratio was the lagging effect of economic growth. From the above analysis, the change of bank non-performing rate lagged behind macroeconomic factors. In addition to economic growth, the economic variables such as inflation and policy variables such as interest rates had an important impact on the bank's non-performing loan rate.

Thirdly, about the impact channels of macroeconomic downturn on the bank's non-performing rate, there were three main understanding. First, it was the impact of corporate finance. In the economic downturn cycle, the borrower would be more difficult to operate and the level of profit, repayment ability and willingness to repay would all fall. Second, it was the value of assets. Because the economy downturn was easy to trigger a burst of asset bubbles, asset value with the bubble burst would be fully shrunk and affected the source of repayment. Third, it was the bank's own "Pro cyclical" behavior. During the economic boom, banks tended to be overly optimistic, relaxed the requirements for collateral and blindly increased credit loans leading to more non- performing loans.

This paper focuses on the impact of economic growth on the volatility of bank non- performing loan ratio, compares with the differences between different countries and in-depth analysis of the causes of differences.

2.2Summary of research methods

Most of the previous research methods are time series, for example VAR model, multiple regression model and dummy variable model, etc. Except that, the assumption that the error terms are subject to normal distribution is not able to be satisfied because of financial data. The quantile regression model is based on the weighted average absolute error as the objective function to estimate the regression coefficient which can be used to investigate the difference of different countries' economic growth to non-performing loan ratio.

3Introduction of model

3.1Quantile regression model

The traditional linear regression model is now very popular, mainly based on the following three points. First, the obvious fact is that the calculation process is easier and it is the main reason for the initial success. Second, the least squares method is considered to be an optimal method if the error terms are subject to normally

distribution (e.g., Gauss distribution). Third, the least square method provides a method for estimating the conditional mean function. Although the least square method has the advantages, the estimation method is not very reasonable if the error terms are not subject to normally distribution. The estimation results may vary greatly, the least square method can only provide a "average level" and is not able to provide a detailed characterization of different points. Mosteller and Tukey had pointed out that it couldn't just stay in the study of the mean value of the data, but to find a new statistical analysis method to improve the regression results. In 1978, Roger Koenker and Bassett proposed the method of quantile regression which was an improvement and supplement to the traditional means regression method. Roger Koenker (2005) introduced quantile regression estimation systematically in a book of "quantile regression". Quantile regression estimation was a sample of the conditional distribution of a certain point of the sample which was affected by the variables. The weighted average absolute error was the objective function to estimate the regression coefficient and QR could be used to study the variables' different points.

The quantile regression's advantages are as follows. Firstly, the distribution of the error term is not assumed to be constrained. Second, the number of points for the abnormal value of the sensitivity is much less than the mean. The effect of the abnormal value is related to the existence of the exception, but it has nothing to do with the specific position. Therefore, the robustness of the method of quantile regression estimation is better than that of the least square method.

3.2Construction of model

In this paper, we used a panel data regression model. The expression is as follows:

$$y_{it} = x_{it}^{'}\beta + \alpha_i + u_{it}, i = 1, 2, \cdots, N.t = 1, 2, \cdots, T.$$

Where i representing different sample individuals, t representing different sample observation time points, u representing the random error term, β representing the coefficient vector of explanatory variables, α_i indicates that the random effect of the i sample is not able to be observed, $x_{it} = \left(1, x_{it1}, x_{it2}, \cdots, x_{itp}\right)^{'}$. There are two kinds of methods for estimating the fixed effects and random effects.

During the fixed effects, the estimation of β is

$$\min_{\alpha,\beta} \left\| y - X\beta - Z\alpha \right\|^2$$

$$\hat{\beta} = \left(X'MX\right)^{-1} X'My, M = I - P, P = Z\left(Z'Z\right)^{-1} Z'.$$

During the random effects, assuming $u \sim N(0,R)$, $\alpha \sim N(0,W)$, $v = Z\alpha + u$. Then $E\left(vv'\right) = \left(ZWZ' + R\right) = V$. We can use GLS or PLS to estimate β。

GLS method: $\min_{\beta} \left\| y - X\beta \right\|^2_{V^{-1}}$;

PLS method: $\min_{\alpha,\beta} \left\| y - X\beta \right\|^2_{R^{-1}} + \left\| \alpha \right\|^2_{W^{-1}}$.

The common solution of both of methods is $\hat{\beta} = \left(X'V^{-1}X\right)^{-1} X'V^{-1}y$。

We also use quantile regression to estimate parameters. We set up conditional quantile equation: $Q_{y_u}\left(\tau_j \middle| x_{it}, \alpha_i\right) = x_{it}^{'}\beta\left(\tau_j\right) + \alpha_i$. Koenker (2004) put forward PQR to estimate parameters. As follows,

$$\left\{\left\{\hat{\beta}\left(\tau_j, \lambda\right)\right\}_{j=1}^{J}, \left\{\hat{\alpha}_i\left(\lambda\right)\right\}_{i=1}^{N}\right\} = \arg\min_{\alpha,\beta} \sum_{j=1}^{J}\sum_{t=1}^{T}\sum_{i=1}^{N} w_j \rho_{\tau_j}\left(y_{it} - x_{it}^{'}\beta\left(\tau_j\right) - \alpha_i\right) + \lambda\sum_{i=1}^{N}\left|\alpha_i\right|$$

Where w_j is for the corresponding to each quantile weights. λ is for adjustment coefficient. If λ=0, it is a fixed effect quantile regression estimator (FEQR). If λ>0, it is penalized quantile regression (PQR). In addition, Koenker studied the asymptotic properties of punishment amount of FEQR and PQR. On this basis, the effect of different regression methods is analyzed by using Monte Carlo simulation method (to see table 1).

If the error terms are independent and identically distributed, the function form is as follows $y_i = \beta_0 + x_i\ \beta_1 + \mu_i$. The conditional quantile function of the variable y is $Q_y(\tau|x) = \beta_0 + x\beta_1 + F_u^{-1}(\tau)$, where F_u is the common distribution function of the error term, $\hat{\beta}(\tau)$ is $(\beta_0 + F^{-1}(\tau), \beta_1)^T$。

If the error terms are variance, the function form is as follows $y_i = \beta_0 + x_i\beta_1 + \sigma(x_i)u_i$. Where $\sigma(x) = \gamma x^2$ and $\{u_i\}$ is subject to independent and identically distributed (independent and identically distributed , iid-error). Then distribution function of independent variable y is $Q_y(\tau|x) = \beta_0 + x\beta_1 + \sigma(x)F_u^{-1}(\tau)$. The parameter is obtained by solving $\sum \rho_\tau(y_i - \beta_0 - x_i\beta_1 - x_i^2\beta_2)$, $\hat{\beta}(\tau)$ is $(\beta_0, \beta_1, \gamma F^{-1}(\tau))^T$.

Table 1 The comparison of OLS and QR estimation

error terms distributed		LS	PLS	LSFE	QR	PQR	QRFE
Normal distributed	Deviation	0.0031	0.0048	0.0056	0.0048	0.0067	0.0047
	Square root of mean square error	0.0847	0.0604	0.0668	0.0977	0.0781	0.0815
T distributed	Deviation	-0.0062	-0.0054	-0.0051	-0.0063	-0.0101	-0.0082
	Square root of mean square error	0.1377	0.1031	0.1143	0.1274	0.0881	0.0921
Chi square distribution	Deviation	-0.0068	0.0002	0.0032	-0.0052	0.0063	0.0072
	Square root of mean square error	0.2155	0.1503	0.1650	0.2362	0.1506	0.1513

4.Variable selection and descriptive statistics

4.1Variable selection

The object of this paper is the international difference of the fluctuation of economic growth and the rate of non-performing loans. The main research content is the influence of the former on the latter. This determines that economic growth and non-performing loan rates should come from different countries. The economic growth indicators are annual growth rate of different countries GDP. Non-performing loan ratio is the three of the total amount of loans in five categories of loans in different countries.

Due to the limitations of data sources, this paper selects 13 countries as the research object including North America (USA, Canada), South America (Argentina, Brazil, Mexico), Asia (China, Indonesia), Europe (Russia, Turkey, Arabia, Austria), Africa (South Africa), Oceania (Australia). Data comes from the "Statistical Yearbook", "financial Yearbook" and the global macroeconomic data of sina finance and economics.

4.2Descriptive statistics

（1）Overall analysis on the rate of non-performing loans of banks in various countries

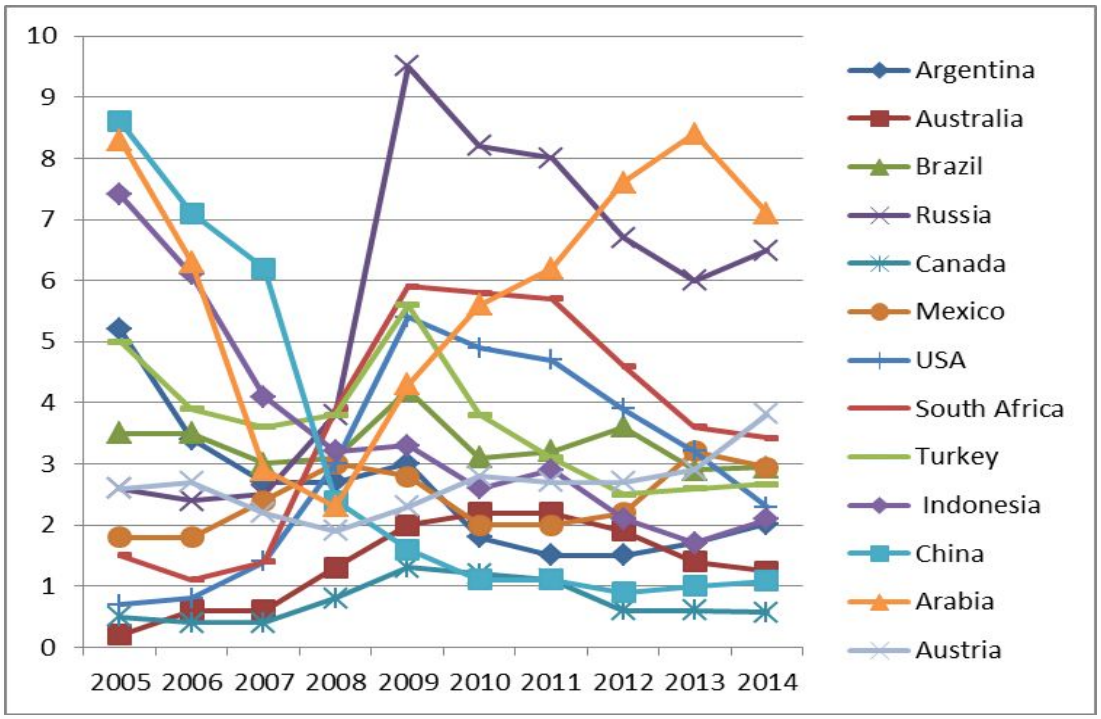


Fig.1 the change of 13 countries' NPL ratio from 2005 to 2014

Explain: The horizontal axis unit for years, the vertical axis unit for %.

From Fig. 1, we can see that the 13 countries' non-performing loan rate changed in the year of 2008 where the financial crisis was as a watershed. The low point of non-performing loan rate of the country, such as Brazil (3%-3.5%), the United States (2%-3%), South Africa (2%-3%), Russian Federation (3%), their non-performing loan ratio were more than 5% (of which the Russian Federation is close to 10%) after the financial crisis. There was a slow decline until 2010. The high point of non-performing loan rate of the country, such as China (3%-8.5%), Indonesia (3%-7.5%), Argentina (3%-5%), etc., their non-performing loan rate was lower than 3% and showed a downward trend after the financial crisis. In particular, the United Arab Emirates (3%- 5%) was declining before the financial crisis and falling after the financial crisis. It was more than 8% in 2013. Non-performing loan rate of Turkey (3.5%-5.5%) was declining before the financial crisis and falling after the financial crisis. It was more than 5% in 2009. It was slow down until 2010. Before and after the financial crisis, little changes of non-performing loans ratio in the country were Austria (3%), Mexico (2%-3%), Australia (2%), Canada (1%).

(2) Overall analysis on the rate of GDP in various countries

From Fig. 2, we also obtain that the 13 countries' economic growth also changed in the year of 2008 where the financial crisis was as a watershed. Before the year of 2008, the 13 countries' GDP growth rate was declining trend, but all were positive. After the financial crisis, the GDP growth rate fell to negative value (except in China, Indonesia, Australia, Argentina and other countries were negative). It reached the lowest point in 2009. It gradually restored and slowly changed from negative to positive growth until 2010. Economic growth in the country has gradually become stable after 2014. The fluctuation range of China and Indonesia' economic growth were small, while Turkey, Brazil, Arabia, Argentina, Mexico were more volatile than other countries.

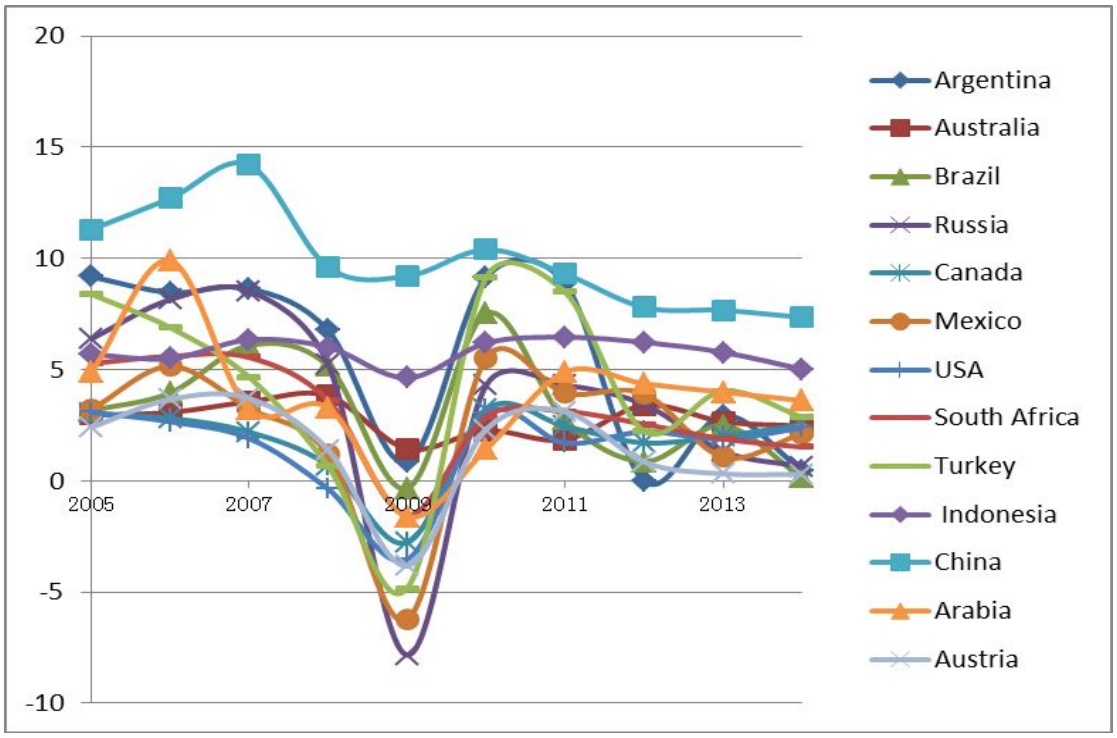


Fig.2 the change of 13 countries' GDP ratio from 2005 to 2014

Explain: The horizontal axis unit for years, the vertical axis unit for %.

5.Results and analysis

5.1 Analysis of non-performing loan ratio distribution of different countries

From Fig.3 to Fig12, we obtained that the data was not subject to normal distribution and most of the year is the right side of the distribution. Because the error terms were not subject to normal distribution, the OLS was not suitable. We used the quantile regression model which is based on the weighted average absolute error as the objective function to estimate the regression coefficient which can be used to investigate the difference of different countries' economic growth to non-performing loan ratio.

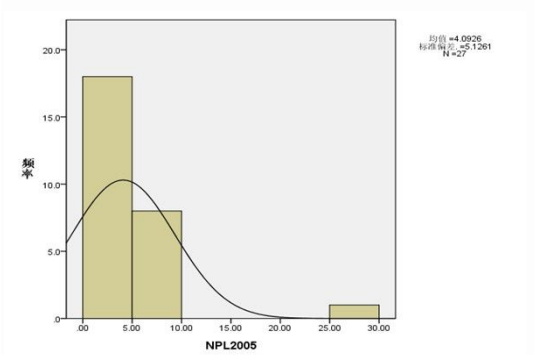


Fig.3 NPL ratio distribution in 2005

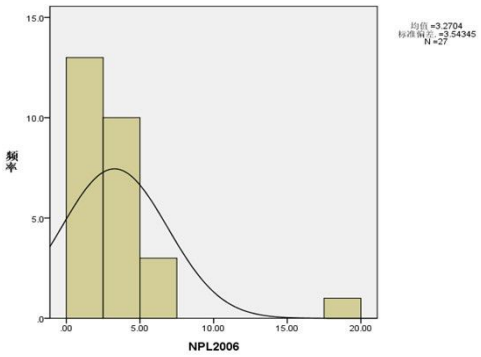


Fig.4 NPL ratio distribution in 2006

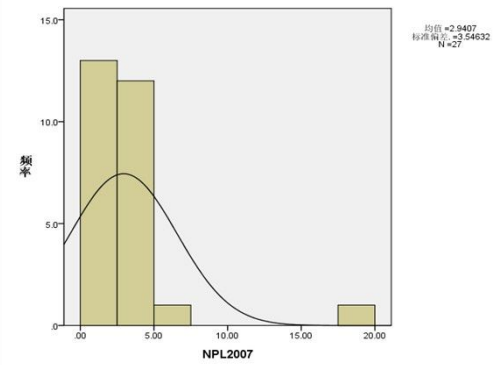


Fig.5 NPL ratio distribution in 2007

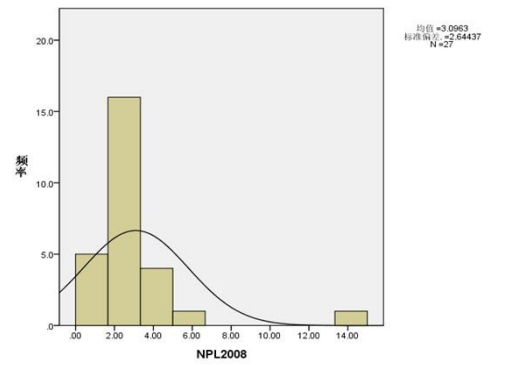


Fig.6 NPL ratio distribution in 2008

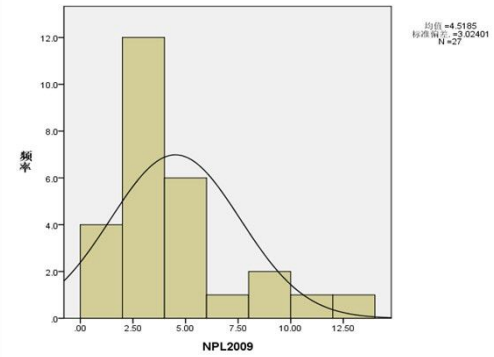


Fig.7 NPL ratio distribution in 2009

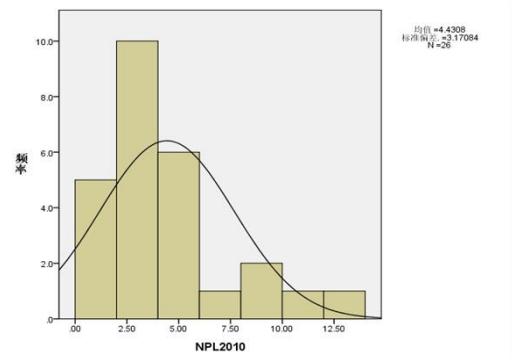


Fig.8 NPL ratio distribution in 2010

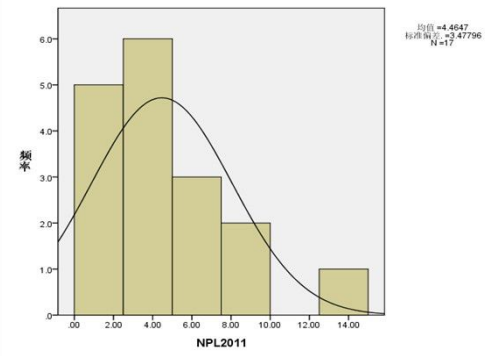


Fig.9 NPL ratio distribution in 2011

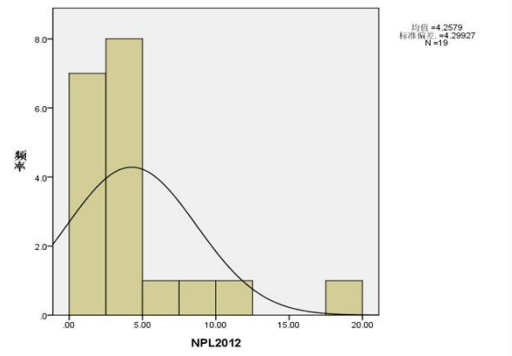


Fig.10 NPL ratio distribution in 2012

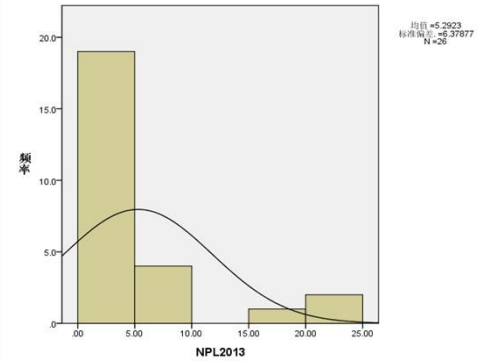


Fig.11 NPL ratio distribution in 2013

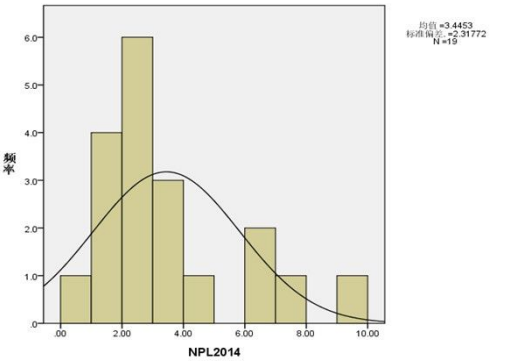


Fig.12 NPL ratio distribution in 2014

5.2 Regression analysis

(1)America countries were in low level of non-performance loan ration before 2008, while they were in high level after2008. Before 2008, countries who were in the low

rate of non-performing loan such as the United States, Canada, the growth rate were smaller, but the economy was relatively slow growth rate, such as Australia who had the high rate of NPL.

(2)From Fig.13, the relationship between the rate of GDP and non-performing loan ratio was positive before the year of 2008. That is to say, non-performing loan ratio increased with the increase of the rate of GDP, while non-performing loan ratio decreased with the decrease of the rate of GDP. The relationship between the rate of GDP and non-performing loan ratio was negative after the year of 2008. That is to say, non-performing loan ratio increased with the decrease of the rate of GDP, while non-performing loan ratio decreased with the increase of the rate of GDP.

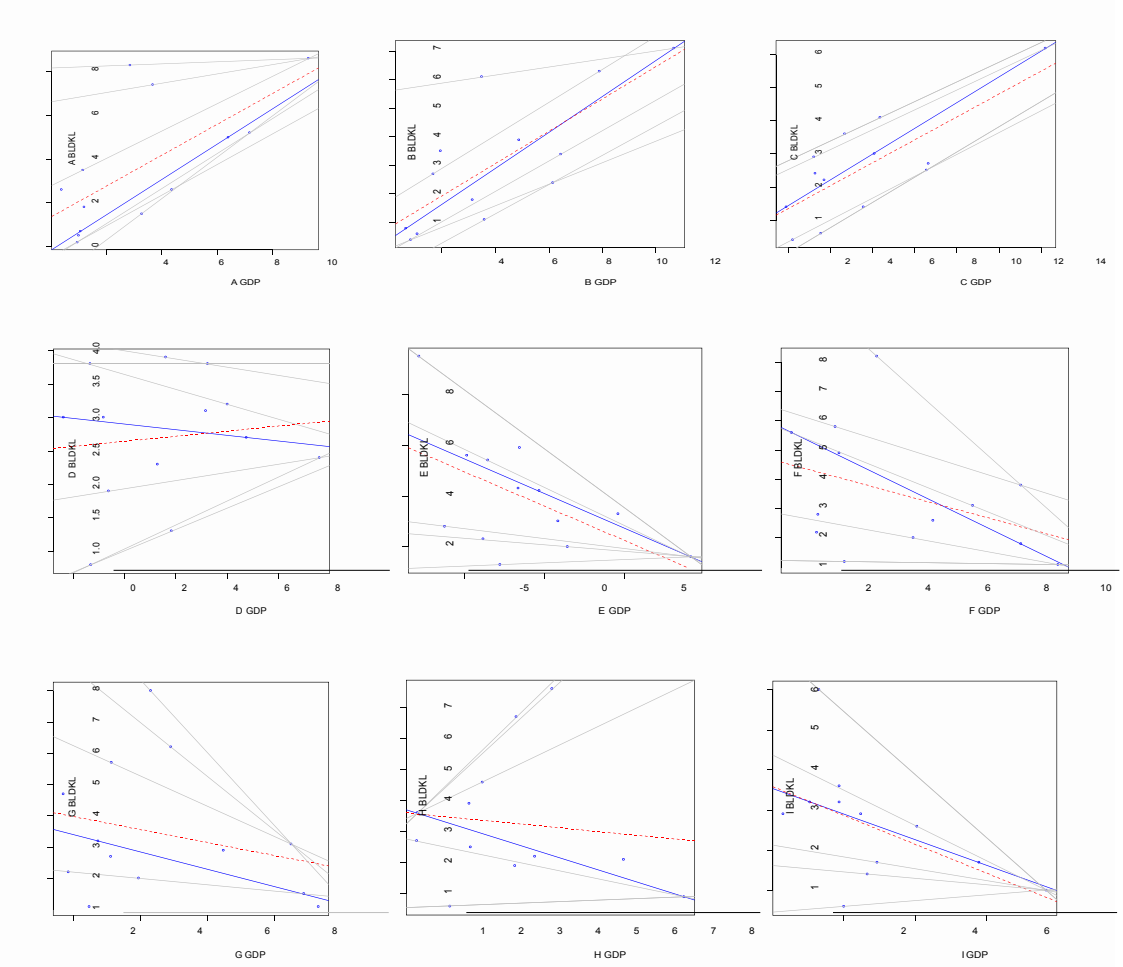


Fig.13 Quantile regression results under variance

Explain: Red dashed line is the least squares estimation of regression model, the solid blue line for quantile regression models for 0.5, while the remaining grey solid line for a cluster of the quantile regression model(τ = 0.05,0.1,0.25,0.75,0.9,0.95).

From Fig.14, when τ <0.2 or τ >0.8,the the growth rate of GDP had a greater impact on the volatility of non-performing loan ratio before 2008.When 0.2< τ <0.8,the GDP growth rate had little effect on the volatility of non-performing loan ratio before 2008. Before financial crisis, the growth rate of GDP had a positive impact on the volatility of non-performing loan ratio and the influence didn't change with different points of non-performing loan ratio significantly. After 2008, in addition to the year of 2012, the growth rate of GDP had negative impact on the non-performing loan ratio, especially in high points of NPL ratio. Because the most of the countries who were in high point of NPL ratio were those countries from European, American (such as the United States, Russia, etc.), after the financial crisis, the impact of economic growth on NPL ratio in Europe and the United States was negative significantly.

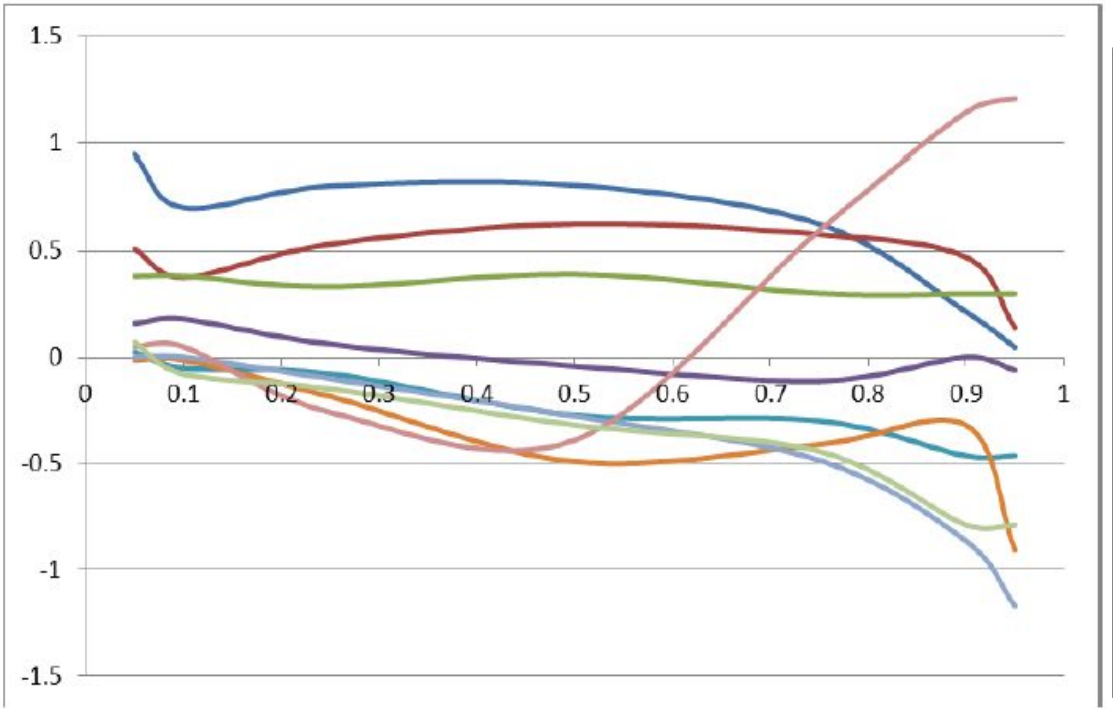


Fig.14 The results of different points

Table 2 The regression analysis of different points

points\year	2005	2006	2007	2008	2009
0.05	0. 94872	0. 5098	0. 38153	0. 15924	0. 02506
0.10	0. 70175	0. 37523	0. 38153	0. 17957	−0. 05161
0.25	0. 80386	0. 53097	0. 33123	0. 06098	−0. 07772
0.50	0. 80827	0. 62749	0. 39056	−0. 0421	−0. 27282
0.75	0. 62654	0. 57695	0. 30027	−0. 11215	−0. 29851
0.90	0. 2139	0. 47059	0. 29762	0	−0. 46389
0.95	0. 04658	0. 13889	0. 29762	−0. 06135	−0. 46389
points\year	**2010**	**2011**	**2012**	**2013**	
0.05	−0. 01391	0	0. 04926	0. 0708	
0.10	−0. 01391	0	0. 04926	−0. 07984	
0.25	−0. 18443	−0. 10142	−0. 25899	−0. 14831	
0.50	−0. 49159	−0. 27687	−0. 38961	−0. 31847	
0.75	−0. 40984	−0. 48417	0. 59524	−0. 44199	
0.90	−0. 31898	−0. 86351	1. 14286	−0. 7874	
0.95	−0. 90535	−1. 16945	1. 20623	−0. 7874	

6 Concluding remarks

The relationship of economic growth and non-performance loan ratio of 13 different countries from 2005~2014 were analyzed based on the quantile regression models with panel data. The difference characters between 13 countries were also got. The results showed the relationship of economic growth and non-performance loan ratio was positive before Financial Crisis in 2008, while the relationship of them was negative after 2008. America countries were in low level of non-performance loan ration before 2008, while they were in high level after2008. The impact of economic growth and non-performance loan ratio of countries which were in high level non-performance loan ratio was more significant than countries which were in low level of non- performance loan ratio.

REFERENCES

[1]Aver, B. (2008) " An Empirical Analysis of Credit Risk Factors of the Slovenian Banking System", *Managing Global Transitions* 6, 317-334.

[2]Bucur, I. and Dragomirescu, S.(2014)"The Influence of Macroeconomic Conditions on Credit Risk: Case of Romanian Banking System", *Studies and Scientific Researches*, Economics Edition, No. 19.

[3]Crouhy, M.D., Galai, D. and Mark, R. (2000)"A Comparative Analysis of Current Credit Risk Models", *Journal of Banking and Finance* 24, pp. 59-117.

[4]Castro, V.(2013)"Macroeconomic determinants of the credit risk in the banking system:the case of GIPSI", *Economic Modeling* 31, pp. 672-683.

[5]Das, A. and Ghosh, S.(2007)"Determinants of Credit Risk in Indian State-owned Banks: An Empirical Investigation", *MPRA Paper* No. 17301.

[6]Fama, E.(1986)"Term Premiums and Default Premiums in Money Markets", *Journal of Financial Economics* 17, pp. 175-196.

[7]Fofack, H. (2005)"Nonperforming Loans in Sub-Saharan Africa: Causal Analysis and Macroeconomic Implications", *World Bank Policy Research Working Paper* No. 3769.

[8]Gunsel, N.(2012)"Micro and Macro Determinants of Bank Fragility in North Cyprus Economy", *African Journal of Business Management* 3, pp. 1323-1329.

[9]Jimenez, G. and Saurina, J. (2006) "Credit Cycles, Credit Risk, and Prudential Regulation", *International Journal of Central Banking* 2, pp. 65-98.

[10]Jakubik, P.(2007) "Macroeconomic Environment and Credit Risk", *Czech Journal of Economic and Finance* 57, pp. 50-78.

[11]Li JinHong(2008)."Economic Growth, Economic Freedom and Non-Performing Loan", *Renmin University of China*.

[12]Li Lin, Suo YanFeng.(2009)"economic volatility, Non-Performing Loan and Banking Systemic Risk", *Studies of International Finance,* No.6, pp.55-63.

[13]Louzis, P.,Vouldis,T.and Metaxas,L.(2012)"Macroeconomic and bank-specific determinants of non-performing loans in Greece: a Comparative study of mortgage, business and consumer loan portfolios", *Journal of Banking and Finance* 36, pp. 1012-1027.

[14]Poudel, R.P.S.(2013)"Macroeconomic determinants of credit risk in Nepalese banking industry", *Proceedings of 21st International Business Research Conference*.

[15]Salas, V. and Saurina, J.(2002)Credit risk in two institutional regimes:Spanish commercial and savings banks, *Journal of Financial Services Research,* 22, pp. 203-224 [16]Wilson, T.(1997)"Credit Portfolio Risk", *Risk Magazine*, October.

[16]Zribi, N. and Boujelbene, Y.(2011) "The factors influencing bank credit risk: the case of Tunisia", *Journal of Accounting and Taxation* 3, pp. 70-78.

[17]Roger.Koenker, Ma LingJie(2008). "Quantile Regression", *Shanghai University of Finance and Economics press*, No.1.

[18]Antonio F. Galvao, Kengo Kato(2015)"Smoothed quantile regression for panel data", *working paper.*

[19]Wang ZhenLei(2014). "A Statistical Research on Determing Impacts on Non-Performing Loans Ratio in Commercial Banks", *ZheJiang GongShang University*.

Author in brief:

Qin Song, mainly engaged in quantitative economy and statistics on social development, risk management. E-mail: moiduoduo@gmail.com.

Generating Trading Rules on the Stock Markets with Robust Genetic Network Programming and Portfolio Beta

Yan Chen and Zhihui Shi

School of Statistics and Management, Shanghai University of Finance and Economics, Shanghai 200433, China E-mail: chenyan@mail.shufe.edu.cn

In this paper, Robust Genetic Network Programming (R-GNP) for generating trading rules on stocks is described. R-GNP is a new evolutionary algorithm, which represents its solutions using graph structures. It has been clarified that R-GNP works well especially in the dynamic environments. In the proposed hybrid model, R-GNP is applied to generating stock trading rules with variance of fitness values. The unique point is that the generalization ability of R-GNP is improved by using the robust fitness function, which consists of the fitness functions with the original data and a good number of correlated data. Generally speaking, the hybrid intelligent system consists of three steps, the priority selection by portfolio β, the optimization by Genetic Relation Algorithm (GRA) and the stock trading by R-GNP. In the simulations, the trading model is trained using the stock prices of 10 brands in Tokyo Stock Exchange, and then the generalization ability is tested. From the simulation results, it is clarified that the trading rules created by the proposed R-GNP model obtain much higher profits than the traditional methods even in the world-wide financial crisis in 2007, and its effectiveness has been confirmed.

Keywords: Portfolio Beta; Genetic Relation Algorithm; Robust Genetic Network Programming; Stock Trading

1. Introduction

Research on stock price prediction and trading model using intelligent techniques has been done in recent years. Generally speaking, there are two kinds of methods for predicting stock prices and determining the time of buying or selling stocks: fundamental analysis and technical analysis. Fundamental analysis is the study of economic trend, industry, and company conditions in an effort to determine the intrinsic value of a company's stock. As another kind of tool, technical analysis has played an important role in the stock market prediction, while it studies historical data surrounding the price and volume movements of stocks to forecast the future price movements. In this paper, we will focus more on the technical analysis.

In recent years, intelligent techniques, such as neural networks (NNs), fuzzy logic (FL), and genetic algorithms (GAs) [1]-[3] have been applied to a large variety of applications in areas of stock market prediction, investment strategy, and trading models. Furthermore, in the last few years, numerous studies have been conducted in these areas by combining various computational techniques to develop the intelligent or expert systems. However, each computational technique has its own strengths and weaknesses. For example, neural networks are good for learning ability and forecasting, but lack explanatory capability, which leads to so-called black-box model. Fuzzy logic is good for knowledge representation and imprecision tolerance, but lacks learning

capability. Genetic algorithms are good for optimization, but rather poor for knowledge representation. As a result, hybrid intelligent system modeling is being developed to bring the advantages of different techniques together. This kind of synergy allows the combined hybrid model to extract knowledge from raw data, use human-like reasoning mechanisms, deal with uncertainty, and learn to adapt to a dynamic and unknown environment.

Due to the bottlenecks of the traditional intelligent techniques, as an evolutionary computation, Genetic Network Programming (GNP) with Reinforcement Learning [4]-[6] has been proposed and applied to the stock trading model in the previous study. It has been clarified that GNP is an effective method mainly for dynamic problems since it represents the solutions using graph structures. Moreover, based on the graph structure of GNP, Genetic Relation Algorithm (GRA) was developed to solve the optimization problems in data mining [7] and portfolio selection fields [8]. Thus, there are three contributions in this paper: First, as an improved approach of GNP, Robust Genetic Network Programming (R-GNP) is proposed, coming from the concept of robust Universal Learning Network [9], [10], which uses the second order derivatives of the evaluation function with respect to inputs. Compared with the traditional GNP, the unique point of R-GNP is that the generalization ability of R-GNP is improved by using the robust fitness function, which consists of the fitness function by original data and fitness functions by a good number of correlated data. The second contribution is the use of portfolio beta β, which is quite an important coefficient in modern portfolio theory since it efficiently measures portfolio volatility relative to the benchmark index or the capital market. So far, $\beta$is usually used for portfolio evaluation or prediction, but scarcely for the portfolio construction process. Thus, in this paper, β is expected to shed light on various unknown properties as stock selection criterion. As the third contri bution, a hybrid stock trading system has been developed, combining the portfolio β, GRA and R-GNP into an integrated system. Generally speaking, the proposed algorithm consists of three steps, the priority selection step, optimization step and stock trading step. In the priority selection phase, industry sectors selected according to their market capitalization pick up competitive stocks by working with the individual beta for each stock. In the optimization step, stocks with large correlations are selected using GRA, and these data will be used in the next step. Finally, in the stock trading process, the trading rules are generated through R-GNP based on the prices data selected with GRA. The proposed hybrid system is applied to the Nikkei 500 Index from January 2004 to December 2007. This includes 500 major companies in Tokyo Stock Exchange.

The rest of this paper is organized as follows. Section 2 describes the concepts of portfolio β and GRA in general. Section 3 explains the stock trading model of R-GNP.Section 4 shows the simulation environments, conditions and results. Section 5 is devoted to conclusions and future work

2. Portfolio Beta and Genetic Relation Algorithm

2.1. Portfolio Beta

As a major component of β -GRA portfolio selection strategy, the beta β captures the systematic risk of the portfolio. Higher beta values imply higher levels of volatility. For

instance, the portfolio with the β of 0.5 has half as much as systematic risk of the market, while the portfolio with the β of 2 has twice as much. The beta also indicates the degree of independence and sensitivity of the stock prices. Positive β means that the stock follows the market behavior and has the same tendency. Contrarily, negative β means that the stock has an opposite tendency to the market. Large values indicate the strong price sensitivity to the market behavior, and when β equals to 0, it shows the independence from the market. In the proposed method, β sheds light on the property as a portfolio construction tool.

The β coefficient of stock *i* is defined as

$$\beta_i = \frac{Cov(r_i, r_m)}{Var(r_m)}, \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

where, r_i is the rate of return of stock *i*, and r_m is the rate of return of the benchmark index or the capital market *m*. It is easy to see that βi measures stock volatility relative to the benchmark index or the capital market. Eq.(1) comes as an estimate of the slope by assuming a simple linear relation between r_i and r_m. Generally, if a stock is well chosen, the returns of the benchmark index and the stock are highly correlated, then β efficiently approximates the volatility ratio of the stock to the benchmark index and hence measures the sensitivity of the stock to market fluctuation.

2.2. Genetic Relation Algorithm

Basically, GRA is an extension of Genetic Programming (GP) [11] and Genetic Network Programming (GNP) [4] in terms of gene structures. The original idea is based on the more general representation ability of both directed and undirected graphs. As a new evolutionary computation, GRA is used for determining the best relations between events. There are two kinds of gene structures in GRA, i.e., GRA with directed and undirected edges. In this paper, GRA with undirected edges are used for the optimization

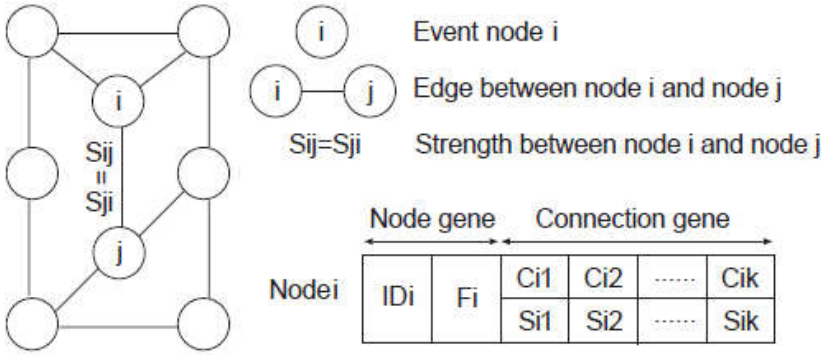


Fig. 1. Basic structure of GRA with undirected edges

Fig. 1 shows the basic structure and genotype expression of GRA with undirected edges. GRA is composed of nodes and edges, where nodes represent events and directed edges represent the relations between nodes with their strength. As shown in Fig. 1, the relation between node *i* and node *j* has a strength of S_{ij}=S_{ji} in GRA with undirected edges.

Fig. 1 also describes the gene of node *i*, then the set of these genes represents the genotype of GRA individuals. Concretely speaking, ID_i represents an identification

number of the node, e.g., ID_i=1 means node i has the di- rected edges with other nodes, while ID_i=2 means node i has the undirected edges with other nodes. F_i denotes the function of node i. In this paper, F_i represents different stock brands in the portfolio. C_{i1}, C_{i2}, ..., C_{ik} show the nodes which are connected from node i firstly, secondly and so on. S_{i1}, S_{i2}, ..., S_{ik} denote the strength of edges from node i to node C_{i1}, C_{i2}, ..., C_{ik}, respectively. All individuals in a population have the same number of nodes.

Like other evolutionary algorithms, selection, crossover and mutation are used as the genetic operators of GRA. The outline of evolution is described as follows:

(1) Initialize a randomly generated population.
(2) Evaluate the fitness of individuals in the population.
(3) Generate new individuals for the next generation by tournament selection and genetic operations of crossover and guided mutation [12].

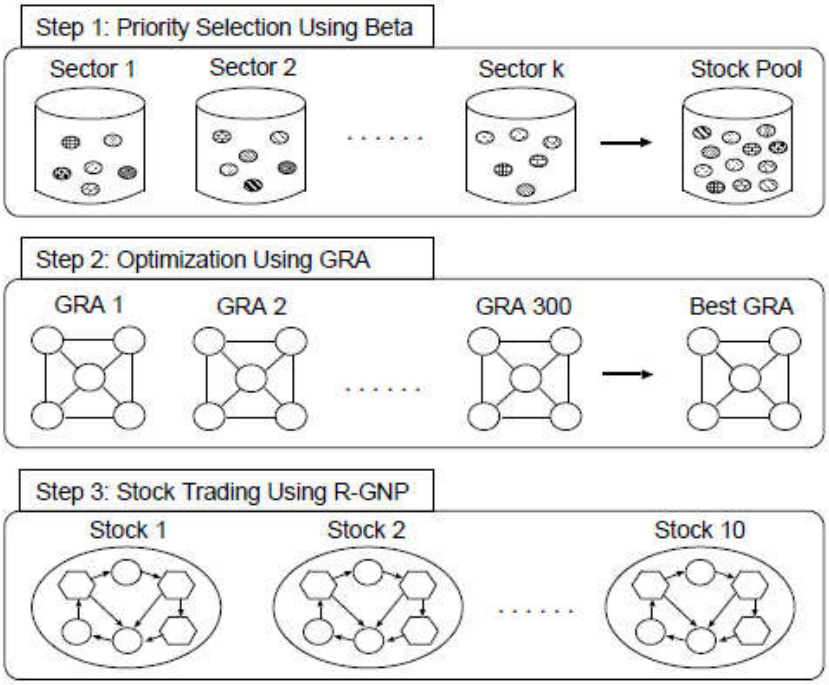


Fig. 2. Procedure of portfolio selection and stock trading using the hybrid intelligent model

(4) Replace the current population by the new population.
(5) If the termination condition is satisfied, then stop, else go to step 2.

One important point of GRA is that all the connections between node do not have to be defined, but the connection itself could be evolved.

2.3. Portfolio Selection Using β and GRA

The general procedure of portfolio selection and stock trading using the hybrid intelligent system can be described as follows (Fig. 2):

- Step 1: Selects stocks based on β, i.e., the stock having the largest priority in each industry sector will be picked out and added to the stock pool.
- Step 2: Optimize the stocks in each sector using GRA, which evaluates the relationships between stock brands using a measure of correlation coefficients and generates the optimized portfolio in the final generation of GRA. The selected stocks

has the largest correlations with each other, and one of them will be considered as target stock while others will be used as correlated stocks in the R-GNP trading model at the next step.

- Step 3: Test the target stock in each sector by using the stock trading model of R-GNP, which considers the technical indices and candlestick chart as trading signals to make decisions. The unique point is that the generalization ability of R-GNP is improved by using the robust fitness function, which consists of the fitness function by original data of the target stock and fitness functions by the data of correlated stocks.

2.3.1. Selection Phase Using β-based Priority

First, we define the notations used in the algorithm as follows.

- K: the number of industry sectors comprising the benchmark index
- L: the number of stocks comprising the industry sector
- $\beta_{i(j)}$: the individual beta for the jth stock of the ith industry sector (j=1, 2, ..., L and i=1, 2, ..., K), where the subscript $i(j)$ is used to stress the dependence of j on i.
- $r_{i(j)}(t)$: rate of return for the jth stock of the ith industry sector at time t
- $r_m(t)$: rate of return of benchmark index m at time t
- T: set of training periods for the priority selection

Given $\overline{X} = \frac{1}{T}\sum_{t\in T} X(t)$, the priorityfor $P_{i(j)}$ the jth stock of the ith industry sector is defined by

$$P_{i(j)} = \frac{\{\frac{1}{|T|}\sum_{t\in T}(r_m(t) - \overline{r}_m)^2\}^{1/2}}{\{\frac{1}{|T|}\sum_{t\in T}(r_{i(j)}(t) - \overline{r}_{i(j)})^2\}^{1/2}}. \quad . \quad . \quad . \quad (2)$$

A stock $i(j)$ with a large $P_{i(j)}$ implies that it behaves in a rather stable manner, while stock with a small $P_{i(j)}$ implies that it may behave in a rather risky manner, which means $P_{i(j)}$ has an opposite tendency compared to β.

As the first step of portfolio selection, the procedure can be described as follows.

(1) Calculate the market capitalization for each industry sector in the Nikkei 500 Index.
(2) Select the industry sector having the largest amount of market capitalization.
(3) For the selected industry sector i (i=1, 2, ..., K), calculate the priority $P_i(j)$ for j=1, 2, ... L and then choose the stock $i(j)$ having the largest priority to add it to the portfolio and remove it from the selected industry sector i.
(4) Without the stock $i(j)$, update the market capitalization and return to step (2).

After the above procedure of priority selection, a port- folio with 300 stocks out from Nikkei 500 Index are established. Then, 300 stocks are classified into 10 industry sectors. Genetic Relation Algorithm are used to further optimize the portfolio to obtain a target stock and 9 correlated stocks in each industry sector.

2.3.2 Optimization Phase Using GRA

As shown in Fig. 3, the basic structure of GRA is described as follows: The nodes in GRA are used to represent different stock brands in a portfolio, and the strength

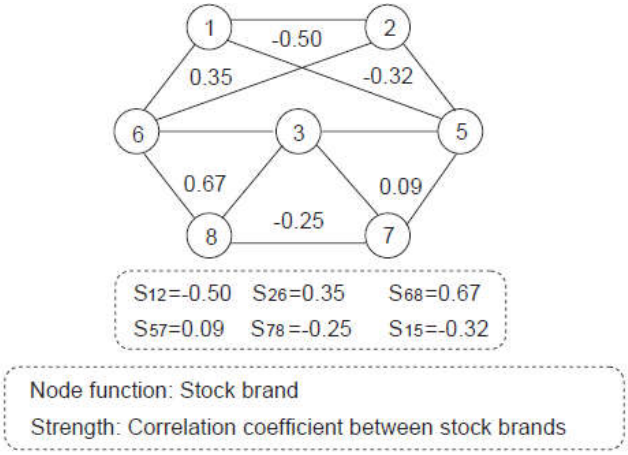


Fig. 3. GRA for portfolio selection

between two nodes is used to indicate the relationship between stock brands, i.e., the value of correlation coefficient. The main point of the proposed model is to select a given number of appropriate stocks in a portfolio. Before detailing the GRA algorithm, the following quantities are defined.

- D: set of days
- S: set of stocks
- $S(G)$: set of stocks in GRA
- $S(G_i)$: set of stocks whose strength is defined between node i in GRA
- R_i: rate of return of stock i
- P_{io}: opening price of stock i at the beginning of the period
- P_{ic}: closing price of stock i at the end of the period
- d_i: dividend of stock i during the period
- $Price(i, d)$: price of stock i on day d
- μ_i: mean of the price of stock i
- σ_i^2: variance of the price of stock i
- σ_{ij}: covariance between the prices of stock i and stock j
- ρ_{ij}: correlation coefficient between the prices of stock i and stock j

The object of GRA is to select appropriate $|S(G)|$ stocks out of a total number of stocks $|S|$. Therefore, the fitness function of GRA is defined as follow.

$$Fitness = \frac{1}{|S(G)|} \sum_{i \in S(G)} \frac{1}{R_i |S(G_i)|} \sum_{j \in S(G_i)} \rho_{ij}^2, \quad . \quad (3)$$

where,

$$R_i = \frac{P_{ic} - P_{io} + d_i}{P_{io}},$$

$$\rho_{ij} = \frac{\sigma_{ij}}{\sigma_i \sigma_j},$$

$$\sigma_i^2 = E[(Price(i,d) - \mu_i)^2] = \frac{1}{|D|} \sum_{d \in D} (Price(i,d) - \mu_i)^2,$$

$$\sigma_{ij} = E[(Price(i,d) - \mu_i)(Price(j,d) - \mu_j)]$$
$$= \frac{1}{|D|} \sum_{d \in D} (Price(i,d) - \mu_i)(Price(j,d) - \mu_j),$$

$$\mu_i = E[Price(i,d)] = \frac{1}{|D|} \sum_{d \in D} Price(i,d).$$

In the fitness function of Eq. (3),

- if ρ_{ij} is around 1.0, then stock *i* and stock *j* have positive correlation.
- if ρ_{ij} is around -1.0, then stock *i* and stock *j* have negative correlation.
- if ρ_{ij} is around 0.0, then stock *i* and stock *j* have no correlation.

The fitness function evaluates the GRA individuals so that the strengths between stock brands have a large value of correlation coefficient ρ_{ij}. It is our interest to find out the stock brands with large absolute values of the correlation coefficient ρ_{ij} in the fitness function. By the portfolio selection model of GRA, the stocks having large correlations with each other are selected, since they will be used as the target stock and correlated stocks in R-GNP trading model at the next step.

2.3.3. Genetic Operators of GRA

In this sub-section, the genetic operators in the evolution phase are introduced. In order to get the best individual, the function of nodes in GRA should be changed, which can be realized effectively by genetic operations. GRA has three kinds of genetic operators: selection, crossover and mutation. In GRA, mutation operation could be executed not only on the connections between nodes but also on the node functions.

1)Selection

In each generation, all of the individuals are ranked by their fitness values and the best individual in the current generation is preserved for the next generation by elite selection. Then, tournament selection of individuals is carried out for reproducing the next generation.

2)Crossover

As shown in Fig. 4, crossover is executed between two parents and two offspring are generated. The procedure of crossover is as follows.

- Select two individuals using tournament selection twice and produce them as parents.
- Each node is selected as a crossover node with the probability of P_C.

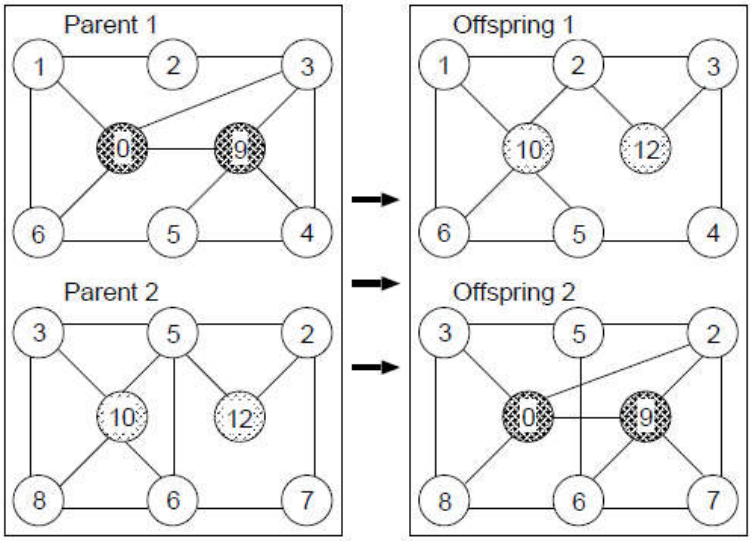


Fig. 4. Crossover

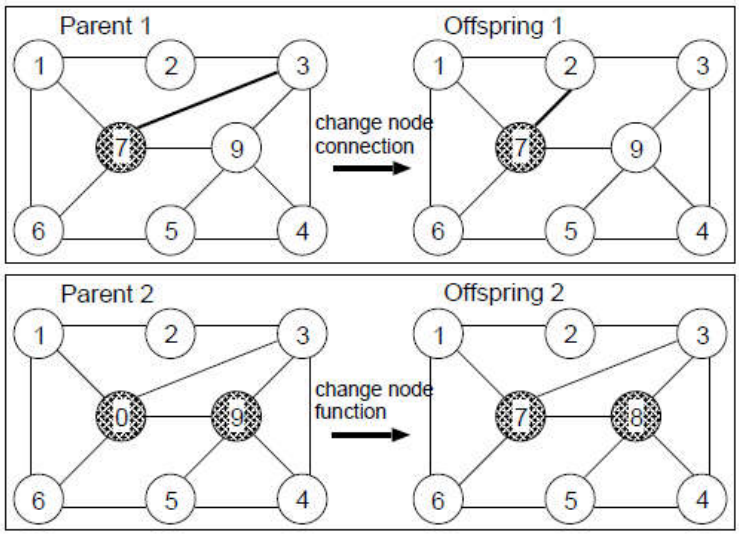


Fig. 5. Mutation

- Two parents exchange the genes of the corresponding crossover nodes.
- Generated new individuals become the new ones of the next generation.

3)Mutation

Fig. 5 shows an example of the mutation operator. Mutation is executed in one individual and a new one is generated. The procedure of mutation is as follows.

- Select one individual as a parent using tournament selection.
- Mutation operation

-change connection: Each node edge (C_{i1}, C_{i2}, ..., C_{ik}) is selected with the probability of P_m, and the selected edge is reconnected to the other node.

-change node function: Each node function (F_i) is selected with the probability of P_m, and the selected function is changed to the other one.

- Generated new individual becomes the new one of the next generation.

4)Flowchart of GRA

Fig. 6 shows the flowchart of GRA. At first, priority selection is carried out based on β . Then, the selected portfolio is further optimized by GRA. For the first GRA population, each individual is generated assigning a certain stock brand selected randomly from the stock pool

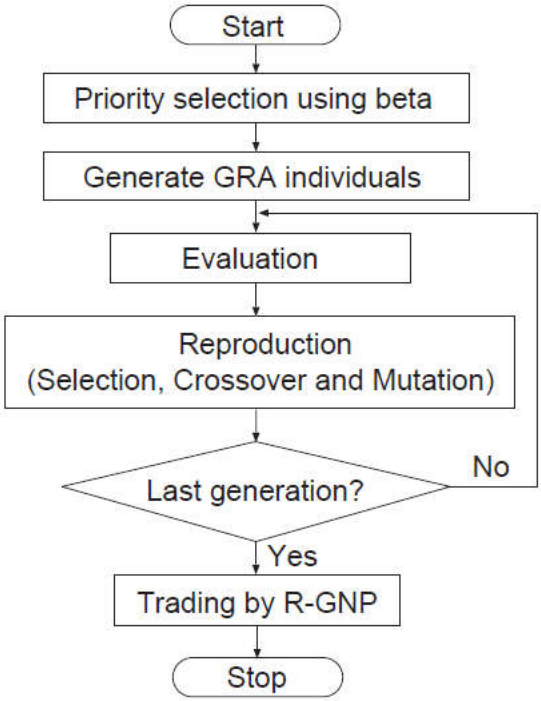


Fig. 6. Flowchart of GRA

built by priority selection to one of the nodes of GRA. It is ensured that all nodes are different within one individual. In the next, evaluation of the individuals is carried out according to their fitness values. At the reproduction phase, selection, crossover and mutation are used as genetic operators to generate the population for the next generation. This process is repeated until the last generation. Finally, after obtaining the best GRA individual in the last generation, the selected target stock will be traded by the model of R-GNP.

3. Stock Trading Model of Robust Genetic Network Programming

Fig. 7 shows the basic structure and flowchart of R- GNP. R-GNP consists of start node, judgment nodes and processing nodes [6], which are connected to each other. Judgment nodes have if-then type branch decision functions and return judgment results for assigned inputs and determine the next node. Processing nodes take actions of buying or selling stocks. The role of a start node is to determine the first node to be executed. R-GNP has two kinds of time delays: time delays R-GNP spend on judgment or processing, and the ones it spends on node transitions. The node transition starts from a start node and continues depending on the node connections and judgment results. In this paper, the role of time delays is to determine the maximum number of technical indices and candlestick information to be considered when R-GNP determines buying or selling actions at a certain day.

The basic idea of R-GNP is coming from the concept of traditional GNP [6] and

robust Universal Learning Network [9], [10], which uses the second order derivatives of the evaluation function with respect to inputs. Compared with the traditional GNP, the unique point of R-GNP is that the generalization ability of R-GNP is improved by using the robust fitness function (Fig. 7), which includes the fitness function of target stock and fitness functions of the correlated stocks. In the proposed method, the use of correlated stocks enables R-GNP to adapt to a changing environment in the stock market, and the robustness of R-GNP has been obtained consequently. Since the stock trading model of traditional GNP has been described in [6], only the new point of R-GNP will be emphasized in this paper.

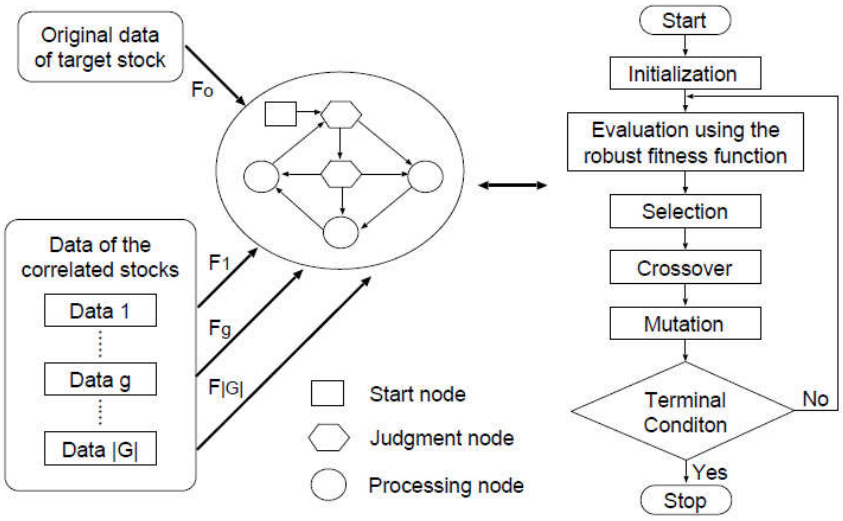


Fig. 7. Basic structure of R-GNP

3.1. Judgment Node

Concretely speaking, when a current node is a judgment node, R-GNP judges a technical index or a candlestick chart. That means, judgment results are determined by the technical index functions and the candlestick chart patterns. As we know, candlestick chart has been widely used as the means of indicating the fluctuations of the stocks. R-GNP has judgment nodes which check candle- stick chart patterns, i.e., when the selected sub-node has a judgment function of candlestick chart, R-GNP judges yesterday's candlestick and the candlestick of the day be- fore yesterday.

3.2. Processing Node

When a current node is a processing node, Q value of it and the value of a are selected based on ε-greedy policy [6]. Here, Q value means an action value in the reinforcement learning [13], and the selected value of a means a threshold for determining buying or selling stocks. The procedure of buying and selling stocks can be described as follows.

(1) Q value is selected based on ε-greedy policy, then the corresponding value of a is selected.
(2) Calculate an average value of the Importance Index (IMX) [6] obtained at the judgment nodes executed in the node transition from the previous processing node to the current processing node.
(3) Determine buying or selling action based on the comparison between the average value of IMX and the value of a.

3.3. Fitness Function of R-GNP

The concept of R-GNP is that the robustness of GNP is acquired by evaluation process of GNP evolution, where the total fitness function is defined as the sum of the fitness function obtained by the original data of the target stock and the fitness functions obtained by the data of correlated stocks as follows.

$$F = F_o - \omega \sqrt{\frac{1}{|G|} \sum_{g \in G} (F_o - F_g)^2} \quad . \ . \ . \ . \ . \ . \ . \quad (4)$$

$$F_o = \sum Reward \quad . \ . \ . \ . \ . \ . \ . \ . \ . \ . \ . \ . \quad (5)$$

$$Reward = sellingprice - purchaseprice \quad . \ . \quad (6)$$

where, F is total fitness function, F_o is the fitness function of the original data, ω is a weight parameter, F_g is the fitness function by the gth correlated data, and G is the set of suffixes of the correlated data. In the simulation, the fitness of the original data F_o is the sum of the rewards obtained from the stock trading, while reward shows a capital gain or loss of one trade.

4. Simulations

In order to confirm the effectiveness of R-GNP, we applied the proposed hybrid system to the Nikkei 500 Index from January 2004 to December 2007, which includes 500 major companies in the first section of Tokyo Stock Exchange in Japan. The simulation is divided into two periods: one is used for training and the other is used for testing. Especially, the stock market is being affected by the world-wide financial crisis in the year of 2007, thus, we would like to test the effectiveness of the proposed method in the special time period.

- Training: January 5, 2004-December 29, 2006
- Testing: January 4, 2007-December 28, 2007

After the first step of priority selection with β, a portfolio with 300 stocks out from Nikkei 500 Index are established. Then, GRA are used to further optimize this portfolio to obtain a target stock and 9 correlated stocks, i.e., stocks with large correlations are selected. In the R-GNP trading phase, we suppose that the initial funds is 5,000,000 Japanese yen in both training and testing periods, and the order of buy or sell is executed at the opening of the trading day, i.e., we can buy and sell stocks with the opening price.

4.1. Conditions of GRA and R-GNP

Table 1 shows the parameters of the evolution of GRA. The total number of nodes in each individual of GRA is 10 which indicates 10 different stocks in a portfolio. Those stocks are selected from the Nekkei 500 Index listed in the first section of Tokyo stock market in Japan. The content Fi in each node is determined randomly at the beginning of the first generation, and changed appropriately by

Table 1. Parameter conditions for evolving GRA

Number of individuals=300 (mutation:179, crossover:120, elite:1)
Number of generations=300
Number of nodes=10
P_c=0.3

Table 2. Parameter conditions for evolving R-GNP

Number of individuals=300 (mutation:179, crossover:120, elite:1)
Number of nodes=31 (Judgement node=20, Processing node=10, Start node=1)
Number of sub-node in each node=2
P_c=0.1, P_m=0.03, α=0.1, ω=0.5

evolution. The initial connections between nodes are also determined randomly in the first generation. At the end of each generation, 179 new individuals are produced by mutation, 120 new individuals are produced by crossover, and the best individual is preserved. The other parameters for crossover and mutation are the ones showing good results in the simulations. The terminal condition is 300 generations.

Table 2 shows the parameters of the evolution of R-GNP. R-GNP uses the judgment nodes to judge the information from stock markets, and uses the processing node to take buying and selling actions. The total number of nodes in each individual is 31 including 10 processing nodes, 20 judgment nodes and 1 start node. The initial connections between nodes are also determined randomly in the first generation. At the end of each generation, new individuals are produced by selection, crossover and mutation. Since ω in Eq. (4) is a weight parameter in the robust fitness function, it can be any positive values according to the risk preference of investors. Generally speaking, small value of ω indicates the preference of high return and high risk, while large value of ω indicates the preference of low return and low risk. We suppose that the investor is risk-seeking and the value of ω is set at 0.5 in the simulations.

4.2.Simulation Results

Fig. 8 shows the fitness curve of the best individual at each generation in the training period using the data of Nissan Motor, and the line is the average over 30 independent simulations. From the figure, we can see that R-GNP can obtain larger profits for the training data as the generation goes on. The fitness curves of the other companies have almost the same tendency as that of Nissan Motor.

In the next, the testing is carried out using the best individual obtained at the last generation in the training period. The values in Table 3 are the average of the 30 independent simulations with different random seeds. Table 3

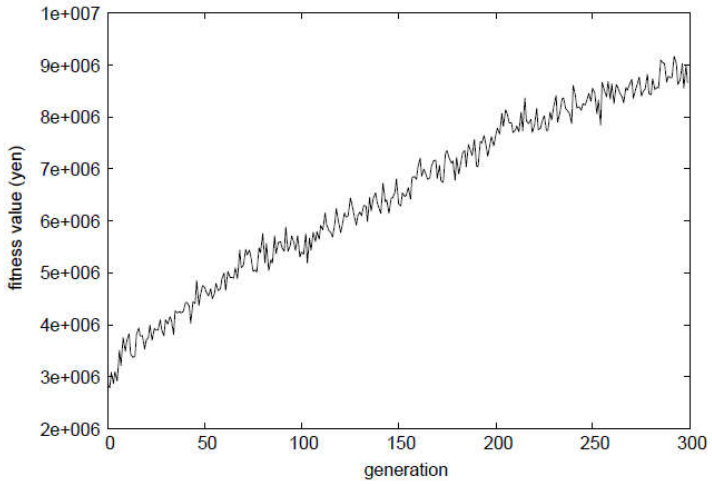


Fig. 8. Average fitness value in the training period of R- GNP (Nissan Motor)

also shows the comparison of simulation results by using R-GNP, traditional GNP [6] and Buy&Hold. Buy&Hold is often considered as a benchmark in the stock market, which buys as much stocks as possible at the opening of the market on the first day, and sells all the stocks at the opening on the last day in the simulation period. From the table, the proposed R-GNP method can obtain larger profits than Buy&Hold in the trade of all 10 stock brands. When comparing with traditional GNP, the proposed method can get larger profits than tradition GNP in the trade of 7 brands out of 10. Especially, the stock market is being affected by the world-wide financial crisis in the year of 2007, thus Buy&Hold makes a loss in most of the brands, however, R-GNP still obtains profits in the stock market with down trends. The generalization ability of R-GNP has been confirmed by the good performance in the testing period.

5. Conclusions and Future Work

This paper presents a hybrid stock trading model using β, GRA and R-GNP. In the priority selection phase, industry sectors selected according to their market capitalization pick up competitive stocks by working with the individual β for each stock. In the optimization phase, stocks with large correlations are selected using GRA. Finally, in the stock trading process, the trading rules are generated through R-GNP. In this paper, Robust Genetic Network Programming is a new point in the hybrid intelligent system, which comes from the concepts of robust Universal Learning Network [9], [10] and GNP [4]. Compared with the traditional GNP, the generalization ability of R-GNP is improved by the robust fitness function, consisting of the fitness function by the original data of the target stock and fitness functions by the data of correlated stocks. In the simulations, the trading model is trained using the stock prices of 10 brands selected from the Nikkei 500 Index, then the generalization ability is tested. From the simulation results, it is clarified that the generalization ability of R-GNP has

Table 3. Profits and losses in the testing period

Industry Sector	Target Stock	R-GNP	GNP	Buy and Hold
Electric Power & Gas	Chubu Electric Power Inc.	271,830 (5.4)	192,893 (3.9)	-947,075 (-18.9)
Foods	Marudai Food Co. Ltd.	208,356 (4.2)	336,780 (6.7)	-1,502,809 (-30.1)
Textiles & Apparels	Daito Woolen Spinning & Weaving Co. Ltd.	130,986 (2.6)	70,733 (1.4)	-1,940,789 (-38.8)
Pulp & Paper	Daio Paper Corporation	96,033 (1.9)	-39,066 (-0.8)	-270,270 (-5.4)
Chemicals	Mitsui Chemicals Inc.	321,000 (6.4)	-150,466 (-3.0)	-954,198 (-19.1)
Information & Communication	Otsuka Corporation	417,466 (8.3)	339,006 (6.8)	-1,104,746 (-22.1)
Iron & Steel	Mitsubishi Steel Mfg. Co. Ltd.	77,800 (1.6)	71,466 (1.4)	-1,317,114 (-26.3)
Electric Appliances	Fujitsu Limited	-35,700 (-0.7)	272,400 (5.4)	-1,006,356 (-20.1)
Transportation Equipment	Nissan Motor Co. Ltd.	387,100 (7.7)	25,300 (0.5)	-779,310 (-15.6)
Banks	The Chugoku Bank Limited	58,733 (1.2)	199,266 (4.0)	3,147 (0.1)
Average		193,360 (3.9)	131,831 (2.6)	-981,952 (-19.6)

been improved by using the robust fitness function.

For the future work, first, the intelligent model presented can be further investigated by modifying the fitness function and combining with other soft computing techniques. Second, it is necessary to evaluate the proposed method using other data and time periods.

Acknowledgements

This research is supported by National Natural Science Foundation of China (Grant No. 71271128, 71331006 and 71571113); Program for Innovative Research Team of Shanghai University of Finance and Economics.

REFERENCES

[1] D. Enke and S. Thawornwong, "The use of data mining and neural networks for forecasting stock market returns", *Expert Systems with Applications*, Vol. 29, No. 4, pp. 927-940, 2005.

[2] A. Fernandez and S. Gomez, "Portfolio selection using neural net- works", *Computers & Operations Research*, Vol. 34, No. 4, pp. 1177-1191, 2007.

[3] C.C Lin and Y.T. Liu, "Genetic algorithms for portfolio selection problems with minimum transaction lots", *European Journal of Op- erational Research*, Vol. 185, No. 1, pp. 393-404, 2008.

[4] S. Mabu, K. Hirasawa and J. Hu, "A graph-based evolutionary al- gorithm: Genetic network programming and its extension using re- inforcement learning", *Evolutionary Computation*, MIT Press, Vol. 15, No. 3, pp. 369-398, 2007.

[5] K. Hirasawa, T. Eguchi, J. Zhou, L. Yu, J. Hu and S. Markon, "A Double-Deck Elevator Group Supervisory Control System Using Genetic Network Programming", *IEEE Transactions on Systems, Man and Cybernetics, Part C*, Vol. 38, No. 4, pp. 535-550, 2008.

[6] Y. Chen, S. Mabu, K. Shimada and K. Hirasawa, "Trading Rules on Stock Markets Using Genetic Network Programming with Sarsa Learning", *Journal of Advanced Computational Intelligence and In- telligent Informatics*, Vol. 12, No. 4, pp. 383-392, 2008.

[7] E. Gonzales, K. Taboada, K. Shimada, S. Mabu and K. Hirasawa, "Evaluating Class Association Rules using Genetic Relation Pro- gramming", *In Proc. of the IEEE congress on evolutionary compu- tation 2008*, pp. 731-736, 2008.

[8] Y. Chen and K. Hirasawa, "A Portfolio Selection Model using Genetic Relation Algorithm and Genetic Network Programming", *IEEJ Transactions on Electrical and Electronic Engineering*, Vol. 6, No. 5, 12 pages, 2010. (to appear)

[9] K. Hirasawa, X. Wang, J. Murata, J. Hu and C. Z. Jin, "Universal Learning Network and Its

Application to Chaos Control", *Neural Networks*, Vol. 13, No. 2, pp. 239-253, 2000.

[10] K. Hirasawa, J. Murata, J. Hu and C. Z. Jin, "Universal Learning Network and Its Application to Robust Control", *IEEE Transactions on Systems Man and Cybernetics, Part B*, Vol. 30, No. 3, pp. 419- 430, 2000.

[11] J. R. Koza, *Genetic Programming, on the programming of comput- ers by means of natural selection*, Cambridge, Mass.: MIT Press, 1992.

[12] Y. Chen, C. Yue, S. Mabu and K. Hirasawa, "A Genetic Relation Algorithm with Guided Mutation for the Large-Scale Portfolio Op- timization", *In Proc. of the ICROS-SICE International Joint Con- ference 2009*, pp. 2579-2584, 2009.

[13] R. S. Sutton, A. G. Barto, *Reinforcement Learning-An Introduction*, Cambridge: Massachusetts, London, England, MIT Press, 1998.

A Modified Radial Basis Function Neural Network Model for Bankruptcy Prediction

Pey Yun Goh, Shing Chiang Tan and Wooi Ping Cheah
Faculty of Information Science and Technology
Multimedia University
Jalan Ayer Lama, 75450, Melaka, Malaysia
{pygoh; sctan; wpcheah}@mmu.edu.my

ABSTRACT. *Financial losses due to bankruptcy will leave a great impact to the society and country. As such, early identification of potential bankrupt firms will help to reduce the negative impacts, especially on financial institutions. This study proposes a pruning neural network which acts as a decision support tool for bankruptcy prediction. The proposed model is evaluated with a data set available in a public portal. The classification performance between the baseline model and the proposed model is compared. The reported paired t-test shows that the proposed model not only can extract useful knowledge within a shorter time than the baseline model, but is also a less complex network architecture without affecting the classification performance. The proposed model is also compared with other classification methods. Results show that its classification accuracy is as highly competitive as compared to those accuracy results of other state-of-art classification methods.*

Keywords: Bankruptcy prediction, radial basis function network, histogram, neural network

1. **Introduction.** Interest income from loan is one of the main sources of profit for financial organization. However, if financial organization makes a wrong decision in predicting the business failures, it may cause serious problems such as financial crisis and distress [1]. The negative effects from bankruptcy, is not only on the financial organization, but also affect the workers, stakeholders, suppliers and others who have the business relationship with the debtors. As such, bankruptcy prediction is one of the most important decisions in financial decision making [1-2]. Data has been growing fast in a big volume which adds difficulties for the human experts to analyze. Automatic techniques, such as data mining is widely used to extract meaningful information from available data. Different data mining approaches have been applied in helping the human experts to extract useful patterns from the data. Approaches that are widely used in bankruptcy prediction are neural networks [3-5], logistic regression [6] and Bayesian classifier [7].

Neural network gives a promising result in prediction [8]. Successful application to a variety of real world tasks can be seen in field such as handwriting recognition [9], speech recognition [10], medical diagnosis [11] and of course, bankruptcy prediction [3-5]. Among various types of neural network, the radial basis function network (RBFN) is a popular classification model. RBFN has an ability to perform universal function approximation [12]. Examples of real-world applications using RBFN include classifying clinical data [13] and handling industrial tasks [14]. A desirable property of RBFN is that it should have an

ability to perform incremental learning where additional hidden nodes are created automatically to update information extracted from data continuously. Information is organized in a form of a node prototype. In this paper, a new variant of RBFN is built by using a dynamic decay adjustment (DDA) algorithm. DDA learns the incoming data incrementally without a need to retrain the network with all data samples. However, one drawback of DDA is that it may greedily include non-related node prototypes that are redundant, abnormal and noisy. Therefore, a statistical technique, i.e. histogram (HIST) is proposed to integrate with RBFNDDA to remove the superfluous prototypes. Histogram is a simple method to find data distribution. It has good computational efficiency [15]. In this paper, the proposed RBFNDDA-HIST is applied to perform bankruptcy prediction. The following reasons caught our interest in bankruptcy prediction: (i) to accurately predict bankruptcy is considered a critical issue in finance [16]; (ii) the data nature is qualitative, i.e. nominal or refer as categorical data. RBFNDDA-HIST is originally designed for processing numerical data. The application of RBFNDDA-HIST in this data set will demonstrate its prediction capability based on categorical data. At the same time, as mentioned in [16], such application reveals the association between the qualitative judgment of human expert with bankruptcy prediction.

In the next sections, the original models, i.e. RBFNDDA and HIST, are explained. The proposed model is described in Section 3. Section 4 presents a experimental study of RBFNDDA-HIST for bankruptcy prediction. Conclusion and future work are described in Section 5.

2. **RBFNDDA and HIST.** RBFNDDA was originally proposed by [17]. It has three layers, i.e. input layer, hidden layer and output layer. The most important layer is the hidden layer, where representative prototypes are selected. The prototypes are then linked to the output node through the linear function (see eq. 1) which involves the weight:

$$Output(\vec{i}) = \sum_{j=1}^{n} \vec{W}_j * Radius_j(\vec{i}) \quad (1)$$

where i = input vector, W = weightage of j-th RBF. RBFNDDA includes the prototypes automatically based on probabilistic approach. This behavior is called incremental learning. It includes new prototype based on two user defined threshold, the positive threshold (θ^p, usually set as 0.4) and negative threshold (θ^n, usually set as 0.2). θ^p is used to determine the minimum correct-classification probability of an input to be included as the sample that covered by a prototype of the similar class. θ^n is used to reduce the overlapping of a prototype from its neighbors from the other classes. The procedure of training in one epoch is as follows:

Parameters: H = prototype, W = weight, j = j-th prototype, c = class,
i = training input, S = activation of a prototype,
d_i^c =radius of i-th prototype of class c,
m_i^c =center of i-th prototype of class c
θ^p = positive threshold, θ^n = negative threshold,
n_c = number of prototypes of class c

Step 1: For all H_j^c in hidden layer with j=1,2,…,n_c, c=1,2,…C, set W_j^c of each hidden prototype to zero.

Step 2: Assume that a H_j^c is in the network. If a training input, i^c, has the Gaussian activation level $S_j^c \geq \theta^p$ (indicates that the input is correctly classified), increase the weight of the hidden prototype that has the largest S_j^c by one, i.e.,

$W_j^c = W_j^c + 1$

Otherwise, when none of H_j^c fulfils the condition, update the number of prototypes of class c, $n_c = n_c + 1$;

{

Introduce input i as a new prototype H_n^c

Set $W_{n_c}^c = 1$

Set the centre of H_n^c, $m_{n_b}^c = i$

Adapt the radius of H_n^c, $d_{n_c}^c = \min_{\substack{k \neq c \\ 1 \leq a \leq n_k}} \left\{ \sqrt{-\frac{\| m_a^k - m_{n_c}^c \|^2}{\ln \theta^n}} \right\}$

}

Step 3: Adjust the radius of all conflicting prototypes where $k \neq c$, $1 \leq a \leq n_k$,

$d_a^k = \min\left\{ d_a^k, \sqrt{-\frac{\| i - z_a^k \|^2}{\ln \theta^n}} \right\}$

Step 4: Steps 2 to 3 are repeated until all the training samples have been presented.

For the pruning part, we adopt the HIST which is proposed by Shimazaki and Shinomoto [18]. This method is considered because it can find the optimum number of bins with equal width from the data distribution. Such goal is achieved through minimizing the cost function: $Cost_q(\Delta)$. During the optimization process, few parameters are changed automatically to look for the most minimum $Cost_q(\Delta)$, i.e. the number of bin B, the width Δ and the q sequences to obtain the firing rate. The setting for B is between 2 to 50 whereas q is set as 30.

Parameters: T = a time period, q = number of sequence, Δ = width of bin,
B = number of bins, p = frequency of spikes, i = i-th bin,
$\overline{p}$ = mean of spikes, var = variance of spikes

Step 1: Observation T is divided into B bins of width Δ. The p_i from all q sequences that enter the i-th bin is calculated.

Step 2: Determine the $\overline{p}$ and var as follows.

$$\overline{p} \equiv \frac{1}{B} \sum_{i=1}^{B} p_i \tag{2}$$

$$var \equiv \frac{1}{B}\sum_{i=1}^{B}(p_i - \overline{p})^2 \tag{3}$$

Step 3: Calculate the $Cost_q$ where

$$Cost_q(\Delta) = \frac{2\overline{p} - var}{(q\Delta)^2} \tag{4}$$

Step 4: Repeat steps 1 to 3 by varying different B values to find the corresponding Δ that minimizes $Cost_q$.

3. **Integration of RBFNDDA and HIST.** The proposed RBFNDDA-HIST model is an integration of RBFNDDA and HIST. RBFNDDA is used in the learning stage while HIST is used to prune the superfluous nodes. However, to integrate RBFNDDA and HIST, some modifications should be made. RBFNDDA deals with multi-dimensions data but HIST deals with one dimension data. Their nature of process is different. How could the generated prototypes from RBFNDDA be used as the input in HIST that accepts only one dimension data? Therefore, the attributes of each prototype are aggregated to provide a one dimension data according to class label. For example, class c contains n number of prototypes after the training process in RBFNDDA. This group of prototypes H will contain the following:

$$H = \left\langle m_{1,\cdots,n_b}, W_{1,\cdots,n_b}, d_{1,\cdots,n_b} \right\rangle, \quad c = 1, 2, \cdots, C \tag{5}$$

where m = reference vector, W = weight, d = radius. The sum up process of all attributes of a prototype is as below:

$$I_j^c = \sum_{f=1}^{F} m_{d_j}^c \tag{6}$$

where I = input, j = j-th prototype, F = number of dimensions. As the sequence to obtain the frequency of I is completed in once, so q = 1. The range for number of bins, B is set as minimum 3 till 50, instead of 2. This is to avoid information loss due to reduction when prototypes are presented with only 2 bins. The complete procedures of HIST are as below:

Step 1: After the transformation through aggregate sum, all input Is of class c are divided into B bins of width Δ (eq. 7).

$$\Delta = \frac{I_{\max}^c - I_{\min}^c}{B} \tag{7}$$

Step 2: The frequency p_i of Is which enter the i-th bin is counted. Mean $\overline{p}$ (eq. 2) and variance var (eq. 3) are generated based on p_i.

Step 3: The $Cost_q$ (eq. 4) is then computed.

Step 4: The setting of B and Δ will change (steps 1 to 3 are repeated) until the optimum bin size which minimize $Cost_q$ are found.

Step 5: The outcome from step 4 is then used to construct histogram.

Step 6: The magnitude $p(g)$ (eq. 8), where g = RBFNDDA weightage is computed for each bin i. For example, assume that optimum bin size, B = 3. B_1 contains 7 Is, where 3

*I*s with DDA weightage = 1, 3 *I*s with DDA weightage = 4 and 1 *I* with DDA weightage = 9. Therefore, the probability $p(g)$ for B_1 are $\frac{3}{7}$, $\frac{3}{7}$ and $\frac{1}{7}$ respectively. The category of RBFNDDA weightage for B_1 is 3, i.e. 1, 4 and 9. The number of weight category y for this bin is 3.

$$p(g) = \frac{\text{frequency of } I \text{ of RBFNDDA weightage category}}{\text{Total frequency of } I \text{ per bin}} \tag{8}$$

Step 7: Compute the expected value *E(g)* for each bin.

$$E(g) = \sum_1^y g * p(g) \tag{9}$$

(*E(g)* reflects the score of weightage for each bin. Revisit example in step 6, $E(g) = (1)\frac{3}{7} + (4)\frac{3}{7} + (9)\frac{1}{7} = 3.43$. The highest the score, the more important is the bin.)

Step 8: *E(g)* is then normalized within 0 and 1. With *B*=3 as mention in step 6, assume that each bin has the *E(g)* score as 3.43, 0.50 and 4.50. After normalization, the obtained scores are 0.73, 0 and 1.00 respectively.

Step 9: A bin with the normalized value that is lowered than a threshold (we set it as 0.25) will be deleted. As such, based on the threshold 0.25, bin 2 is deleted.

Step 10: Repeat Steps 1 to 9 for all the classes.

Step 11: After complete, send the retain prototypes back to RBFNDDA and proceed to testing phase.

4. **Experiments and Discussion.** The experiment was conducted in two ways. First, the proposed model was compared with the baseline model, i.e. RBFNDDA. The purpose of comparison was to evaluate the efficacy of RBFNDDA-HIST. The parameter settings are presented as below:

i. For RBFNDDA, threshold positive = 0.4, threshold negative = 0.2, maximum epoch = 6
ii. For HIST, *N* is set within the range from 3 to 50, pruning threshold = 0.25.

A paired *t*-test is used as the evaluation method to see whether the result of RBFNDDA is different from RBFNDDA-HIST. Second, a comparison between the proposed model and other methods used for bankruptcy prediction from the literature was also made. The experiment was repeated for 30 runs and the average accuracy rate was computed.

The bankruptcy data set consists of 250 samples which is downloaded from the UCI Machine Learning Repository [19]. 40% of the data is labeled as bankrupt (B) while the remaining 60% of the data is labeled as non-bankrupt (NB). The nature of the data type is nominal. Six factors are examined: industry risk, management risk, financial flexibility, credibility, competitiveness and operating risk. Three ratings are used to categorize each factor, i.e. positive, average and negative. For more details on the factors, we refer readers to [20]. A hold-out technique is applied [8]. Data is partitioned into a training set and a

testing set (see Table 1).

TABLE 1. Training set and testing set

Compared Methods	Training set	Testing set
RBFNDDA	125 (50%)	125 (50%)
Naïve Bayes classifier (NBC), Multilayer Perceptron (MLP), J48 and classification via regression [20]	75 (30%)	175 (70%)

The result between RBFNDDA-HIST and the baseline model, i.e. RBFNDDA is as below:

TABLE 2.Comparison between RBFNDDA and RBFNDDA-HIST

	Number of prototypes	Accuracy (%)	Time (s)
RBFNDDA	15.830	96.230	0.560
Std. Dev.	3.710	2.910	0.290
RBFNDDA-HIST	10.110	95.660	0.390
Std. Dev.	2.930	2.760	0.210
Paired *t*-test	0.000*	0.076	0.000*

*significant difference

As shown in Table 2, RBFNDDA-HIST is able to maintain as high accuracy rate as RBFNDDA because the *p*-value from the Paired *t*-test is greater than 0.05. RBFNDDA-HIST has a significant smaller number of prototypes and shorter training time than RBFNDDA because the *p*-values are below 0.05. The number of prototypes has been reduced significantly from 15.83 to 10.11. The training has become more efficient where it is improved from 0.56 to 0.39 seconds.

RBFNDDA-HIST is then benchmarked with other classification methods. Authors in [20] applied 4 different techniques for bankruptcy prediction: i.e. Naïve Bayes classifier (NBC), multilayer perceptron (MLP), J48 (a simple C4.5 decision tree) and classification via regression (CR). The details of these techniques can be found in [20]. The classification performance of RBFNDDA-HIST is compared with these techniques. Based on the results in Table 3, RBFNDDA-HIST is comparatively good in bankruptcy prediction, where the average accuracy is 96.77%.

TABLE 3.Benchmark study with other classification techniques

Classification Techniques	Average Accuracy (%)
RBFNDDA-HIST	**96.77**
NBC	96.57
CR	96.00
J48	95.43
MLP	94.88

5. **Conclusions.** As the negative leverage from firm bankruptcy could be disastrous, a better knowledge discovery in bankruptcy prediction will have great impact on making financial decision. The proposed model, i.e. RBFNDDA-HIST has shown good knowledge discovery result in bankruptcy prediction. This shows that RBFNDDA-HIST can classify categorical data effectively. On the other hand, superfluous prototypes can be managed in a fast and simple pruning process. This is shown through experimental results where RBFNDDA-HIST has reduced the prototypes and training time significantly from its original model RBFNDDA. The benchmark study reveals that RBFNDDA-HIST is compatible with other classification techniques. In the future, we aim to improve the classification performance of RBFNDDA-HIST. Besides that, additional experiments are needed to evaluate the effectiveness of RBFNDDA-HIST in different application domains.

REFERENCES

[1] C.-F, Tsai, and J.-W, Wu, Using neural network ensembles for bankruptcy prediction and credit scoring, *Expert Systems with Applications*, vol. 34, no. 4, pp. 2639–2649, 2008.

[2] I. M. Premachandra, Y. Chen, and J. Watson, DEA as a tool for predicting corporate failure and success: A case of bankruptcy assessment, *Omega*, vol. 39, no. 6, pp. 620–626, 2011.

[3] K.-S Shin, T. S. Lee, and H. Kim, An application of support vector machines in bankruptcy prediction model, *Expert Systems with Applications*, vol. 28, no. 1, pp. 127–135, 2005.

[4] S. Cho, J. Kim, and J. K. Bae, An integrative model with subject weight based on neural network learning for bankruptcy prediction, *Expert Systems with Applications*, vol. 36, no. 1, pp. 403–410,. 2009.

[5] K. C. Lee, I. Han, and Y. Kwon, Hybrid neural network models for bankruptcy predictions, *Decision Support Systems*, vol. 18, no. 1, pp. 63–72, 1996.

[6] I. M. Premachandra, G. S. Bhabra, and T. Sueyoshi, DEA as a tool for bankruptcy assessment: A comparative study with logistic regression technique, *European J. Operational Research*, vol. 193, no. 2, pp. 412–424, 2009.

[7] A. Aghaie, and A. Saeedi, Using Bayesian Networks for Bankruptcy Prediction: Empirical Evidence from Iranian Companies, *Proc. of IEEE International Conference* on *Information Management and Engineering*, Kuala Lumpur, Malaysia, pp. 450–455, 2009.

[8] F.-M Tseng, and Y.-C Hu, Comparing four bankruptcy prediction models: Logit, quadratic interval logit, neural and fuzzy neural networks, *Expert Systems with Applications*, vol. 37, no. 3, pp. 1846–1853, 2010.

[9] S., Knerr, L., Personnaz, and G., Dreyfus, Handwritten digit recognition by neural networks with single-layer training, *IEEE Transactions on Neural Networks*, vol. 3, no. 6. pp. 962–968, 1992.

[10] R. P., Lippmann, Review of Neural Networks for Speech Recognition, *Neural Computation*, vol. 1, no. 1, pp. 1–38, 1989.

[11] H. B., Burke, P. H., Goodman, D. B., Rosen, D. E., Henson, J. N., Weinstein, F. E., Harrell, J. R., Marks, D. P., Winchester, and D. G., Bostwick, Artificial neural networks improve the accuracy of cancer survival prediction, *Cancer*, vol. 79, no. 4, pp. 857–862, 1997.

[12] G. A., Montazer, and D., Giveki, D., An Improved Radial Basis Function Neural Network for Object Image Retrieval, *Neurocomputing*, no. 0, 2015.

[13] S. N. Qasem, and S. M. Shamsuddin, Radial basis function network based on time variant multi-objective particle swarm optimization for medical diseases diagnosis, *Applied Soft Computing*, vol. 11, no. 1, pp. 1427–1438, 2011.

[14] C.-F Hsu, C.-M Lin, and R.-G Yeh, Supervisory adaptive dynamic RBF-based neural-fuzzy control system design for unknown nonlinear systems, *Applied Soft Computing*, vol. 13, no. 4, pp. 1620–1626, 2013.

[15] P. A. Legg, P. L. Rosin, D. Marshall, and J. E. Morgan, *Improving accuracy and efficiency of registration by mutual information using Sturges' histogram rule*, University of Aberystwyth, pp. 26 – 30, 2007.

[16] M.-J Kim, and I. Han, The discovery of experts' decision rules from qualitative bankruptcy data using genetic algorithms, *Expert Systems with Applications*, vol. 25, no. 4, pp. 637–646, 2003.
[17] M. R. Berthold, and J. Diamond, *Boosting the performance of RBF networks with dynamic decay adjustment*. MIT Press, pp. 521-528, 1995.
[18] H. Shimazaki, and S. Shinomoto, A method for selecting the bin size of a time histogram, J. Neural Computation, vol. 19, no. 6, pp. 1503–1527, 2007.
[19] K. Bache, and M. Lichman, *UCI Machine Learning Repository*, University of California, School of Information and Computer Science, 2013. [Online]. Available: http://archive.ics.uci.edu/ml.
[20] M. Koklu, M. and K. Tutuncu, Qualitative bankruptcy prediction rules using artificial intelligence techniques, *Proc. of International Conference on challenges in IT, Engineering and Technology*, Phuket, Thailand, pp. 21–25, 2014.

Responsive Web Application for Car Status System

Hesham Ali Alsayed Elbendary, Afizan Azman ,Narisha Husna Kamarudin,
Sumendra Yogarayan, Kirbana Jai Raman, Zailina Aishah Zainal,
, Siti Zainab Ibrahim and Mohd Fikri Azli Abdullah
Faculty of Information Science and Technology
Multimedia University,
Malacca, Malaysia.
hysham.bendary@icloud.com, afizan.azman@mmu.edu.my, mastersumen@gmail.com,
jpk_kirbz@hotmail.com, zaishah.zbahren@gmail.com, sitizainab.ibrahim@mmu.edu.my
and mfikriazli.abdullah@mmu.edu.my

ABSTRACT. *The proposed system in this paper is an application software communicating with both electronic control unit (**ECU**) and body control module (**BCM**) to assist car owners to check and monitor their car from anywhere in the world through an easy and user friendly software that can be run in all platforms. In general, the main function of the application is to provide and display car real time information and status remotely. The application is developed with purpose of providing assistance for the car owner to have safety measures through features such as car's door lock, fuel level, location of the car and windows status check. In addition, remote function becomes the key value added to the application for car owner mobile accessibility for convenience purpose.*

Keywords: connected car, intelligent control system, on-board diagnostic-II, body control module, engine control unit, tracking system, arduino uno

1. **Introduction.** In automotive electronics, body control module (BCM) is a generic term for an electronic control unit responsible for monitoring and controlling various electronic accessories in a vehicle's body. Typically in a car the BCM controls the power windows, power mirrors, air conditioning, immobilizer system, central locking, etc. The BCM communicates with other on-board computers via the car's vehicle bus, and its main application is controlling load drivers – actuating relays that in turn perform actions in the vehicle such as locking the doors or dimming the salon overhead lamp. [1]

Throughout the car are various computers called electronic control units, or ECUs. Each ECU has several jobs: controlling the engine or transmission, rolling up windows, unlocking doors, and the like. These computers have sensors and switches wired in to detect variables such as temperature, pressure, voltage, acceleration at different angles, braking, yaw and roll of the vehicle, steering angle, and many other signals. Let's take for instance, power sliding doors, a common feature on modern minivans. These doors are operated by an ECU called the body control module (**BCM**). Sensors constantly report whether the door is open or closed, and when the driver pushes a button to close the door, the signal from that switch is broadcast across the network. When the ECU gets that signal, however, it doesn't simply close the door. First, it checks the data stream to make sure the car is in park and not moving. If all is well, it then gives a command to a power circuit that

energizes the motors used to close the door. It goes even further, though—the ECU then monitors the voltage consumed by the motors. If it detects a voltage spike, which happens when a door is hindered by an errant handbag or a wayward body part, the ECU immediately reverses the direction of the door to prevent potential injury. If the door closes properly, the latch electrically locks the door shut. In the old days, this would have been an engineering feat. Just electrically powering the doors would have required dedicated wires running between the shifter, the door switch, and the motor. [2]

The data collected by the ECU is very important so eventually a standard was created that manufacturers were encouraged to follow to retrieve the data from the ECU. The standard became commonly known as Onboard Diagnostic (OBD). The introduction of the standard was in an effort to encourage vehicle manufacturers to design more reliable emission control systems.

2. **Problem Statement and Preliminaries.** Vehicle crime is a highly organized criminal activity affecting all regions of the whole world and with clear links to organized crime and terrorism. Vehicles are not only stolen for their own sake, but are also trafficked to finance other crimes. They can also be used as bomb carriers or in the perpetration of other crimes. In 2014, around 132,000 motor vehicles worldwide were identified as stolen [3]

A motor vehicle is stolen every 45 seconds in the United States only, top 10 model year 2012 vehicles stolen in 2012:

- Mercedes-Benz CL-Class
- Mitsubishi Eclipse
- Mazda 6
- Dodge Charger
- Nissan Infiniti FX35/FX50
- Dodge Avenger
- Chrysler 300
- Chevrolet Impala
- Mitsubishi Galant
- Chevrolet Captiva

Safety check is a must for a car owner to keep their car safe from a car theft. Before a car owner leaves their car unattended, they need to check whether their car is lock or have they switch off the lights and etc. but sometimes people in a rush or tend to forget or being careless and did not check their car before they leaves it. From that many things could happen for example a car robbery and that would be a lost for a car owner.

Recent statistics shows that nearly half of vehicle theft is due to driver error. Unlocked windows and/or an open cars' door can lead to a car theft. [4]

The purpose of the proposed system in this paper is to develop an application to solve the problem faced by the car owners which it provides a car checking and it is also easy to understand and a user-friendly application.

This application will meet a certain objectives that are:

- To make it easier for a car owner to check their car status.
- To develop the application in an adaptive design.

- To make it convenient for car owner to access the application whenever and wherever they want to.

The application proposed will grant the car owner to check and monitor his car from anywhere in the world with any device equipped with internet connection. Such feature will contribute to add an additional security and safety to the cars and reduce the sharp rise in cases of car thefts and abduction.

3. Current Application. Car status application is a software application that will check the car condition in such a way where the apps is registered based on the car Id. Nowadays, most of car brand has developed this kind of application which will increase the revenue of car sold because people are attracted to this kind of technology that will helps them to connect to their car.

3.1. Volvo on Call. Volvo has developed a system call Volvo On Call, a mobile application that offers a variety of features that gives a Volvo vehicle owners a more convenient way to understand more and taking care of their vehicle. Volvo On Call is an app that allows Volvo car owners to literally take control over everyday elements in their Volvo car. This application is a graphical interface and has a user friendly interface which would be easy for a new user to use it without having any trouble to figure out on how to use it. This application also have been introduced from a different platform which it can runs on Apple watch and Android Wear where it gives a step ahead from other automotive brands smart app. [8]

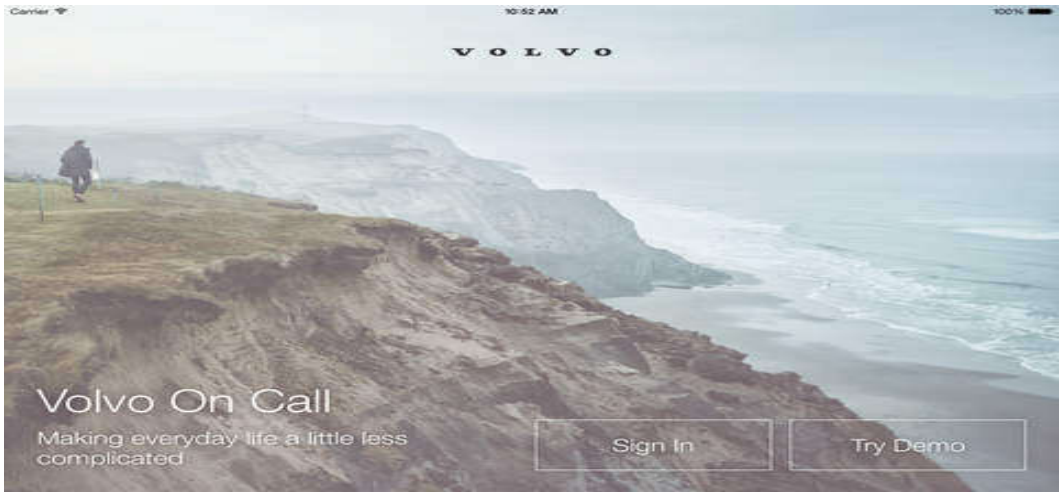


Figure 1: Volvo On Call – Sign In page [5]

Figure 1 is the sign in page of Volvo On Call application for iPad user that consist of their slogan, a sign in button which only a Volvo vehicle owners have the VOC PIN code and a "Try Demo" for anyone who wanted to explore this application without having to enter the VOC PIN code. It will be exactly the same as for user who sign in using VOC PIN code, the only different is that it will only act as a dummy.

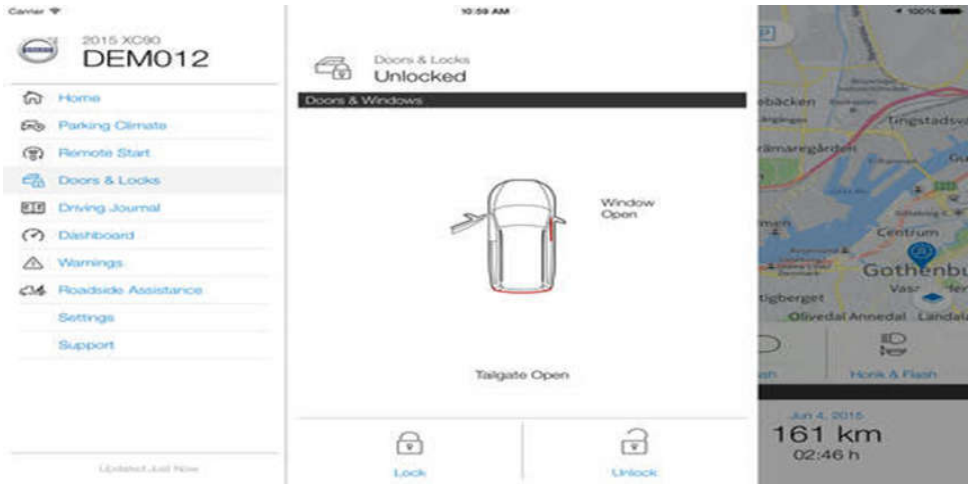


Figure 错误！文档中没有指定样式的文字。: Volvo On Call – Doors & Locks features. [3]

Figure 2 shows one of the features in Volvo On Call application which is the Doors & Locks function. This function provides a way to ensure that the vehicle doors are locked and the windows are full closed. Besides that, it allow user to lock or unlock the vehicle remotely but for a safety reasons the lock function will engage the alarm and not a deadlock which it allows user to unlock the vehicle from the inside. As for the unlock function, to unlock the vehicle it requires some physical contact which is to pull the handle of the luggage compartment as this is to avoid accidental unlock of the vehicle. It is also need to be done in two minutes else it will relock itself automatically as for safety reasons. Also, before the vehicle unlocks itself, it requires a PIN code to unlock the vehicle remotely as this is for security purpose.[8]

3.3. Mercedes connect me. Mercedes-Benz is one of the famous distributed luxury automobile companies. Recently, Mercedes-Benz has launched a new apps called Mercedes connect me, a mobile application that offers variety of features which gives a more safety, more comfort for the user. The Mercedes connect me services links user vehicle with everything that is important for user. The main focus for this mobile application is to make life easier by providing Standard Services such as vehicle diagnosis and Tele diagnostics, Breakdown Management and Accident Recovery or the emergency call system for rapid assistance in the event of an emergency. It also provides Remote Online Services where user can control their vehicle just from the smartphone. [6]

3.4. Comparisons between applications. Based on the comparison in table 2, there's a limitation in the above applications, we can find those application are helpful within short distance, but what if the car owner would like to check his car status from faraway distance or from another state or another country, the above application won't provide that .

Another limitation is the compatibility with different platforms, for example both Volovo on call and Mercedes connect me are not available to run in blackberry operating system, or in windows phone.

In the proposed project in this paper a responsive web design will be implemented where it will be compatible with Desktop, smartphone and tablet with different platforms and various operating system. There will be different designs for each device. Therefore, user does not need to worry about compatibility because it will runs on a web browser with a responsive design.
Another feature will distinguish this project is it will be available for the user to check their car status and monitor it from anywhere in the world, so there will be no distance limitation when the car owners check their car status.

Table 1: Contrast of characteristics between applications

Features	**Applications**	
	Volvo On Call	**Mercedes connect me**
Lock door	Yes	Yes
Lock window	Yes	No
User-friendly	Yes	Yes
Ease of navigation	Fairly easy	Fairly easy
Find car location	Yes	Yes within 1.5 km
Picture book navigation	No	No
In car Wi-Fi	No	No
Compatibility	Android, iOS	Android, iOS, web browser
Journal log	Yes	No
Can connect with social channels	No	No
Traffic Information	No	Yes

4. **Proposed System.** In this section, we present the framework of the proposed system and the interface design.

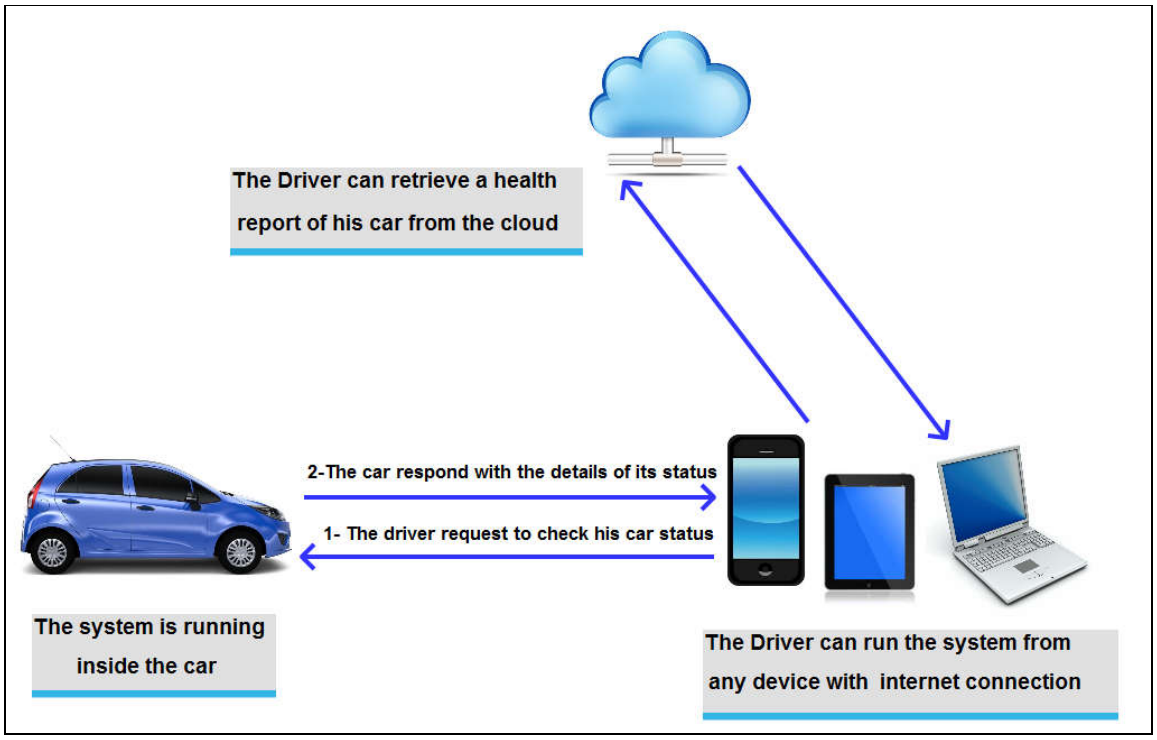


Figure 3: The diagram of the proposed system

The system proposed in this paper is designed to use the data retrieved from the onboard diagnostic and provide useful features and functionality to the car enthusiast that tunes his engine or a mechanic for easily monitoring engine behavior.
The data will be manipulated and processed to display it to the customer through an easy to use interface. Figure 4 shows the diagram of the proposed system and the flow of the system will be as following:

1. The car owner can use the system from any device with internet connection to send a request to the car to check the car status
2. The system running inside the car will respond to the car owner request accordingly to the specific request sent by the owner.

There are four main features will be available in the proposed system:

A. Doors and windows status.
B. Side mirror status.
C. Fuel level status.
D. Car location.

A and B. **Doors, windows, and side mirror** status are operated by an ECU called the body control module (BCM). And available to be retrieved from the BCM through the on-board diagnostic-II, once retrieved will be stored in local database inside the car and ready to be manipulated and processed by the system.

C. **The fuel level** sensor is mounted in the fuel level sensor unit. The sensor detects a fuel level in the fuel tank and transmits a signal to the Engine Control Module (ECM). The fuel level sensor consists of two parts, one is mechanical float and the other side is variable

resistor. The fuel level sensor output voltage changes depending on the movement of the fuel mechanical float. [7]

D. **Car location** can be achieved by building track system and integrate it with the proposed system. To build the track system will use the following components:

- Arduino Uno
- Geolocation Tracker (GPRS + GPS) with SIM908
- 2300mA/h Rechargeable Battery
- External GPRS-GSM Antenna
- External GPS Antenna
- 9V Alkaline Battery
- 9V to Barrel Jack Adapter or 9V Battery Holder

This project will cover on developing an application that is applicable for any platform e.g. mobile phones, tablet and desktop. It is a web-based application that in a way will help a car owner to check their car condition online through their devices. Before a car owner wants to use this application, they need to register their username and their car ID so only authorized car owner can log into this application. It include checking a car doors either it is unlock or not plus checking the windows, whether it is open or close, fuel level and the car location. Also, by using this application will provide safety check for the car owner who sometimes forgot to check their car before leave them. It also reduces time for a car owner to go back to their car just to make sure their car is locked. It is useful also for a car owner, who is on vacation which sometimes does not bring their car along with them; they can check their car every day during the vacation period using this application.

This project could be useful for people who find that it is important to check their car to make sure it is safe. The experiments and the test of this project will run on Proton, the Malaysian first national car. Next section is introducing an initial design of the project and will be explained briefly.

Figure 4 . index and login page

Figure 4 is the index page of the system where there is two options i.e. Sign In or Sign Up button. The Sign In button is for user who already has username and password while for Sign In button is for user who does not have username and password. User need to fill in the details in the textbox provided with correct information to gain access to the system.

5. **Conclusions.** The main objective of this project is to solve problem faced by car owner as discussed earlier. The development of this project is to give user an interactive and a user-friendly web-based application that serve the information needed by user. In the future, this web-based application could be develop with a new advance features and more attractive user interface that would be helpful for

Acknowledgment. This research was carried out within the framework of a project entitled Connected Car Services - Automatic Facial Recognition For Driver Satisfaction Detection and For Vehicle Data Analytics funded by TM R&D between Multimedia University (MMU), Melaka, Malaysia and Proton, Malaysia

REFERENCES

[1] Automotive Diagnostic Systems: Understanding OBD-I & OBD-II (S-A Design Workbench Series) Paperback – July 21, 2011 by Keith McCord

[2] Body Control Module & Gateway – BCM (03-Oct-2013) Retrieved from: *http://www.ti.com/solution/automotive_central_body_controller*

[3] INTERPOL CONFERENCE POLICE FOR A SAFER WORLD [Vehicle Crime] (2010) Retrieved from: *http://www.interpol.int/Crime-areas/Vehicle-crime/Vehicle-crime.*

[4] NHTSA National Highway Traffic Safety Administration [Vehicle Theft Prevention] Retrieved from: *http://www.nhtsa.gov/Vehicle+Safety/Vehicle-Related+Theft/Theft+Prevention*

[5] Volvo Car Volvo on call (2014) Retrieved from: *http://www.volvocars.com/intl/own/owner-info/volvo-on-call#volvo-on-call-story-carousel-1/check-your-car*

[6] Mercedes Me(n.d) Retrieved from : *https://www.mercedes-benz.com/en/mercedes-me/connectivity/*

[7] Engine-Codes P0462 Nissan - Fuel Level Sensor Circuit Low Input (2010) Available: *http://engine-codes.com/p0462_nissan.html#ixzz3nN9rr05W*

[8] Corporation, V. C. (2014). Status Car Locator: User Guide for the Volvo on Call mobile application. Retrieved September 3, 2015, from User Guide for the Volvo on Call mobile application: *http://www.volvocars.com/SiteCollectionDocuments/Campaigns/Misc/Volvo-on-call-2011/PDF/User%20Guide%*

Bio-Graphical Password Authentication with Face Spoofing Detection: A Graph Structure and Support Vector Machine Techniques

Liew Tze Hui[1], Housam Khalifa Bashier[1], Lau Siong Hoe[1], Mohd Fikri Azli[1] and Wee Kuok Kwee[1]

[1]Faculty of Information Science and Technology

Multimedia University, Melaka, Malaysia

{thliew, housam.khalifa.bas12, lau.siong.hoe, mfikriazli.abdullah, wee.kuok.kwee}@mmu.edu.my

ABSTRACT. *This paper discusses a solution for bio-graphical password authentication by adopting face spoofing techniques to eliminate fake face attack in face recognition process. In particular, this study address one of the most prominent issue in face recognition process which known as face spoofing. This attack is one of the recent security threats in biometrics based authentication system including bio-graphical password solution. The spoofing attack happens when an attacker uses a copy of a legitimate user's face to spoof the biometric system. This threat is found to be very easy to fool the face recognition algorithms with compare to other biometrics measures. In order to eliminate the threat, this study uses a well-organized classifying method to verify whether the input image corresponds to real or fake face.*

In practical, printed face has less quality defect which can be observed. In this paper, we investigate the use of local graph structure to tackle and cope with spoofing threat. Further, the Local Graph structure had been adopted to extract the local texture features. Next, the histogram is computed for classification with support vector machine. The machine learning algorithms is adopted to produce a better a classification result. Finally, extensive experimental analysis shown an encouraging performance.

Keywords Bio-Graphical password authentication, Face spoofing, Face recognition, Texture classification, Local graph structure, Local features, Support vector machine.

1.Introduction. Bio graphical password systems are the representation of a hybrid approach for security access by combining at least two layers of security for authentication. For instance graphical password with face recognition as in this paper. The graphical password becomes popular nowadays as people are better in recognizing and remembering pictures [18].Nowadays face recognition algorithms become very popular and have been implemented in many applications. This means that there's a significant improvement of the algorithms with compare to other biometrics measures. Face recognition is straightforward, natural and nonintrusive. In order to achieve a very good performance, researchers suggested that the faces need to be frontal and normalized [1]. Moreover, pose and illumination have proved to be very challenging problems for research [1-2].

On the other hand, there's a major weakness in the current face algorithms which is face spoofing. This problem is considered to be a major security threat for face applications. Furthermore, Authors in [3] define the spoofing attack as outwitting a biometric sensor by presenting a counterfeit biometric evidence of a valid user. This attack is very straight forward, the attacker only needs a copy of legitimate user's face in front of the sensor in order to spoof the algorithm. This attack does not needs a previous knowledge about the recognition scheme. Furthermore, most of the face recognition algorithms designed to identify and verify the user who wants to gain access without concerning whether the input data is live or not. Despite the existence of very sophisticated biometric authentication and verification systems nowadays, implementing anti-spoofing schemes for them is still in its infancy. Researchers at the University of Hanoi have shown that an attacker can easily spoof the algorithms at black hat conference in (2009). In addition, national institute of standards

and technology (NIST) have listed this problem in the national vulnerability database. On the other hand , face images captured from printed photos look similar to the image where captured directly from the sensor as shown in the below Figure.1.

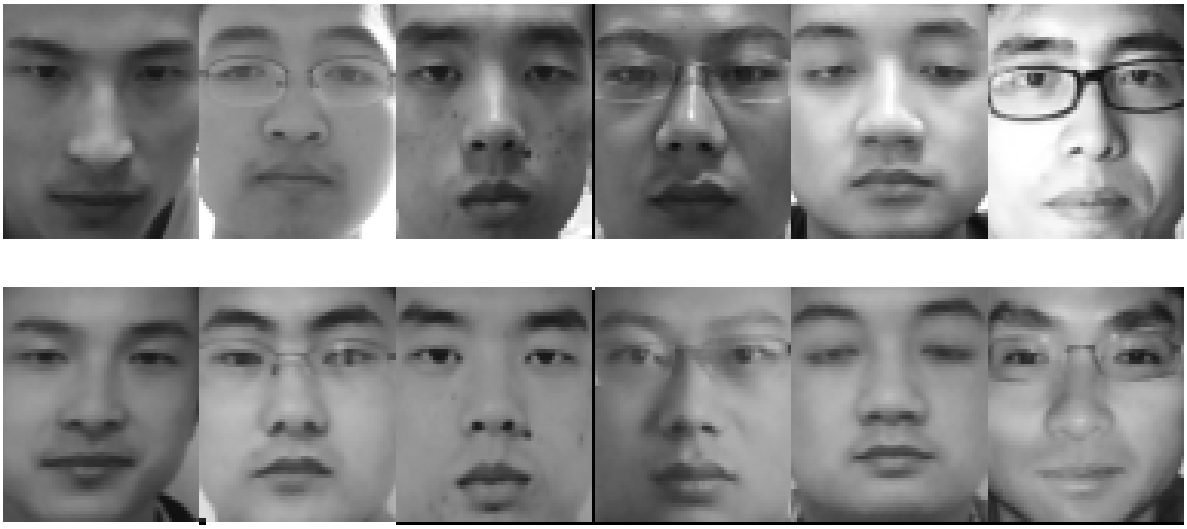


FIGURE. 1. Live Face vs. Imposter Face (Row1. Live Face, Row2. Imposter Face)

The first row shows real face images, whereby the second row shows fake face images from NUAA database. There's no different which can be observed between the two rows when we simply look at the images. However, in image quality assessment point of view, there's a huge difference. Analysing the textures data would be a good solution. In this paper, we investigate the use of local graph structure to tackle and cope with spoofing problem.

2.Face Description with Local Features: Related Work. Using a simple photograph of a legitimate user displayed using mobile, hard copy or etc. can easily fool any face recognition algorithm [4, 5]. Therefore, most of the state of the art methods are vulnerable to this attack; most of the researchers are just studying the problem of illumination, features extractions, dictionary learning or classification. Whereas, some researchers identify liveness based on detecting eye blinking, facial expression changes or mouth movement. Authors in [4] developed a method to classify live faces from fake faces by detecting the eye blinking every 4-5s. The algorithms simply works by counting the number blinks and then makes a decision on whether to accept or reject the face image. Moreover, researchers in [6, 7] utilized optical-flow to track movements of facial faces. Another way for face spoofing can be done by analysing the skin properties of the received facial data such as skin texture or skin reflectance. Authors [8] claimed that printed-face has a smaller high frequency component with compare to live facial image and thus proposed a method to tackle the spoofing attack. In their approach Fourier transform is adopted to extract the frequency components. However, the method fails for high quality image while on down-sampled image gives encouraging performance.

In recent research, Tan et al proposed a work which adopted lambertian reflectance to classify between fake face and real face and this simply between (2 dimension vs. 3 dimension) data [9]. The algorithm uses l retinas-based and difference of Gaussian to extract

latent reflectance features. The results reported in their research are quite good. The database used for this study is NUAA photograph imposter which is publically available [9]. Therefore, our research is carried out using this database.

On the other hand, Local graph structure is proposed by Eimad et al [10] for face recognition. Many applications have been considered in the literature for instance tracking, recognition, plant identification and others extensions of LGS [11-15] but none of them have paid attention to use LGS with support vector machine for face anti-spoofing. Hence, our target in the study is to implement LGS with SVM for face anti-spoofing.

3.Bio-Graphical Password Authentication. The aim of this research work is to develop a bio-graphical password authentication solution. In the proposed system, we adopt two layers of security. The first layer is face recognition, which a biometric solution needs to be implemented in order to recognizing legitimate user's face. However, before the face recognition, there's an essential step which is known as face spoofing. The main purposed of the face spoofing is to verify that the input image is a live face not a fake one and hence, this paper studied the implementation of a texture operator with SVM to tackle the liveness detection. The second layer of security is graphical password, which used pictures as password. Finally the system makes a decision based on the information from the two layers in order to gran or reject access to a secure system. The below Figure.2 shows the framework of the proposed system.

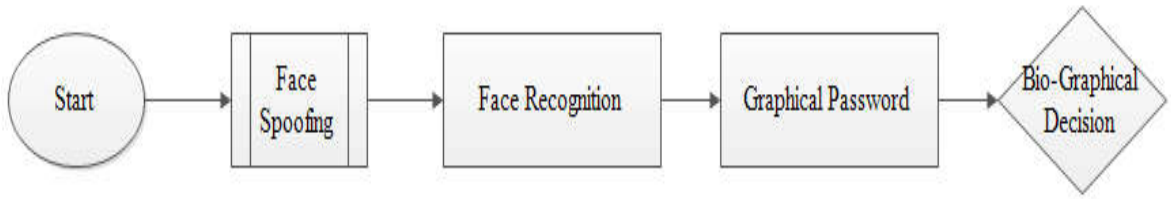


FIGURE. 2. Proposed Bio-Graphical Solution

4.Spoofing detection using graph-texture analysis. Normally images captured from live faces may visually look similar to fake images captured from printed photos. Furthermore, these images are overlapping in the original input space. Thus, there's a need to find a suitable feature space to separate the two classes (fake vs. real). Moreover, we need to find a method to learn the difference between the two classes in the feature space. Real face and printed-face reflect light in different ways and this is because of the fact that our human face is a complex no-rigid 3D object whereas printed-face is a 2D object. This may cause different specular shades and reflections. In addition, printed-face has a less quality with compare to real face and also there's a blur in the printed-face. Based on the above observations, graph texture analysis can be used to separate the two classes. We drive a facial representation to capture the characteristics of real and fake faces. Our algorithm adopts the local graph structure [10], a good operator for describing graph texture feature and the spatial information. Moreover, LGS is based on a dominating graph with six pixels.

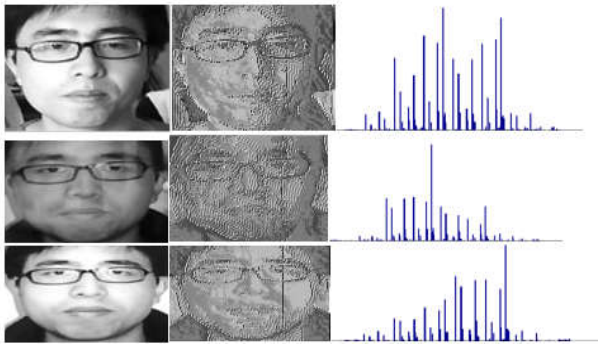


Figure. 3: Example of generated images using LGS for (live Face and printed-face)

The first row shows a picture for a real user and its corresponding LGS and histogram. The second and third rows shows fake pictures for the same user. From the above Figure.3, we can observe that the original photos look similar whereas LGS images have some differences. Therefore, the differences between the images are the key point for separating the two classes. LGS is obtained based on the below formula.

$$\text{LGS}\,(a_c) = \sum_{k=0}^{7} 2^k\, g(a_{k-}a_{c)} \qquad (1)$$

Where k runs over the seven vertices of the dominant graph for the target pixel a_c and $a_{k,}a_c$ are the gray-level values at c and k. In addition, $g\ (A)$ is 1 if $A>=0$ and 0 otherwise. LGS utilizes six pixels to form the neighbours of target pixel *I(x,y)* . Then we start finding the pattern by moving anti-clockwise for the target pixel *I(x,y)* for the left region of the graph. If a neighbour pixel has a high or equal gray value than the target *I(x,y)* then assign a binary value equal to 1 on the edge connecting the two vertices, else 0. Next task is to process right region of the dominant graph, the process here is the same as the left region. The only difference is we have to move first horizontal and then continue in clockwise. The motivation of using this operator is because, LGS takes into consideration the relationship between the pixels that form the local graph structure and not the target pixel with its neighbours as in LBP. Please see Figure 4.

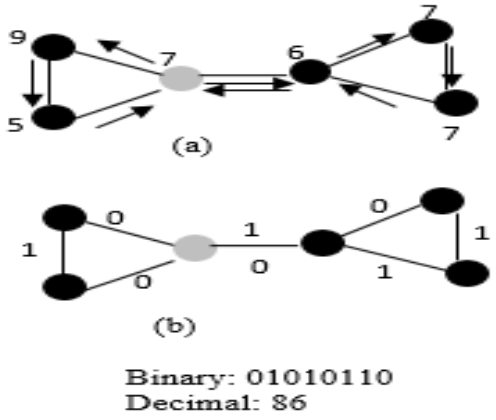


FIGURE. 4. Local Graph Structure (a. Direction, b. binary).

The first step in the proposed approach is to convert the input image into gray-scale and followed by cropping and resizing the data to 64x64 pixel image. Then we apply local graph

structure LGS operator on the facial image. The 256-bin histogram is computed and then we use our classification method for determining whether the input facial fata corresponds to a real face or not refer to figure 4 for more information.

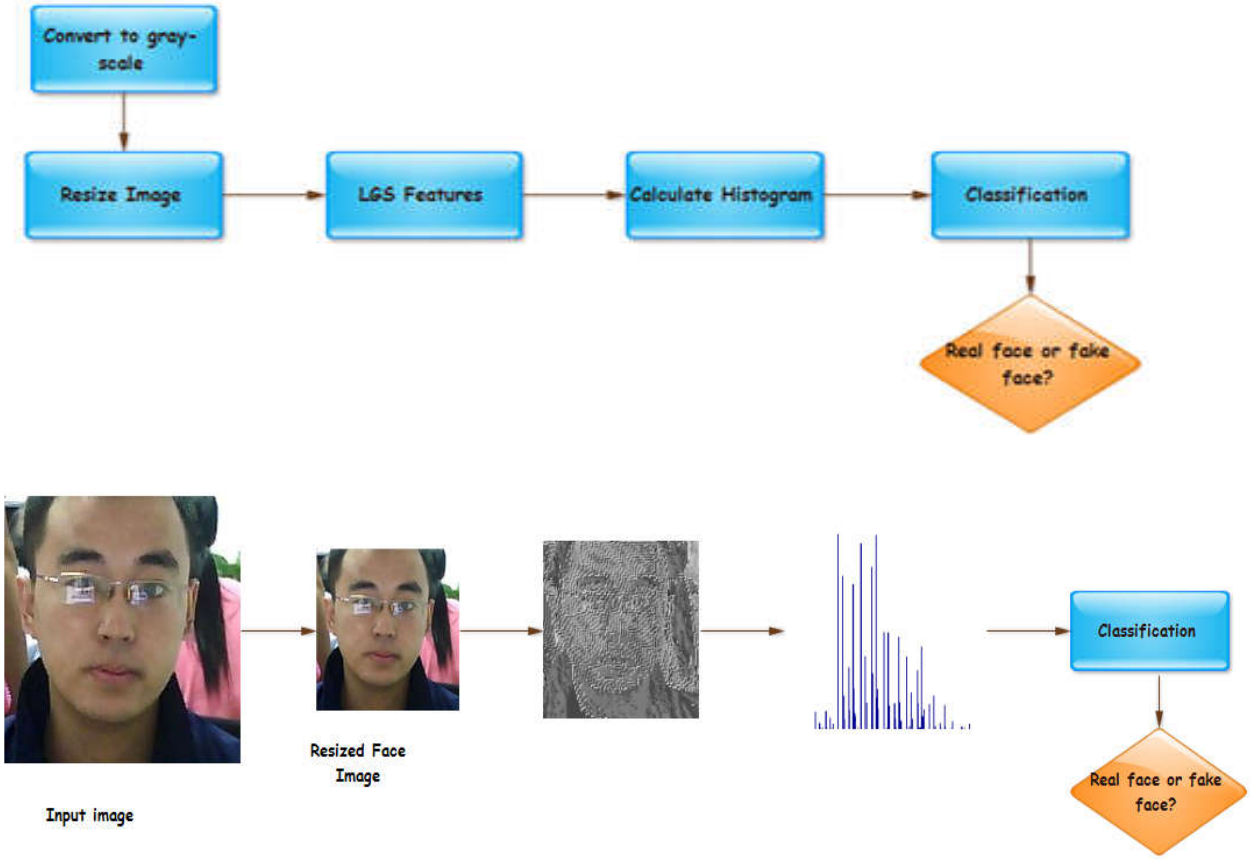


FIGURE. 5. Proposed approach.

As illustrated in the above Figure.5, LGS captures the spatial information from the input image and the classification is performed by computing histogram similarities. Furthermore, our investigations have shown that, the needed gradient structure and texture details for discriminating and separating the two classes (real vs. fake) can be detected based on the proposed graph structure.

4.1. Classification: Support Vector Machine (SVM). Support vector machine (SVM) are one of the classifiers which used for pattern recognition. The basic functionality is by making a decision for a particular testing image and the output of the classifier is based on finding the closet distance point to the training set. In addition, the training set is also prepared by support vector machine. Finally the goal of (SVM) is to separate the two classes which in our case (real vb. Fake) such that the distance to the support vectors is maximized.

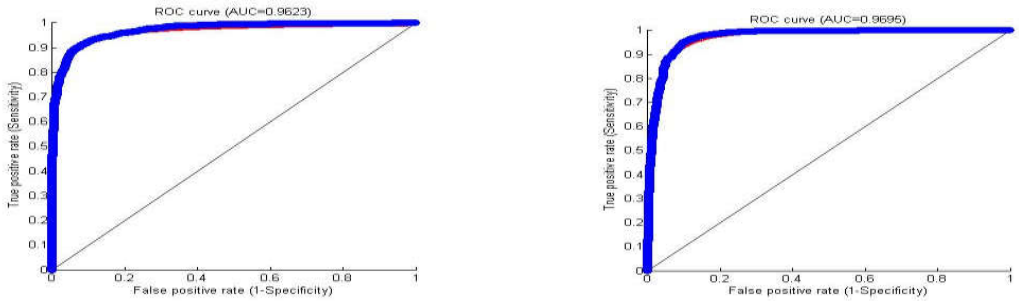
In our experiments, once the histograms are computed we utilized support vector matching with a linear kernel for classifying whether the input facial data corresponds to a live face or not. Moreover, we have trained the classifier using a set of positive (real faces) and negative (imposter faces) samples.

5.Experimental Design. The experiments start first by evaluating the performance of two powerful texture operators, namely Local Phase Quantization LPQ [17] and Local Binary

Pattern [16]. We have applied both LBP and LPQ into the input facial data. The computed features are then fed into support vector machine for classifications. This process is repeated for all the groups (A, B, C, D, E, and F). The below table shows the classification performance for both LPQ and LBP as well as the accuracy obtained based on the ROC. In addition, the performance of the operators in terms of Receiver Operating Characteristics ROC curves are shown in Figure 6. Due to limited space in the paper, we only show the best obtained ROC curve for each method instead of showing for each experiment.

TABLE 1. Performance of the two operators based on SVM classification result

Group	AUC-LBP	Error Rate (LBP)	AUC-LPQ	Error Rate (LPQ)
Group A	0.96	8.46 %	0.96	7.19 %
Group B	0.95	11.34 %	0.95	9.81 %
Group C	0.93	14.33 %	0.94	13.05 %
Group D	0.91	16.22 %	0.96	8.58 %
Group E	0.91	16.66 %	0.96	9.49 %
Group F	0.89	18.23 %	0.96	9.08



A) LBP B) LPQ

FIGURE. 6. Best obtained ROC for LBP and LPQ

As shown from the presented results, Local binary pattern and Local phase quantization perform quite well and the accuracy obtained for LPQ is better than LBP and LPQ has a less error rate with compare to LBP. In addition, LPQ performs well because some images look blur especially the printed-photo whereas LPQ is blur tolerant [17].

On the other hand, we still need an operator that can detect the fine details in order discriminate between a fake face and a real face. Moreover, one fact is that, the difference between real and fake face is that the 2D printed photo can contain specular reflections whereas in 3D object is different. Our LGS assigns weight for target pixels by considering not only the relationship of one pixel to its neighbours but also the relationship between the pixels that form the local graph of the target pixel; this feature enable us detecting the fine details and specular reflections.

Table 3, shows the performance of our proposed approach for all the groups. The results obtained show the superiority of our approach (0.99 vs. 0.96) of both LBP and LPQ. We

almost achieve a good spoofing detection yielding accuracy of 99 %. The errors in the proposed research are because the samples used for testing are over exposed and very blurry.

TABLE 2. Performance of the proposed approach based on SVM classification result

Group	AUC-LGS	Error Rate (LGS)
Group A	0.98	4.82 %
Group B	0.97	6.12 %
Group C	0.97	6.42 %
Group D	0.99	3.59 %
Group E	0.99	3.45 %
Group F	0.99	3.40 %

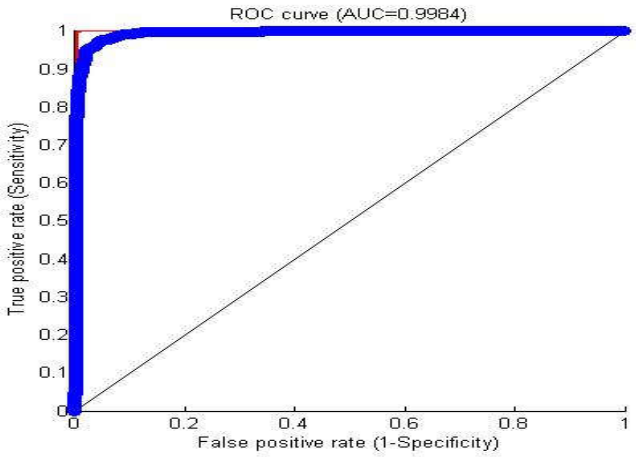


Figure. 7: Best obtained ROC for LGS

6.Discussion and Conclusion. State of the art bio-graphical system that grounded on biometrics algorithms are vulnerable to spoofing attack and especially face recognition algorithms since it's a very easy to be spoofed. This paper addressed the problem of face spoofing from image quality, reflections in light and artifact point of view. The proposed approach to tackle the problem performs well and the reason behind this is because LGS take into consideration the pixels that form the local graph in order to capture the spatial information. In addition, the problems need to be considered for next research are detecting printed-photos in very blurry image and in over exposed pictures.

REFERENCES

[1] P. J. Phillips , P. Grother , R. Michaels , D. Blackburn , E. Tabassi and M. Bone, *Facial Recognition Vendor Test 2002: Evaluation report*, 2003.

[2] R. Gross, S. Baker, I. Matthews and T. Kanade, Face Recognition Across Pose and Illumination, Chapter 9, Handbook of Face Recognition, Stan Z. Li and Anil K. Jain (Eds.), *Springer-Verlag*, 2004.

[3] C. Ivana, A. Anjos and S. Marcel, On the effectiveness of local binary patterns in face anti-spoofing, Biometrics Special Interest Group (BIOSIG), *2012 BIOSIG-Proceedings of the International Conference of IEEE*, 2012.
[4] G. Pan, Z. Wu and L. Sun, Liveness detection for face recognition, *Recent advances in face recognition*, 236-252, 2008.
[5] K. A. Nixon, V. Aimale and R. K. Rowe, Spoof detection schemes, *In Handbook of biometrics*, pp. 403-423, Springer US, 2008.
[6] K. Kollreider, H. Fronthaler and J. Bigun, Non-intrusive liveness detection by face images, *Image and Vision Computing,* 27(3), 233-244, 2009.
[7] W. Bao, H. Li, N. Li and W. Jiang, A liveness detection method for face recognition based on optical flow field, *International Conference on Image Analysis and Signal Processing*, pp. 233-236, IEEE, 2009.
[8] J. Li, Y. Wang, T. Tan and A. K. Jain, Live face detection based on the analysis of fourier spectra, In Defense and Security, pp. 296-303, *International Society for Optics and Photonics*, 2004.
[9] X. Tan, Y. Li, J. Liu, L. Jiang, Face Liveness Detection from a Single Image with Sparse Low Rank Bilinear Discriminative Model, *ECCV (6)*, pp. 504-517, 2010.
[10] E. E. Abusham and H. K. Bashir, Face recognition using local graph structure (LGS), In Human-Computer Interaction, Interaction Techniques and Environments, pp. 169-175, *Springer Berlin Heidelberg*, 2011.
[11] E. E. Abusham, H. K. Bashier, F. Khalid, S. Sayeed, J. Hossen and S. M. A. Kalaiarasi, Illumination Normalization using Eimad-housam Technique, *Trends in Applied Sciences Research*, 7(8), 2012.
[12] H. K. Bashier, E. A. Abusham and F. Khalid, Face Detection Based on Graph Structure and Neural Networks, *Trends in Applied Sciences Research*, 7(8), 2012.
[13] E. E. Abusham and H. K. Bashier, Face recognition using local graph theory (LGT), *2013 International Conference on Computing, Electrical and Electronics Engineering (ICCEEE)*, pp. 593-596, IEEE, 2013.
[14] H. K. Bashier, E. E. Abusham, M. F. A. Abdullah, T.H. Liew, I. Yusof and S. H. Lau, Real Time Face tracker based on Local Graph Structure Threshold (LGS-TH), *Australian Journal Of Basic & Applied Sciences*, 7(2), 632-638, 2013.
[15] S. Sayeed, I. Yusof, H.K. Bashier, E., J. Hossen and M. F. A. Abdullah, Plant Identification Based on Leaf Shape and Texture Pattern Using Local Graph Structure (LGS), *Australian Journal Of Basic & Applied Sciences*, 7(11), 2013.
[16] T. Ojala, M. Pietikäinen, and T. Mäenpää, Multiresolution Gray-scale and Rotation Invariant Texture Classification with Local Binary Patterns, *IEEE Trans. Pattern Analysis and Machine Intelligence*, 24(7), pp. 971-987, 2002.
[17] V. Ojansivu and J. Heikkilä, Blur insensitive texture classification using local phase quantization, Image and Signal Processing, pp. 236-243, *Springer Berlin Heidelberg*, 2008.
[18] H. K. Bashier, S. H. Lau., & Y. H. Pang, Graphical password: Pass-images Edge detection, *2013 IEEE 9th International Colloquium* on Signal Processing and its Applications (CSPA), pp. 111-116, IEEE, 2013.

Factor Affecting Cross-Border Knowledge Transfer

Law Yi Sheng[1] and Yuen Yee Yen[2],
[1,2] Faculty of Business, Multimedia University,
Jalan Ayer Keroh Lama,
75450 Melaka,Malaysia.
[1]agen613@gmail.com, yyyuen@mmu.edu.my

Received August 2015; accepted October 2015

ABSTRACT. *Cross-border knowledge transfer plays a significant role in multinational companies' competitiveness. Limited research has been done on key factors affecting knowledge transfer in multinational companies Malaysia and currently, there is still a lack of research framework to examine the success of cross-border knowledge transfer. This study proposes a research framework with 4 independent variables (knowledge characteristics, recipient characteristics, relationship quality and reward system) and a dependent variable (cross-border knowledge transfer). Prior to the development of the proposed research framework, intensive literature review was conducted to identify a list of possible key factors affecting cross-border knowledge transfer in multinational companies. After that, questionnaires were distributed to senior managers in 13 selected multinational companies and the senior managers were required to rank the most important factors affecting cross-border knowledge transfer from a list of relevant factors identified from literature reviews. This research will be able to enhance the current understanding of cross-border knowledge transfer in multinational companies by proposing a research framework, which would serve as a strong foundation for other researchers to conduct future research in similar research areas. This study also contributes to international business literature through determining the key success factors of cross-border knowledge transfer.*

Keywords: Knowledge transfer, Multinational companies, Framework

1. **Introduction.** Malaysia is one of the desired countries for many multinational companies with more than five thousand foreign companies from more than forty countries are currently operating in Malaysia (Why Malaysia, 2015). According to the World Investment Report (2014), Malaysia is the fifth largest foreign direct investment countries in East and Southeast Asia and one of the fifteen most preferred countries by multinational companies. As Malaysian government plans to transform the country into a knowledge-based high income economy by the year 2020, multinational companies in Malaysia are now eagerly looking into critical success factors of cross-border knowledge transfer among workers in to improve their overall organizational performance in the era of globalization (Ling and Nathan, 2009). Knowledge Transfer Partnership (KTP) programme has been launched by Malaysian government to promote efficient and effective transfer of tangible and intangible knowledge, expertise and skills across community and industry in 2011, but the initiative is unlikely to be successful without active involvement of knowledge workers from multinational companies (KTP Programme, 2011). The current competitive nature of global market compels multinational companies to be more

productive and innovative in attracting and retaining talents and knowledge locally or from other nations (Aguzzoli and Geary, 2014). The key success of multinational companies relies on the ability of their employees in sharing and applying knowledge resides in their mind to help the organizations attain their goals (Tallman, 2014).

2. **Problem Statement and Preliminaries.** Cross-border knowledge transfer is receiving more attention by multinational companies in the last 5 years, as the knowledge transfer across geographic boundaries will directly influence the global competitiveness of the company (Peltokorpi, and Vaara, 2014). Previous researches have focused primarily only on individual aspect that affect the success of cross-border knowledge transfer in multinational companies, such as knowledge characteristics (Shen, Li and Yang, 2015; Williams et al., 2014; Teo, and Bhattacherjee, 2014), culture characteristics (Barak, 2013; Vaara, Sarala, Stahl, and Björkman, 2012; Huang, Rode and Schroeder, 2011); technology characteristics (Aman and Aitken, 2014; Goh and Sandhu, 2013; Piccoli and Lu, 2014); and trust (Hatak, and Roessl, 2015; Ko, 2014; Rotsios, Sklavounos and Hajidimitriou, 2014). However, there is currently lack of a comprehensive and holistic framework that integrates and validates all key factors affecting cross-border knowledge transfer in multinational companies. Current understanding of key factors that lead to successful cross-border knowledge transfer in multinational companies is also still fragmented as there is very limited previous research on cross-border knowledge transfer in multinational companies Malaysia. Previous researches were conducted in other country such as China (Miesing, Kriger, and Slough, 2007; Wang, Tong, and Koh, 2004) and Hungary (Dobrai, Farkas, Karoliny, and Poór, 2012) with no up-to-date study on multinational companies in Malaysia. In order to address the above research gaps, this study is one of the pioneer studies in Malaysia, which develops a research framework to examine factors affecting knowledge transfer in multinational companies. This research will be able to enrich the current knowledge on key factors affecting the cross-border knowledge transfer. This research will propose a framework, which will serve as a foundation for other researchers to conduct future research in similar research areas. The research instrument of this study will also help the future researchers to identify other moderating and mediating factors that may influence the effectiveness and efficiency of knowledge transfer. This study also contributes to international business literature through determining the key success factors of knowledge transfer across borders.

A multinational organization should be able to reach better performance to survive in the market if they have an effective and efficient transfer of knowledge across borders. Practically, this research is important for multinational company as it gives industry practitioners a better and clearer understanding of the main factors that would affect the success of knowledge transfer. This will assist the company management to transform the knowledge residing in the mind of the employee into organizational knowledge that would not easily deplete during employee turnover. This research will not only can bring the benefits to the organization, but it will also benefits the employees and contribute to the economy of the country. Employees will have a better insight on how to receive and

contribute knowledge to the organization in a more effective and efficient way. This will allow them to improve their transfer of knowledge and willingness to share knowledge with their counterparts across borders.

3. Literature Review.

3.1. Cross-Border Knowledge Transfer. Cross-border knowledge transfer can be defined as the relocation of knowledge in new subjects which comprises activities of knowledge transmission and absorption across companies in different nations (Shen, Li,and Yang, 2015), an occurrence of organization obtaining new experiences that involves few phases that begins from finding the knowledge in the knowledge transfer process till the application of that knowledge (Lee and Wu, 2010), or the perception of recipient on the knowledge transmitted from the source as inclusive, valuable and satisfactory (Al-Salti and Hackney, 2011). Knowledge transfer is also known as a process where a group, a product line, a department, or a division changed due to the experience of another unit (Argote and Ingram, 2000). Knowledge transfer is often initiated with the aim to transfer knowledge from a source to a recipient successfully (Cummingsa and Teng, 2003).

Success of knowledge transfer in the organization can be measured by the ability of the organization to achieve an organizational desired or intended goal in a process where knowledge is transmitted by one department and is absorbed and applied by a second one effectively and efficiently (Argote and Ingram, 2000 Laframboise, Croteau, Beaudry, and Manovas, 2007). Knowledge transfer is considered to be efficient if it involves only a minimal number of problems by using minimal resources and able to complete on time, while it is said to be effective when the knowledge is properly transmitted, used by, and has value attached to the knowledge intended recipient unit (Laframboise, Croteau, Beaudry, and Manovas, 2007). Past literature (Dobrai et al., 2012; Hatak, and Roessl, 2015; Ko, 2014) indicated that organizational knowledge transfer has a positive relationship with organizational performance and innovativeness. Besides that, research that focused on relations of knowledge transfer and innovativeness shown organizational knowledge transfer increase the ability of an organization to produce new goods and services with new ideas (Ling and Nathan, 2009). In addition, gathered knowledge will also allow the organization to have a better understanding of evaluating the value of certain technological advances that would really help in strategic decision making. Thus, organizational knowledge transfer increases innovativeness (Wijk, Jansen, and Lyles, 2008).

3.2 Knowledge Characteristics. Knowledge characteristics is the first factor that affects cross-border knowledge transfer. Knowledge exists in two main form which are tacit knowledge and explicit knowledge (Nonaka, 1994). Due to the fact that individuals or organizations possess much more knowledge in non-written form than in written form, work to define and explain tacit knowledge is more complex and difficult as compared to explicit knowledge. The value of tacit knowledge is much higher than the explicit as it cannot be documented or recorded in any physical forms (Shen, Li and Yang, 2015; Williams et al., 2014; Teo, and Bhattacherjee, 2014). Explicit knowledge refers to the properly recognised, systemic and clear knowledge that can be written documents and

records and often embedded in organizational procedures (Hajidimitriou, Sklavounos, and Rotsios, 2012). Hence, transfer and dissemination of explicit knowledge are much easier and able to measure it based on quantitative measurements (Hajidimitriou, Sklavounos, and Rotsios, 2012). The perceived value of the knowledge motivates members to use them more regularly and knowledge ambiguity hinders knowledge acquisition more than knowledge exchange (Watson and Hewett, 2006). Knowledge ambiguity means the inherent and complicated vagueness as to accurately what the core knowledge components and sources are and also their interaction. It will minimize knowledge to be imitated by competitors and but also impedes the knowledge transfer within and between organizations (Coff, Coff, and Eastvold, 2006). Therefore, the knowledge characteristics are expected to have an impact on the cross-border knowledge transfer. Hypothesis 1: There is a relationship between knowledge characteristics and cross-border knowledge transfer is thus developed.

3.3 Recipient Characteristics. Second key determinant of cross-border knowledge transfer is recipient characteristics. There are many different ways that a multinational company can use to cultivate the desired skills, abilities, capabilities, and required aptitudes of expatriates to transfer knowledge (Juceviciene and Mozuriuniene, 2014). One of the examples will be sending expatriates abroad for a long period of time to build up the expatriates' enthusiasm to transfer knowledge (Juceviciene and Mozuriuniene, 2014; Kilar, 2014). In the other hands, giving short-term projects or projects that require unique solution will enhance their knowledge transfer skills. A person' ability and motive on transferring knowledge will also affect the knowledge transfer process (Dobrai, Farkas, Karoliny, and Poór, 2012). The individual interest also would affect the knowledge transfer. When a person is interested in certain knowledge, they tend to show their aspiration of getting that knowledge (Hanna, and Mohamad Saleh Hammoud, 2014). Lack of motivation may result in lower aspiration, refuse and reject the new knowledge implementation and application (Minbaeva et al., 2014). Recipient with low motivation, absorptive capacity, and retentive capacity can lead to poor knowledge transfer (Minbaeva et al., 2014). Organization need to make sure that both knowledge owner and the recipient have the necessary knowledge base to acquire and disseminate knowledge (Goh, 2002). For cross-border knowledge transfer to be successful, it is important to let organization members understand the value of a particular knowledge to the target unit before they engage in knowledge transfer activity as knowledge recipients (Javidan, Stahl, Brodbeck, and Wilderom, 2005). Therefore, Hypothesis 2: There is a relationship between recipient characteristics and cross-border knowledge transfer.

3.4 Relationship Quality. Next determinant of cross-border knowledge transfer is relationship quality. The transfer of knowledge between two parties establishes a provider-recipient relationship (Wijk, Jansen, and Lyles, 2008). As cross-border knowledge transfer involves a higher number of individuals, there is a higher chance of cross-cultural misinterpretation that will hampers the success of knowledge transfer (Javidan, Stahl, Brodbeck, and Wilderom, 2005). Researchers (Aguzzoli, and Geary, 2014; Goh and

Sandhu, 2013) have identified that when a knowledge recipient agrees with a knowledge provider, the knowledge provider will like the knowledge recipient more, experience greater positive feeling, and more willing to share knowledge with them. This attraction is particularly salient when both knowledge provider and knowledge recipient share common attribute which is important to their daily business interactions (Goh and Sandhu, 2013). Research has also shown that more knowledge transfer can be conducted between the knowledge provider and recipient who demonstrate similar attitudes and between firms that have come across similar problems before (Darr and Kurtzberg, 2000). The willingness of organization member to share their valuable knowledge to the knowledge repositories is crucial in determining the success of the knowledge transfer process rather than the extent to which the system is accessed and used (Watson and Hewett, 2006). Cummingsa and Teng (2003) and Wijk, Jansen, and Lyles (2008) stated that the success of knowledge transfer depends on level of the social bonds between knowledge provider and recipient, which can be evaluated through the ease of communication, the personalities and abilities, and on the closeness of both the sender and recipient relationship. In short, the closer the relationship between people, the easier the transfer of knowledge. Hypothesis 3: There is a relationship between relationship quality and cross-border knowledge transfer is therefore developed.

3.5 Reward System. Individuals tend to perform better and engage more readily in organizational citizenship behaviour if they feel that their contributions have been recognized and valued by their organizations (Watson and Hewett, 2006). The existence of a reward system that appreciate the knowledge sharing activity will increase the knowledge transfer in a multinational organization (Al-Alawi, Al-Marzooqi, and Mohammed, 2007; Laframboise, Croteau, Beaudry, and Manovas, 2007) and can promote and sustain a long-term knowledge transfer culture in the multinational organization (Rahman and Hussain, 2014). Hypothesis 4: There is a relationship between reward system and cross-border knowledge transfer is therefore developed.

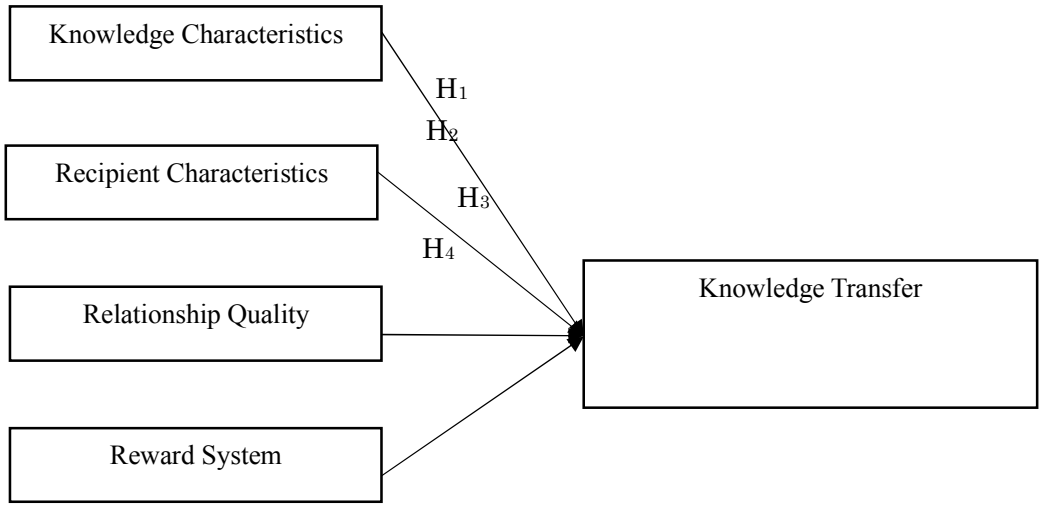


FIGURE 1. Proposed research framework

4. Development of Proposed Research Framework. The research framework in Figure 1 is developed based on intensive reviews on previous literature and also the results of a quantitative survey questionnaires administrated to senior managers in 13 randomly selected multinational companies Malaysia. The results of the review of past studies and survey questionnaires indicated that knowledge characteristics, recipient characteristics, relationship quality and reward system are four most important factors affecting knowledge transfer, from the perspective of senior managers in multinational companies Malaysia. Therefore, the four constructs are included as the independent variable and knowledge transfer as the dependent variable in the proposed research framework of this study.

4.1 Review of Past Studies. This study adopts keyword searching as a research methodology to select the relevant cross-border knowledge transfer literature worldwide (Wijk et al., 2008). Boolean keywords AND and OR are used to create search strings in online databases such as Science Direct, Pro Quest and Web of Science to collect the relevant cross-border knowledge transfer literature. The search strings in online databases are (cross-border knowledge transfer and multinational companies) or (transfer success and multinational companies) or (knowledge and management and multinational companies) were used to identify a list of possible key factors affecting cross-border knowledge transfer in multinational companies.

4.2 Survey Questionnaire. After intensive literature reviews, quantitative survey questionnaire approach was used to examine important factors affecting knowledge transfer in multinational companies. Target companies of this study were identified using the 2015 Malaysian Investment Development Authority (MIDA) directory. The MIDA directory contains information about multinational companies in various industries (computer hardware, environmental, manufacturing equipment and software). Multinational companies were required to fulfil two criteria, a) have a minimum of 100 employees and b) have at least 10 per cent in international sales in 2015 before they could be selected as the target companies of this study. A total of 13 multinational companies in Malaysia met the criteria. For each of the13 multinational companies, a questionnaire was distributed to the senior manager of the company. The senior manager was required to rank the most important factors affecting cross-border knowledge transfer from a list of relevant factors identified from literature reviews such as knowledge characteristics, recipient characteristics, relationship quality, network characteristics, source characteristics, and reward system. Questionnaire was adopted in this study as it helps the researchers to build rapport with respondents, clarify respondent's doubts directly on the spot and provide a higher level of anonymity of respondents so that the researchers are able to collect the data immediately once respondents had finished answering the questionnaire(Sekaran, 2003).

Questionnaire would also ensure a higher response rate from the respondents as compared with other data collection methods (Sekaran, 2003).

5. Conclusions. The results of the review of past studies and survey questionnaires indicated that knowledge characteristics, recipient characteristics, relationship quality and reward system are four most important factors affecting knowledge transfer, from the perspective of senior managers in multinational companies Malaysia. Therefore, the four constructs are included as the independent variable and knowledge transfer as the dependent variable in the proposed research framework of this study.

6. Future Research. This paper develops a research framework to examine knowledge transfer in multinational companies Malaysia. In the coming future, 300 questionnaires will be distributed to randomly selected employees of 13 targeted multinational companies in Malaysia to examine and verify the hypotheses, developed in Section 2 of this paper, from the perspectives of the employees. Results will be published in the forthcoming papers of the authors.

REFERENCES

[1] A. I. Al-Alawi, N. Y. Al-Marzooqi, , and Y. F. Mohammed, Organizational culture and knowledge sharing: Critical success factors, *J. of Knowledge Management,* vol.11, no.2, pp.22-42, 2007.

[2] C. Y. Lee, and F. C. Wu, Factors Affecting Knowledge Transfer and Absorptive Capacity in Multinational Corporations. *The J. of International Management Studies,* vol.5, no.2, pp.118-126, 2010.

[3] D. G. Ko, The mediating role of knowledge transfer and the effects of client-consultant mutual trust on the performance of enterprise implementation projects, *Information and Management*, vol.51, no.5, pp.541-550, 2014.

[4] D. Minbaeva, T. Pedersen, I. Björkman, C. F. Fey and H. J. Park, MNC knowledge transfer, subsidiary absorptive capacity and HRM, *J. of International Business Studies*, vol.45, no.1, pp.38-51, 2014.

[5] E. Vaara, R. Sarala, G. K. Stahl and I. Björkman, The impact of organizational and national cultural differences on social conflict and knowledge transfer in international acquisitions, *J. of Management Studies*, vol.49, no.1, pp.1-27, 2012.

[6] F. Aman and A. Aitken, The indirect impacts of management support and commitment on knowledge management systems (KMS) adoption: Evidence from Malaysian Technology Industries, *African J. of Business Management*, vol.5, no.27, pp.11131-11145, 2011.

[7] F. Hanna and G. Mohamad Saleh Hammoud, the Impact of National Cultural Distance on Foreign Direct Investment in Iraq, *Global J. of Management and Business Research*, vol.14, no.4, pp.170-190, 2014.

[8] G. Piccoli and T. W. Lui, The competitive impact of information technology: can commodity IT contribute to competitive performance and quest, *European J. of Information Systems*, vol.23, no.6, pp. 616-628, 2014.

[9] H. Shen, Z. Li, and X. Yang, Processes, characteristics, and effectiveness: An integrative framework for successful knowledge transfer within organizations, *J. of Organizational Change Management*, vol.28, no.3, pp.486-503, 2015.

[10] I. R. Hatak and D. Roessl, Relational Competence-Based Knowledge Transfer within Intrafamily Succession an Experimental Study, *Family Business Review*, vol.28, no.1, pp.10-25, 2015.

[11] J. L. Cummingsa and B. S. Teng, Transferring R&D knowledge: the key factors affecting knowledge transfer success, *J. of Engineering and Technology Management*, vol.20, no.1, pp.39-68, 2003.

[12] K. Dobrai, F. Farkas, Z. Karoliny and J. Poór, Knowledge Transfer in Multinational Companies – Evidence from Hungary, *Acta Polytechnica Hungarica,* vol.9, no.3, pp.149-161, 2012.
[13] K. Laframboise and A. M. Croteau, A. Beaudry, and M. Manovas, Interdepartmental Knowledge Transfer Success During Information Technology Projects. *International J. of Knowledge Management,* vol. 3, no.2, pp.47-67, 2007.
[14] K. P Rotsios, N. S. Sklavounos and Y. A. Hajidimitriou, Trust, knowledge transfer and control in IJVs: The case of four Greek firms, *Proc. Economics and Finance*, vol.9, no.1, pp.231-241, 2014.
[15] Knowledge Transfer Partnership (KTP) Programme, *KTP Policy*. Malaysia.2011.
[16] L. Argote and P. Ingram, Knowledge transfer: a basis for competitive advantage in firms, *Organizational Behavior and Human Decision Processes,* vol.82, no.1, pp.150-169, 2000.
[17] M. E. M. Barak, *Managing Diversity: Toward a Globally Inclusive Workplace,* Sage Publications, 2013.
[18] M. Javidan, G. K. Stahl, F. Brodbeck and C. P. Wilderom, Cross-border transfer of knowledge: Cultural lessons from Project GLOBE, *Academy of Management Executive,* vol.19, no.2, pp.59-76, 2005.
[19] M. S. Rahman and B. Hussain, The impact of trust, motivation and rewards on knowledge sharing attitudes among the secondary and higher secondary level students, *Library Review,* vol.63, no.8, pp.637-652, 2014.
[20] P. Juceviciene and V. Mozuriuniene, The organisation's learning in the multinational company: what kind of knowledge sources does influence it, *European Conference on Knowledge Management,* vol.2, pp.499, Academic Conferences International Limited, 2014.
[21] P. Miesing, M. P. Kriger and N. Slough, Towards a model of effective knowledge transfer within transnationals: the case of Chinese foreign invested enterprises, *J. of Technology Transfer,* vol.32, no.1, pp.109-122, 2007.
[22] P. Wang, T. W. Tong and C. P. Koh, An integrated model of knowledge transfer from MNC parent to China subsidiary, *J. of World Business,* vol.39, no.2, pp.168-182, 2004.
[23] R. Aguzzoli and J. Geary, An 'emerging challenge': The employment practices of a Brazilian multinational company in Canada, *Human Relations*, vol.67, no.5, pp.587-609, 2014.
[24] R. Filieri, R. C. McNally, M. O'Dwyer and L. O'Malley, Structural social capital evolution and knowledge transfer: Evidence from an Irish pharmaceutical network, *Industrial Marketing Management*, vol.43, no.3, pp.429-440, 2014.
[25] R. M. Williams, T. C. V. McLeod, J. K. Register-Mihalik, J. P. Mihalik, S. W. Marshall, L. A. Linnan and K. M. Guskiewicz, A preliminary study of helmet fit characteristics and knowledge, *Athletic Training and Sports Health Care*, vol.6, no.5, pp.206, 2014.
[26] R. V. Wijk, J. J. Jansen, and M. A. Lyles, Inter and intra-organizational knowledge transfer: a meta-analytic review and assessment of its antecedents and consequences, *J. of Management Studies*, vol. 45, no.4, pp.830-853, 2008.
[27] S. C. Goh, Managing effective knowledge transfer: an integrative framework and some practice implications, *J. of knowledge management,* vol.6, no.1, pp.23-30, 2002.
[28] S. K Goh and M. S. Sandhu, Affiliation, reciprocal relationships and peer pressure in knowledge sharing in public Universities in Malaysia, *Asian Social Science*, vol. 9, no.7, pp.290, 2003.
[29] S. Tallman, business models and the multinational firm, multidisciplinary insights from New AIB Fellows, *Research in Global Strategic Management, v*ol.16, Emerald Group Publishing Limited, pp.115-138, 2014.
[30] S. Watson and K. Hewett, A multi-theoretical model of knowledge transfer in organizations: Determinants of knowledge contribution and knowledge reuse, *J. of Management Studies*, vol.43, no.2, pp.141-173, 2006.
[31] T. N. Ling and R. J. Nathan, Knowledge managmenet implementation in multinational companies- an empirical study in Malaysian MNCs, *International Conference on Technology Innovation and Industrial Management*, pp.69-80, Bangkok, Thailand, 2009.
[32] T. S. Teo and A. Bhattacherjee, Knowledge transfer and utilization in IT outsourcing partnerships: A preliminary model of antecedents and outcomes, *Information and Management*, vol.51, no.2, pp.177-186, 2014.
[33] U. Sekaran, *Research Methods for Business – A Skill Building Approach,* 4th ed., United States, John Wiley and Sons, 2003.

[34] V. Peltokorpi and E. Vaara, Knowledge transfer in multinational corporations: Productive and counterproductive effects of language-sensitive recruitment, *J. of International Business Studies*, vol. 45, no.5, pp.600-622, 2014.
[35] W. Kilar, Differentiation of Visegrad group international corporations in comparison to world's largest corporations, *International Competitiveness in Visegrad Countries: Macro and Micro Perspectives*, 171-186, 2014.
[36] Why Malaysia, *Multimedia Development Corporation*, Retrieved 19 August, 2015, from Official Portal of MSC Malaysia: http://www.mscmalaysia.my/why_malaysia, 2015.
[37] World Investment Report, *Export Entreprises SA*. Retrieved 19 August, 2015, from Santander Trade Portal: https://en.santandertrade.com/establish-overseas/malaysia/foreign-investment, 2014.
[38] X. Huang, J. C. Rode and R. G. Schroeder, Organizational structure and continuous improvement and learning: Moderating effects of cultural endorsement of participative leadership, *J. of International Business Studies*, vol.42, no.9, pp.1103-1120, 2011.
[39] Z. Al-Salti and R. Hackney, Factors impacting knowledge transfer success in information systems outsourcing, *J. of Enterprise Information Management,* vol.24, no.5, pp.455-468, 2011.

Growth Empirics with a New Path Identification Approach

Bing Xu, Qiuqin He

Research Institute of Econometrics and Statistics,
Zhejiang Gongshang University 18 XueZheng Road, Xiasha University Town,
Hangzhou 310018, China
E-mail: bingxu@zjgsu.edu.cn, heqiuqin1989@126.com

ABSTRACT. *The paper re-examines the problem of the cross-country growth illustrated in Varian(2014)'s work. The highlight of this paper is outlining a new perspective on empirical growth research which will both address some of the major criticisms to which research has been subjected and facilitate policy-relevant empirics by proposing a path identification model.*

Keywords: Growth empirics, Path identification, Variable selection

1. Introduction. In 2014, Journal of Economic Perspectives published a paper with the title Big Data: New Tricks for Econometrics (Varian, 2014). The paper illustrates different methods of variable selection using data from Sala-i-Martín (1997). Varian (2014) shows ten predictors that were chosen by Sala-i-Martín (1997) using a CDF(0) measure defined in the 1997 paper; Ley and Steel (2009) using Bayesian model averaging, LASSO, and spike-and-slab regressions. And he finds that all four of these variable selection methods give similar results for the first four or five variables, after which they diverge. These methods were conducted in order to finally find an answer to the question: What are the main determinants of long-term growth? Or, put slightly differently: Why are some countries rich and others poor?

An explosion of empirical papers on cross-country growth and development in the 1990s was following the seminal contributions by Barro (1991) and Mankiw et al. (1992). The vast number of theories put forth that attempt to explain economic growth has led to an empirical conundrum known as 'theory-openendedness' (Brock and Durlauf, 2001). Theory-openendedness suggests that while numerous theories may indeed explain the growth of an economy's output, no particular theory rules out another theory as a definitive predictor of cross-country growth. This issue of openendness has not been directly dealt with in the literature. Rather, a number of researchers have proposed ways to deal with the robustness of variables in growth regression, and a vast number of explanatory variables appear in the empirical cross-country growth literature, for example, Durlauf, Johnson and Temple (2005) concludes that 145 different proxies have been found to be statistically significant in at least one study.

As a typical study, Barro (1991) firstly presents a new growth theory, then suggests a proxy variable for that theory and finally concludes a cross-country growth regression including this new theory as well as the proximate determinants. A more specific issue was raised by Levine and Renelt (1992). Levine and Renelt (1992) investigated the robustness of earlier findings to different model specifications by employing a variant of the extreme bounds analysis of Leamer (1983). Sala-i-Martin

(1997) criticizes the EBA test as being too strict and proposes to analyze the entire distribution of coefficients of interest, and constructed weighted averages of OLS coefficients and found that some were fairly stable across specifications.

These papers assume that every regression coefficient provides a certain level of confidence that should have in the relationship between the variables in the regression and economic growth. The methods have to find some way in which the confidence can be aggregated, which can only be done in a Bayesian framework. The approaches fall in roughly two categories (Ulasan, 2012): firstly, Bayesian Model Averaging (BMA; Ley and Steel, 1999&2009; Fernandez et al., 2001; Kraay and Tawara, 2010, Eicher et al., 2011, Moral-Benito,2012, Cuaresma, et al., 2014) and, secondly, Bayesian Averaging of Classical Estimates (BACE; Sala-i-Martin et al, 2004). Recently, a number of authors have argued for augmentations to the BMA in order to allow for non-linear models and heterogeneity of parameters for different countries (e.g. Cuaresma and Doppelhofer, 2007; Salimans, 2012; Magnus and Wang, 2014).

The least absolute shrinkage and selection operator (Lasso) is another popular selection procedure, introduced by Tibshirani (1996). One commonly performs model selection via the Lasso and re-estimates the final model using for example, OLS to obtain point estimates and standard errors. Friedman, Hastie and Tibshirani (2010) use cyclical coordinate descent calculated along a regularization path. The algorithm is designed for the more general case of generalized linear models with elastic-net penalties of which the Lasso is a special case. Schneider and Wagner (2012) use the adaptive Lasso estimator (see Zou, 2006, for a detailed discussion) for variable selection in their application to growth regressions. Deckers and Hanck (2014) also apply the Lasso procedures to the well-known data set of Fernandez et al. (2001) (FLS).

There are two main problems of the growth regression discussed above. A fundamental problem with the growth regression is that the vast majority of empirical growth studies assume that the parameters which describe growth are identical across countries. This seems to be a very implausible assumption. Does it really make sense to believe that the effect of a change in the level of a civil liberties index on growth in the United States is the same as that for Russia? While the use of panel data approaches to growth has addressed one aspect of this problem by allowing for fixed effects, it has not addressed this more general question. A second problem with conventional growth analyses is decision making problem. The policy-relevant econometrics needs to explicitly identify the objectives of the policymaker, and then calculate the expected consequences of a policy change. The vast number of explanatory variables appears in the empirical cross-country growth analyses, which confused the policymaker.

This paper has an ambitious objective - to outline a new perspective on empirical growth research which will both address some of the major criticisms to which research has been subjected and facilitate policy-relevant empirics. That is, we attempt to propose a varying-coefficient path identification approach to study the different performance of the growth of the different countries, and give explicitly integrate policy objectives. We re-examine the ten growth determinants presented in

Varian's work with the varying-coefficient path identification approach. We believe that uncertainty of variables does not stem from model selection, but from required research accuracy. Hence, this paper mainly constructs model to achieve the research objective, rather than the model average method, which provides a new perspective on empirical growth research based on big data idea.

The structure of the rest of paper is as follows. Section 2 describes a varying-coefficient path identification approach. Section 3 presents the data and variable. Section 4 presents empirical results. Section 5 provides conclusions.

2. Empirical analysis models. A typical representation of a statistical model of growth is the following regression. This is called a Barro regression, after Barro (1991):

$$Y = \beta_0 + \beta_i X + \beta_j Z + u \tag{1}$$

Where Y is the level of long-run growth, β_0 is a constant, X is a vector, or a list, of variables that are always included in the regression because their relationship with growth is considered to be well-established. These variables serve as covariates. β_i is a vector of parameters to be estimated that capture the effect of the variables in X. Z is a vector of variables whose effect on economic growth are of interest to the researcher, and β_j are the corresponding parameters to be estimated. This regression can take an almost endless amount of concrete forms. It is a crucial assumption of the most common regression model estimation method, the method of the ordinary least squares, that the regressors in a regression model are uncorrelated in order for the estimates to be unbiased (see econometrics text books, such as Verbeek, 2008, or Wooldrige, 2009). Consequently, it becomes more difficult to attribute which part of the variance in the target variable is explained by which explanatory variable. Hence, a path identification approach is proposed to explaining growth, which is very different from the EBA, BMA/BACE, and Lasso approaches discussed above.

2.1. Path identification approach. Durlauf and Johnson (1995), Liu and Stengos (1999), Paap et al. (2005) and Basturk et al. (2012) criticize that it unreasonably restricted attention to the set of linear models. The so-called path identification approach is a semi-parametric model considering the nonlinear character. Varian(2014) illustrates four different methods of variable selection, which investigated the determinants of the growth at general level. Our approach considers investigating the determinants of the growth at country level. It attempts to answer the questions, such as why growth rates vary across countries, and why some countries growing rapidly and some are not growing at all.

Suppose

$$Y_i = \alpha_1(i) X_1 + \cdots + \alpha_p(i) X_p + G\left(Z_{i0}, Z_{i1}, \cdots, Z_{iq}\right) + u_i, \qquad i = 1, 2, \cdots, n \tag{2}$$

Here Y is the level of long-run growth, $X_1,...,X_p$ is a list of variables that are linear variables, $\alpha_1,...,\alpha_p$ is a vector of parameters of the variables in X. Z is a vector of variables whose effect on economic growth are nonlinear, and $G(.)$ is an unknown function, and u_i is a random disturbance with zero expectation. i is the dependent variable represents the different country.

$\alpha_i(i)(i=1,...,72)$ are unknown functions. According to Taylor's theorem, they can be approximated by linear functions such that

$$\alpha_i(i) \approx \alpha_{0i} + \alpha_{1i}(i_i - i_0), \quad i = 1,...,72 \tag{3}$$

The model (2) is an infinite dimensional benchmark model. Path model and complete model are built by rewriting the infinite dimensional benchmark model, which are used to determine the driving factors of economic growth.

1) Path Model

$$Y_i = \alpha_1(i)X_1 + \cdots + \alpha_p(i)X_p + G(Z_{i0}, Z_{iQ}) + u_i, \qquad i = 1,2,\cdots,n \tag{4}$$

Here Z_{iQ} can be one variable or several variables.

2) Complete Model

$$Y_i = \alpha_1(i)X_1 + \cdots + \alpha_p(i)X_p + G(Z_{i0}, Z_{i1}, Z_{i2}, ..., Z_{in}) + u_i, \qquad i = 1,2,\cdots,n \tag{5}$$

Here all nonlinear variables are put into function $G(\bullet)$.

We identify the determinants of economic growth by comparing the difference of path models and complete model.

2.2. Variable selection. Before we build the path identification model, two non-parametric regression methods: local-constant least-squares (LCLS) and local-linear least-squares (LLLS), are applied to detect irrelevant regressors and linearity of regressors of cross-country growth (Hall, Li & Racine, 2007, Henderson, et al., 2012). The additional benefit of LCLS that we exploit here is its ability to detect irrelevant regressors when automated bandwidth selection is used. The additional benefit of LLLS that we exploit here is its ability to detect linearity of regressors when automated bandwidth selection is used.

Now, consider a general growth specification taking the unknown form

$$Y_i = G(x_i) + u_i, \qquad i = 1,2,...,n \tag{6}$$

where x_i are variables associated with several alternative growth theories, $G(\bullet)$ is the unknown smooth growth process (conditional mean) of Y given x.

The LCLS estimate of the conditional mean in the above equation at a specific point x is given by

$$\hat{\mathrm{G}}(x) = [\mathrm{i}'K(x)\mathrm{i}]^{-1}\,\mathrm{i}'K(x)\,\mathrm{Y} \tag{7}$$

Where $Y \equiv (\mathrm{Y}_1, \mathrm{Y}_2, ..., \mathrm{Y}_n)'$, i is a $n \times 1$ vector of ones and $K(x)$ is a diagonal n

matrix of kernel weighting functions for mixed continuous and discrete data with bandwidth vector $h = (h_1, h_2, ..., h_{qc})$ for the continuous variables and bandwidth vector $\lambda = (\lambda_u, \lambda_o)$ for the discrete regressors (Hall, Li and Racine, 2007).

The second non-parametric estimation procedure employed is LLLS. In short, LLLS performs weighted least-squares regressions around a point x with weights determined by a kernel function and bandwidth vector. Specifically, taking a first-order Taylor expansion of (6) around x, yields

$$Y_i \approx G(x) + (x_i^c - x^c)\beta(x^c) + \varepsilon_i \tag{8}$$

where $\beta(x^c)$ is defined as the partial derivative of $\mathrm{G}(x)$ with respect to x^c. The LLLS estimator of $\delta(x) \equiv \begin{bmatrix} \mathrm{G}(x) \\ \beta(x^c) \end{bmatrix}$ is given by

$$\hat{\delta}(x) = (\mathrm{X}'K(x)\mathrm{X})^{-1}\mathrm{X}'K(x)\mathrm{Y} \tag{9}$$

where X is a $n \times (q_c + 1)$ matrix with i th row being $[1, (x_i^c - x^c)]$ and $K(x)$ is the same as in (2).

3. Variable and data. We re-examine growth determinants using the unique path identification approach. There is a large literature on explaining cross-country growth differences, but this literature has not led to a consensus on which determinants to include and which measure of each determinant to use Brock et al. (2003). Growth empirics thus provide a typical and important example of a situation where two types of uncertainty exist: uncertainty about the relevance of a group and uncertainty about which measure of each determinant to use.

Our data are taken primarily from Sala-i-Martin (1997). The dependent variable is the average growth rate of GDP per capita 1960–92. The dataset contains 41 potential regressors to model the average per capita GDP growth over 1960-1992 for a sample of 72 countries. Sala-i-Martín (1997) computed at all possible subsets of regressors of manageable size and used the results to construct an importance measure he called CDF(0). Varian(2014) restudies the growth problem and shows ten predictors that were chosen by Sala-i-Martín (1997) using his two million regressions. This paper is mainly a further study of the Varian's work, therefore we re-examine the ten predictors in order to see which variables appeared to be important predictors of economic growth. The variables and their notations are listed below.

Y: the average growth rate of GDP per capita 1960–92;
i: the i th country;
Z1: GDP level 1960, Log of GDP per capita in 1960, it means the initial income;
Z2: Fraction of Confucius, Fraction of population that follows Confucius Religion;
Z3: Life expectancy, Life expectancy is a measure of non-educational human capital;

Z4: Equipment investment, it focuses primarily on equipment aggregate comprising electrical and non-electrical machinery. It is a share of GDP devoted to equipment investment;

Z5: Sub-Sahara African Dummy, Dummy for Sub-Sahara African Countries;

Z6: Fraction of Muslin, Fraction of population that follows Muslin Religion;

Z7: Rule of law, the rule-of-law index is a subjective indicator of the extent of maintenance of the rule of law;

Z8: Number of years open economy: The fraction of years during the period 1965-1990 in which the country is rated as an open economy;

Z9: Degree of Capitalism. The variable Degree of Capitalism gives countries one of six values according to how important private enterprise is in the organization of the economy;

Z10: Fraction of Protestant. Fraction of population that follows Protestant Religion.

4. Empirical analysis results.

4.1. Variable selections. In this subsection, we apply the results of Hall, Li, and Racine (2007) to select and identify the initial variables by nonparametric regression. First, we select variables from the initial dependent variable set, estimating the unknown function $G(x)$ by LCLS. The bandwidths and twice the standard deviations of the samples are presented in Table 1. If a variable's bandwidth is greater than twice the sample standard deviation, the variable is believed to have no relevance to the growth. As Table 1 shows, GDP level 1960, Fraction Confucian, Life expectancy, Equipment Investment, Fraction Muslim, Rule of law, open economy, degree of capitalism, and fraction Protestant are relevant to the growth.

Second, we identify the remaining variables, estimating $\delta(x)$ by LLLS and specifying the bandwidths by LSCV. The bandwidths are listed in Table 1. Comparing column 3 and column 4 in Table 1, if a variable's bandwidth is greater than twice the sample standard deviation, the variable is linear in the model; otherwise, it is nonlinear. As a result, Fraction Confucian, Equipment Investment, Rule of law, and degree of capitalism are linear. GDP level 1960, Life expectancy, Fraction Muslim, Open economy, and Fraction Protestant are nonlinear.

TABLE 1. Bandwidths and Twice the Standard Deviations of the Sample

Variable	LCLS BW	LLLS BW	2SD
GDPsh560 (z1)	0.224897	0.3396868	1.76932
Confuncious (z2)	0.07980928	**166025.5**	0.174845
Life Exp (z3)	5.404996	6.310418	22.89584
Equip Inv (z4)	0.01422416	**35984.34**	0.06900
SubSahara (z5)	**5368163**	--	0.8179328
Muslim (z6)	0.05564178	0.5251863	0.589196
Rule of Law (z7)	0.1067558	**112147**	0.670484
Yrs Open (z8)	0.254495	0.2492503	0.7106075
Degree of Capitalism (z9)	0.8579081	**1058754**	2.532882
Protestants (z10)	0.1018197	0.2399151	0.503127

4.2. Driving factors of economic growth. One way to gauge whether a variable is important is to exclude it from the prediction and see what happens (Varian, 2014). When this is done, it turns out that the accuracy of the path identification model doesn't change at all: exactly the fitting errors change a little. On the basis of section 4.1, we construct the complete model

$$Y_i = \alpha_1(i)\,Z_2 + \alpha_2(i)Z_4 + \alpha_3(i)Z_7 + \alpha_4(i)\,Z_9 + G(i, Z_1, Z_3, Z_6, Z_8, Z_{10}) + u_i \qquad (10)$$

and path models as following:

$$Y_i = \alpha^1{}_1(i)\,Z_2 + \alpha^1{}_2(i)Z_4 + \alpha^1{}_3(i)Z_7 + \alpha^1{}_4(i)\,Z_9 + G(i, Z_3, Z_6, Z_8, Z_{10}) + u_{i1} \qquad (11)$$

$$Y_i = \alpha^2{}_1(i)\,Z_2 + \alpha^2{}_2(i)Z_4 + \alpha^2{}_3(i)Z_7 + \alpha^2{}_4(i)\,Z_9 + G(i, Z_1, Z_6, Z_8, Z_{10}) + u_{i2} \qquad (12)$$

$$Y_i = \alpha^3{}_1(i)\,Z_2 + \alpha^3{}_2(i)Z_4 + \alpha^3{}_3(i)Z_7 + \alpha^3{}_4(i)\,Z_9 + G(i, Z_1, Z_3, Z_8, Z_{10}) + u_{i3} \qquad (13)$$

$$Y_i = \alpha^4{}_1(i)\,Z_2 + \alpha^4{}_2(i)Z_4 + \alpha^4{}_3(i)Z_7 + \alpha^4{}_4(i)\,Z_9 + G(i, Z_1, Z_3, Z_6, Z_{10}) + u_{i4} \qquad (14)$$

$$Y_i = \alpha^5{}_1(i)\,Z_2 + \alpha^5{}_2(i)Z_4 + \alpha^5{}_3(i)Z_7 + \alpha^5{}_4(i)\,Z_9 + G(i, Z_1, Z_3, Z_6, Z_8) + u_{i5} \qquad (15)$$

where $i = 1, 2, ..., 72$. We gauge the importance of a variable by comparing u_i. For example, we compare the u_i and u_{i1} to investigate the importance of Z_1 (GDP level 1960) for each country. The mean absolute error and relative error of complete model and path models are listed in Table 2&3.

Table 2 the Mean absolute error of complete model and path models

Complete model	Path1	Path2	Path3	Path4	Path5
0.1423851	1.500623	0.4698298	0.1933413	0.2412395	0.1828598

The mean absolute error of path 1 undergoes the biggest changes that concluded from Table 2. It means that GDP level 1960 has the most important effect on growth. A descending order of effectiveness of variables for growth would be: GDP level 1960, Life expectancy, Number of years open economy, Fraction of Muslin, Fraction of Protestant. The rank is a cross-country level; however, as described above, does it really make sense to believe that the effect of a change in the level of GDP per capita in 1960 on growth in the United States is the same as that for India? Hence we study the effect of a change in variables on growth at a country level. Table 3 shows the relative error of each country.

We still gauge the importance of a variable at the country level by comparing u_i. As mentioned above, the impact of GDP level 1960 on growth is measured by comparing u_i and u_{i1}, and the impact of Life expectancy on growth is measured by comparing

u_i and u_{i2}, and so on. We estimate the relative error for every country with the varying-coefficient path identification model.

Obviously, different predictor has different impact on growth for different country. The most important predictor is marked red in Table 3. For example, the initial income (GDP level 1960) is the crucial variable for Algeria, while that for Botswana is the open economy (Number of years open economy). The personalized result puts forwards some suggestions for the policymaker.

Table 3 the relative error of complete model and path models

country	u_i	u_{i1}	u_{i2}	u_{i3}	u_{i4}	u_{i5}
Algeria	1.75E-06	-4.35901	0	-1.3E-15	-1.4E-10	1.28E-11
Botswana	-4.5E-06	-0.00012	0.001684	2.89E-07	-0.02264	-1.3E-09
Cameroon	0.000594	0.000505	3.63E-16	-4.6E-10	0.198473	0.079374
Congo	-0.00066	0.009261	0.183272	-1.4E-07	0.176268	-0.00056
Ethiopia	-8.9E-06	-11.404	-7.25759	0.124028	-0.07682	2.01E-15
Ghana	0.002936	2.195532	-0.23239	0.001647	0.420743	1.75E-05
Kenya	-0.06987	0.000178	-0.78086	-4.6E-16	0	0.049647
Madagascar	-1.6E-07	0.394931	-0.00015	-2.1E-08	0	1.14E-08
Malawi	-6.3E-06	-0.32674	0.000252	4.88E-16	1.3E-15	-6.4E-09
Morocco	1.92E-11	-0.12318	0.000281	8.5E-08	-0.00027	0.047217
Nigeria	0	1.74E-10	0.038078	0.316549	-4.6E-09	0
Senegal	-7.7E-08	2.63E-14	-7.9E-05	-5.43718	0	3.53E-06
Tanzania	-2.7E-06	-1.3E-08	-9.2E-06	0.072803	8.91E-07	4.46E-09
Tunisia	0.000133	-0.19206	0.566412	-8.2E-07	1.37E-05	-0.00033
Uganda	-2.5E-05	-0.02727	0.372575	-2.4E-07	-4.8E-06	0.570036
Zaire	5.01E-12	0.399035	0.186299	0.242296	0.021753	0.00144
Zambia	-2.2E-11	0.274531	0.897505	-2.4E-09	-9.3E-14	0.011961
Zimbabwe	7.66E-12	0.376688	-0.22675	0.000681	-0.92642	0.009708
Canada	1.52E-06	0.001004	0.000532	9.22E-07	0.012025	0.029956
Costa Rica	-0.00637	0.026335	-0.00522	-0.04398	-0.06274	-0.00318
Dominican Rep.	0.359934	0.319163	0.016945	0.290485	0.067729	0.157465
El Salvador	0.000527	0.08602	0.141382	0.067023	-0.23075	-0.2794
Guatemala	0.27753	0.489899	-0.07192	-0.13464	0.412465	0.366452
Haiti	4.87E-10	0.726574	0.893031	-0.02777	1.074838	-1.8E-05
Honduras	0.086141	-0.38625	-0.84898	-0.358	0.054454	0.108746
Jamaica	-0.36138	3.45E-15	-0.01556	-0.00177	-0.02219	-0.00052
Mexico	-0.00362	-0.02422	0.232755	-0.00013	0.095254	0.006804
Nicaragua	0.712234	1.566435	1.849184	1.041406	0.85966	0.775542
Panama	0.103778	0.08576	0.440537	0.063816	0.086321	0.002253
United States	-1.1E-16	0	0.000489	3.4E-16	2.01E-06	-0.00166
Argentina	-0.12839	-0.45682	-0.36268	0.085797	-0.0023	0.158789
Bolivia	-0.01953	0.000472	-0.15308	-0.00576	0.468559	0.001127
Brazil	-0.07527	-0.09592	-0.18796	-0.09736	-0.16255	-0.08048

Chile	0.016522	0.176002	-0.16081	-0.05585	-0.14881	-0.00207
Colombia	0.137115	0.174183	0.267501	0.336565	0.240869	0.100738
Ecuador	-0.08057	-0.01199	-0.10505	-0.02997	-0.10153	-7.2E-06
Paraguay	0.228494	0.209492	0.018939	0.068683	0.019212	0
Peru	2.340729	-9.3449	-36.8601	0.144012	1.148137	1.201435
Uruguay	-0.15774	-0.36187	-0.59124	-0.04758	-0.31898	-0.2378
Venezuela	-6E-10	-3.73196	-5.99823	-0.51104	-0.01638	-0.0315
Hong Kong	0.001154	-0.00018	-0.06481	0.0016	-0.00116	-4E-07
India	0.001379	-0.04237	-0.14518	-0.03438	0.118374	0.047307
Israel	0.001527	0.087047	-0.01276	-9.1E-10	0.001104	-2.7E-09
Japan	0.029544	0.032455	0.033981	-0.00846	0.064197	0.000277
Jordan	6.9E-10	0.000129	2E-07	1.04E-07	-4.5E-16	9.17E-05
Korea	5.96E-14	0.025103	-0.00983	-0.00903	5.42E-07	-2.1E-07
Malaysia	1.03E-16	2.47E-15	-0.0158	0.057293	0.00163	-1E-16
Pakistan	-0.00457	4.121074	0	0.014939	-1.7E-05	0.161018
Philippines	-0.04433	-0.09805	-0.2024	-0.2129	-0.00024	-0.00713
Singapore	0.006523	0.002491	-0.00727	0.00013	-0.00976	0.000119
Sri Lanka	0.00451	0.017355	0.037735	-0.08489	-0.00087	-1.2E-07
Taiwan	-0.01165	-0.00264	0.045387	0.018459	0.009391	-0.00018
Thailand	-0.00575	0.001836	1.94E-16	-0.00082	0.15942	-0.00802
Austria	-0.00287	-0.01409	-0.12513	-0.0003	-0.01554	-0.09682
Belgium	-0.00198	-0.13514	0.001745	-0.00097	-0.06879	0.023196
Cyprus	-0.00075	-2E-16	-0.00694	-0.00064	0.091882	0.097395
Denmark	-0.00771	0.007795	0.079876	-2.7E-05	1.2E-05	-0.04406
Finland	-0.01789	-0.00763	0.002848	-0.00897	-0.00131	-0.16555
France	3.98E-06	-0.09739	0.046152	5.04E-06	-0.03261	0.02168
Germany, West	1.62E-09	3.45E-16	-8.6E-10	2.75E-14	0.003067	-0.08756
Greece	-0.00158	0.063315	-0.01407	-0.00051	-0.03169	0.111697
Ireland	-0.00534	0	-0.01804	-0.01805	-0.05636	0.005071
Italy	2.17E-05	-3.9E-09	0.065707	0.000147	0.164509	0.104276
Netherlands	-4.2E-12	0	-7.5E-05	-6.9E-12	-0.036	-0.04234
Norway	0.017694	0.018548	0.018318	0.009086	0.014473	0.167122
Portugal	-0.00176	2.21E-16	0.004742	-0.00058	-0.00054	1.05E-06
Spain	-0.02507	-0.00661	0.002314	-0.00867	-0.0614	-0.00041
Sweden	0.007389	0.057157	4.63E-16	0.003956	1.92E-08	-0.12983
Switzerland	5.27E-16	0	0	-1.2E-13	0.000498	0.004324
Turkey	-5.6E-15	-2E-07	0.372994	0.000287	1.21E-14	-6.9E-10
United Kingdom	-0.02275	-0.06984	-6.6E-10	-0.00247	-0.01235	0.009569
Australia	2.31E-09	-2.4E-16	1.39E-08	2.25E-07	-2E-07	-0.07126

5. Conclusion. The paper re-examines the problem of the cross-country growth illustrated in Varian(2014)'s work. The highlight of this paper is outlining a new perspective on empirical growth research which will both address some of the major criticisms to which research has been subjected and facilitate policy-relevant empirics

by proposing a path identification model. Different methods lead to different accuracy. The aim of a study determines the accuracy and then determines which methods are adopted, leading to a particular result. Different from the former researches, we confirm that the key point of model uncertainty is not model selection but study accuracy. In the period of big data, researchers should not focus on model uncertainty, as well as sample uncertainty, but on model construction and simulation. Based on the research objective, construct a model that sufficient with required accuracy. Given big data, there not exists a universalistic method, but specialized method for a particular issue. A further study may be proposed to quantify the influence effect of a change in various variables, in order to give clear policy guidelines.

Acknowledgment. The author acknowledges and is grateful for the financial support provided by The Plan of National Statistical Science Project (Grant No:2013LZ15), the Zhejiang Provincial Key Research Base for Humanities and Social Science Research (Statistics 1020XJ3314010 and Applied Economics 1020XJ3314018G).

REFERENCE

[1] Barro, R. Economic growth in a cross section of countries. *Journal of Economics Cvi*, vol.106, no.2, pp.407-444, 1991.

[2] Basturk, N., Paap, R., & van Dijk, D.. Structural differences in economic growth: an endogenous clustering approach. *Applied Economics*, vol.44, no.1, pp.119-134, 2012.

[3] Brock, W. A., & Durlauf, S. N.. Growth empirics and reality. *World Bank Economic Review*, no.15, pp.229-272, 2001.

[4] Brock, W. A., Durlauf, S. N., & West, K. D.. Policy evaluation in uncertain economic environments (with discussion). *Brookings Papers on Economic Activity*, no.15, pp.235-322, 2003.

[5] Cuaresma, J. C., & Doppelhofer, G.. Nonlinearities in cross-country growth regressions: A Bayesian Averaging of Thresholds (BAT) approach. *Journal of Macroeconomics*, vol.29, no.3, pp.541-554, 2007.

[6] Cuaresma, J. C., Feldkircher, M., Cuaresma, J. C., & Feldkircher, M.. The determinants of economic growth in european regions. *Regional Studies*, vol.48, no.1, pp.44-67, 2009.

[7] Deckers, T. and Hanck C.. Variable selection in cross-section regressions: comparisons and extensions. *Oxford Bulletin of Economics and Statistics*, vol.76, no.6, pp.841-873, 2014.

[8] Durlauf, S. N., & Johnson, P. A.. Multiple regimes and cross-country growth behavior. *Journal of Applied Econometrics*, vol.10, no.4, pp.365-384, 1995.

[9] Durlauf, S., Johnson, P., & Temple, J.. Growth econometrics. *Handbook of Economic Growth*, vol.1, no.5, pp.555–677, 2005.

[10] Eicher, T. S., Papageorgiou, C. and Raftery, A. E.. Default priors and predictive performance in Bayesian model averaging, with application to growth determinants. *Journal of Applied Econometrics*, vol.26, no.1, pp.30-55, 2011.

[11] Fernandez, C., Ley, E., & Steel, M.. Model uncertainty in cross-country growth regressions. *Journal of Applied Econometrics*, vol,16, no.5, pp.563–576, 2001.

[12] Friedman, J., Hastie, T., & Tibshirani, R.. Regularization paths for generalized linear models via coordinate descent. *Journal of Statistical Software*, vol.33, no.1 , pp.1–22, 2010.

[13] Hall, P., Li, Q., & Racine, J. S.. Nonparametric estimation of regression functions in the presence of irrelevant regressors. *Review of Economics & Statistics*, vol.89, no.4, pp.784-789, 2007.

[14] Henderson, D. J., Papageorgiou, C., & Parmeter, C. F.. Growth empirics without parameters. *Economic Journal*, vol.122, no.559, pp.125-154(30), 2012.

[15] Kraay, A., & Tawara, N.. Can disaggregated indicators identify governance reform priorities?. *Working Paper No. 5254, World Bank Policy Research, 2010.*

[16] Leamer, E. E.. Global sensitivity results for generalized least squares estimates. Journal of the American Statistical Association, vol.79, no.388, pp.867-870, 1983.

[17] Levine, R., & Renelt, D.. A sensitivity analysis of cross-country growth regressions. *American Economic Review*, vol.82, no.4, pp.942-963,1991.

[18] Ley, E., & Steel, M. F. J.. On the effect of prior assumptions in Bayesian model averaging with applications to growth regression. *Journal of Applied Econometrics*, vol.24, no.4, pp.651–674, 2009.

[19] Liu, Z., & Stengos, T.. Non-linearities in cross-country growth regressions: a semiparametric approach. *Journal of Applied Econometrics*, vol.14, no.5, pp.527-538, 1999.

[20] Magnus, J. R. and Wang W.. Concept-based Bayesian model averaging and growth empirics. *Oxford Bulletin of Economics and Statistics*, vol.76, no.6, pp.874-897, 2014.

[21] Mankiw, A. N. G., Romer, D., Weil, D. N., Gregory Mankiw, N., Romer, D., & Weil, D. N.. A contribution to the empirics of economic growth. *Quarterly Journal of Economics*, vol.107, no.2, pp.409-437, 1992.

[22] Moral-Benito, E.. Determinants of economic growth: a Bayesian panel data approach. *General Information*, vol.94, no.2, pp.566-579, 2012.

[23] Paap, R., Franses, P. H., & Dijk, D. V.. Does Africa grow slower than Asia, Latin America and the Middle East? evidence from a new data-based classification method. *Journal of Development Economics*, vol.77, no.2, pp.553–570, 2005.

[24] Sala-i-Martin, X.. I just ran two million regressions. *American Economic Review*, vol.87, no.2, 178-183, 1997.

[25] Sala-I-Martin, X., Doppelhofer, G., & Miller, R. I.. Determinants of long-term growth: a bayesian averaging of classical estimates (BACE) approach. *American Economic Review*, vol.94, no.4, pp.813-835, 2004.

[26] Salimans, T.. Variable selection and functional form uncertainty in cross-country growth regressions. *Journal of Econometrics*, vol.171, no.2, 267-280, 2012.

[27] Schneider, U., & Wagner, M.. Catching growth determinants with the adaptive lasso. *German Economic Review*, vol.13, no.1, pp.71–85, 2012.

[28] Steel, M. F. J., & Ley, E.. We just averaged over two trillion cross-country growth regressions. *Access & Download Statistics*, vol.16, no.5, pp.563–576, 1999.

[29] Tibshirani, R.. Regression shrinkage and selection via the lasso. *Journal of the Royal Statistical Society*, vol.58, pp.267-288, 1996.

[30] Ulasan, B.. Cross-country growth empirics and model uncertainty: an overview. *Economics-the Open Access Open-Assessment E-Journal 6, 2012*.

[31] Varian, H. R.. Big data: new tricks for econometrics. *Journal of Economic Perspectives*, vol.28, no.2, pp.3-27, 2014.

[32] Zou, H.. The adaptive LASSO and its oracle properties. *Journal of the American Statistical Association*, vol.101, no.476, pp.1418-1429, 2006.

L_1-norm Least Squares Support Vector Regression via the Alternating Direction Method of Multipliers

Yafen Ye, Chunna Li, Yuanhai Shao,
[a]Zhijiang College, Zhejiang University of Technology
Hangzhou 310024, CHINA
E-mail: yafenye@163.com

ABSTRACT: *Focusing on feature selection in regression, this paper proposes a new version of support vector regression called L_1-norm least squares support vector regression (L_1-LSSVR), which are based on the alternating direction method of multipliers (ADMM), a method from the augmented Lagrangian family. For one thing L_1-norm penalty adopted in L_1-LSSVR ensures important features selected; for another applying of ADMM, L_1-LSSVR is decomposed into a sequence of simpler problems, leading to faster training speed. L_1-LSSVR is shown to outperform L_1-norm support vector regression(L_1-SVR) in terms of speed.*

Keywords: Support vector regression, L_1-norm, least squares, feature selection, ADMM

1. Introduction. Feature selection is an important and pervasive problem in regression. Its main goal is to discard the redundant or uninformative features and maintain the useful features. Feature selection in support vector regression (SVR) [1–4] has been widely studied [5–10]. However, the standard SVR [1–4], utilizing all features without discrimination, is not suitable for feature section problem since the solution of SVR lacks of sparseness.

In order to overcome this drawback, combining the L_1-norm penalty and SVR, L_1-norm support vector regression(L_1-SVR) was proposed [7, 8]. Compared to standard SVR, L_1-SVR solution is much sparser. This means that L_1-SVR has an inherent feature selection property[11, 12]. However, the training speed of L_1-SVR is not fast. Following the spirit of least square support vector regression(*LS*SVR)[13], we propose a least squares version of L_1-SVR (L_1-LSSVR) which changes the inequality constraints into equality ones and meanwhile, adopt a simple but powerful algorithm called the alternating direction method of multipliers (ADMM) [14, 15] to solve L_1-LSSVR. Since ADMM can be derived as a variable splitting procedure followed by the adoption of an augmented Lagrangian method to solve the resulting constrained optimization, the computational complexity of L_1-LSSVR is cut down largely.

The main characteristics of L_1-LSSVR includes: (i)Linear L_1-LSSVR has the ability to select important features and discard the rest; (ii)When these selected features is structurally nonlinear, nonlinear L_1-LSSVR realizes regression effectively; (iii) L_1-LSSVR only need to solve the resulting constrained optimization, leading to a fast training speed. Experiment results on both artificial and real world data sets show the superiorities of L_1-LSSVR in both feature selection and regression performance, as well as the training time cost.

Section 2 of this paper briefly introduces standard SVR ,*L*1-SVR, and LSSVR. Section 3 describes our linear and nonlinear L_1-LSSVR. Section 4 describes artificial and UCI data sets experiments and Section 5 concludes the paper.

2. Background

Consider a regression problem in the n-dimensional real space R^n. For column vector $x \in R^n$,

$[x]_i$ denotes the i-th component of x, $i = 1,2,\cdots,n$. $|x|$ denotes the vector in R^n of absolute values of components of x. 1-norm $\|x\|_1$ is defined as $(|[x]_1|+|[x]_2|+\cdots+|[x]_n|)$. (A,Y) denotes a training set, in which A is an $l \times n$ matrix, i-th row $A_i \in R^n$ represents the i-th training sample, $i = 1,2,\cdots,l$, and $Y = (y_1; y_2; \cdots; y_l)$ in R^l denotes the response vector.

We next brief review the standard SVR, L_1-SVR, and LSSVR which are closely related to $L1$-LSSVR. For simplicity, we only introduce the linear version. The optimal linear regression function is constructed as follows:

$$f(x) = w^T x + b, \tag{1}$$

where $w \in R^n$ and $b \in R$.

2.1. Support vector regression. In standard SVR [1–4], an ε-intensive loss function

$$R_{emp}^{\varepsilon}[f] = \frac{1}{l}\sum_{i=1}^{l}|y_i - f(x_i)|_{\varepsilon} \tag{2}$$

is used to measure empirical risk, in which $|y_i - f(x_i)|_{\varepsilon} = \max\{0, |y_i - f(x_i)| - \varepsilon\}$. By introducing regularization term $\frac{1}{2}\|w\|^2$ and slack variables ξ and η, the primal problem SVR is formulated as follows:

$$\begin{aligned} &\min_{w,b,\xi,\eta} \frac{1}{2}\|w\|^2 + C(e^T\xi + e^T\eta) \\ &s.t.\ \ Y - (Aw + be) \le \varepsilon e + \xi, \xi \ge 0, \\ &\qquad (Aw + be) - Y \le \varepsilon e + \eta, \eta \ge 0, \end{aligned} \tag{3}$$

where $\|\bullet\|^2$ represents the L_1-norm, $C > 0$ is a parameter determining the tradeoff between the empirical risk and the regularization term, and e is a vector of ones of appropriate dimensions.

Parameters in function (1) are determined by problem (3). In general, standard SVR may suffer from the presence of redundant or uninformative features since solution w lacks sparseness, meaning that the standard SVR uses all features without discrimination.

2.2 L_1-support vector regression. By replacing the square of the L_2-norm in problem(3)with the L_1-norm, linear L_1-support vector regression (L_1-SVR) [7, 8] is given as follows:

$$\begin{aligned} &\min_{\omega,b,\xi,\eta} \|w\|_1 + C(e^T\xi + e^T\eta) \\ &s.t.\ \ Y - (Aw + be) \le \varepsilon e + \xi, \xi \ge 0, \\ &\qquad (Aw + be) - Y \le \varepsilon e + \eta, \eta \ge 0, \end{aligned} \tag{4}$$

where $\|\bullet\|_1$ represents the L_1-norm, ξ and η are slack vectors, and $C > 0$ is a positive parameter.

By using the L_1-norm, a small enough C will drive some coefficients of w_i toward zero [11, 12]. This means that w is sparser than that of standard SVR. Thus, L_1-SVR has an inherent feature selection property.

2.3. Least squares support vector regression. Standard SVR [1–4] is time-consuming because it requires solving a quadratic programming problem (QPP) with linear inequality constraints. To improve the training speed, [13] introduced the least squares support vector regression (LSSVR). Unlike standard SVR formulation (3), an equality constraint is used to determine the regressor in LSSVR formulation:

$$\begin{aligned} &\min_{\omega,b,\xi} \frac{1}{2}\|w\|^2 + \frac{C}{2}\xi^T\xi \\ &s.t.\ Y - (Aw + eb) = \xi. \end{aligned} \tag{5}$$

Problem (5) is solved by formulating its dual problem. Eliminating the vectors w and ξ, for the purpose of conciseness, the following linear equation set is obtained

$$\begin{bmatrix} 0 & e^T \\ e & \bar{A} \end{bmatrix} \begin{bmatrix} b \\ \alpha \end{bmatrix} = \begin{bmatrix} 0 \\ Y \end{bmatrix}, \tag{6}$$

where $\bar{A} = A^T A + \frac{I}{C}$, and α is the Lagrange multiplier vector. After obtaining α by (6), the linear regression function (1) is estimated.

Note that LSSVR only solves a system of linear equation. Hence, compared with QPP in SVR, LSSVR cuts down the computational costs in a much extent. However, LSSVR tends to lose sparseness [16] since LSSVR is formulated based on L_2-norm.

3.L_1-least squares support vector regression

3.1 Linear L_1-LSSVR

3.1.1 Problem formulation. Combining the idea of L_1-SVR and LSSVR, we propose a new feature-selection algorithm called L1-normleast squares support vector regression (L_1-LSSVR). L_1-LSSVR searches for an optimal linear regression function:

$$f(x) = w^T x + b, \tag{7}$$

where $w \in R^n$ and $b \in R$.By introducing regularization term $|w|_1 + |b|$, slack variable ξ, the primal problem of our L_1-LSSVR is expressed as follows:

$$\begin{aligned} &\min_{\omega,b,\xi} \|w\|_1 + |b| + \frac{C}{2}\xi^T\xi \\ &s.t.\ Y - (Aw + eb) = \xi. \end{aligned} \tag{8}$$

where $C > 0$ is a parameter determining the tradeoff between empirical risk and regularization term. The regularization term $|w|_1 + |b|$ in (8), is similar to [18, 19, 21].

3.1.2. Linear L_1-LSSVR solution. To solve L_1-LSSVR, we adopt the alternating direction method of multipliers (ADMM) algorithm. Define $z = [w; b]$ and $G = [\mathrm{A}, \mathrm{e}]$ so problem (8) is rewritten as follows:

$$\begin{aligned} &\min_{z,\xi} \|z\|_1 + \frac{C}{2}\xi^T\xi \\ &s.t.\ Y - Gz = \xi. \end{aligned} \tag{9}$$

According to the constraint in problem (9), we can get the following problem:

$$\min_{z} \|z\|_1 + \frac{C}{2}\|Y - Gz\|^2 \tag{10}$$

Using following translation form:

$$\begin{aligned} &\min_{z,u} \|u\|_1 + \frac{C}{2}\|Y - Gz\|^2 \\ &s.t.\ \ u\text{-}z\text{=}0. \end{aligned} \tag{11}$$

the ADMM iterating procedures becomes

$$z^{k+1} = \arg\min_{z} \frac{C}{2}\|Y - Gz\|_2^2 + \frac{\mu}{2}\|z - u^k - d^k\|_2^2, \tag{12}$$

$$u^{k+1} = \arg\min_{u} \|u\|_1 + \frac{\mu}{2}\|z^{k+1} - u - d^k\|_2^2, \tag{13}$$

$$d^{k+1} = d^k - (z^{k+1} - u^{k+1}), \tag{14}$$

where $\{z^k \in R^{n+1}, k = 0,1,\cdots\}$, $\{u^k \in R^{n+1}, k = 0,1,\cdots\}$, and $\{d^k \in R^{n+1}, k = 0,1,\cdots\}$ are three

sequences.

Problem (12) requires solving a quadratic problem, the solution of which is

$$z^{k+1} \leftarrow B^{-1}w, \tag{15}$$

where $B \equiv CG^TG + \mu I$, and $w \equiv CG^TY + \mu(u^k + d^k)$. Note that B is always invertible, since $\mu > 0$.

The solution of problem (13) would be the well-known threshold [14, 15]:

$$u^{k+1} \leftarrow soft(\upsilon^k, \frac{1}{\mu}), \tag{16}$$

where $\upsilon^k \equiv z^{k+1} - d^k$. Thus, ADMM algorithm for problem (9) is detailed in Algorithm 1.

Algorithm 1 ADMM for problem (9)

Input: Training data matrix $G = [A, e]$; Parameters C, and μ.

Output: Solution w^* and b^*.

Process:

Step 1: Set $k = 1$, choose u^0, and d^0;

repeat

Step 2: $w \leftarrow CG^TY + \mu(u^k + d^k)$,

$z^{k+1} \leftarrow B^{-1}w$;

Step 3: $\upsilon^k \leftarrow z^{k+1} - d^k$, $u^{k+1} \leftarrow soft(\upsilon^k, \frac{1}{\mu})$;

Step 4: $d^{k+1} \leftarrow d^k - (z^{k+1} - u^{k+1})$;

Step 5: $k \leftarrow k + 1$;

until stopping criterion is satisfied;

Step 6: Obtain solution $(w^*, b^*) = z^*$.

Getting the solution of problem (9) w^* by Algorithm 1, we have either $\left|[w^*]_j\right| \neq 0$ or $\left|[w^*]_j\right| = 0$, $j = 0, 1, \cdots, n$. When $\left|[w^*]_j\right| \neq 0$, their corresponding features are selected. The rest features are considered redundant and thus discarded.

3.2 Nonlinear L_1-LSSVR. To extend the above linear L_1-LSSVR to a nonlinear version, we express regression function in kernel space as follows:

$$f(x) = K(x^T, A^T)w + b, \tag{17}$$

where K is a Gaussian kernel. Following the same idea as linear L_1-LSSVR, the primal problem of our nonlinear L_1-LSSVR is formulated as:

$$\begin{aligned} &\min_{\omega, b, \xi} \|w\|_1 + |b| + \frac{C}{2}\xi^T\xi \\ &s.t.\ Y - (K(A, A^T)w + eb) = \xi. \end{aligned} \tag{18}$$

The above problem is also be rewritten as

$$\begin{aligned} &\min_{z, \xi} \|z\|_1 + \frac{C}{2}\xi^T\xi \\ &s.t.\ Y - Hz = \xi, \end{aligned} \tag{19}$$

where $z = [w; b]$ and $H = [K(A, A^T), \mathrm{e}]$. We now apply ADMM using the following translation form:

$$\begin{aligned} &\min_{z, u} \|u\|_1 + \frac{C}{2}\|Y - Hz\|^2 \\ &s.t.\ u\text{-}z\text{=}0. \end{aligned} \tag{20}$$

The ADMM iterating procedures are

$$z^{k+1} = \arg\min_{z} \frac{C}{2}\left\|Y - Gz\right\|_2^2 + \frac{\mu}{2}\left\|z - u^k - d^k\right\|_2^2 \tag{21}$$

$$u^{k+1} = \arg\min_{u} \left\|u\right\|_1 + \frac{\mu}{2}\left\|z^{k+1} - u - d^k\right\|_2^2 \tag{22}$$

$$d^{k+1} = d^k - (z^{k+1} - u^{k+1}) \tag{23}$$

where $\{z^k \in R^{l+1}, k = 0,1,\cdots\}$, $\{u^k \in R^{l+1}, k = 0,1,\cdots\}$, and $\{d^k \in R^{l+1}, k = 0,1,\cdots\}$ are three sequences.

The z-update, which involves solving a quadratic problem, can be written explicitly as:

$$z^{k+1} \leftarrow B^{-1}w, \tag{24}$$

where $B \equiv CH^T H + \mu I$, and $w \equiv CH^T Y + \mu(u^k + d^k)$.

The solution of problem (22) would be the threshold [14, 15]:

$$u^{k+1} \leftarrow soft(\upsilon^k, \frac{1}{\mu}) \tag{25}$$

where $\upsilon^k \equiv z^{k+1} - d^k$. In summary, the solution of problem (18) is given by Algorithm 3.

Algorithm 2 ADMM for problem (18)

Input: Training data matrix $H = [K(A, A^T), e]$; Parameters C , and μ .

Output: Solution w^* and b^*.

Process:

Step 1: Set $k = 1$, choose u^0 , and d^0 ;

repeat

Step 2: $w \leftarrow CH^T Y + \mu(u^k + d^k)$, $z^{k+1} \leftarrow B^{-1}w$;

Step 3: $\upsilon^k \leftarrow z^{k+1} - d^k$, $u^{k+1} \leftarrow soft(\upsilon^k, \frac{1}{\mu})$;

Step 4: $d^{k+1} \leftarrow d^k - (z^{k+1} - u^{k+1})$

Step 5: $k \leftarrow k + 1$

until stopping criterion is satisfied;

Step 6: Obtain solution $(w^*, b^*) = z^*$.

4. Numerical test. We conduct experiments to demonstrate the feature selection and regression performance of our proposed L_1-LSSVR , comparing to L_1-SVR , LSSVR , and SVR . In our experiments, parameters are obtained by searching in the range $2^{(-8)}$ to 2^8 , including Gaussian kernel parameter δ . Table 1 introduces evaluation criteria [20–22]. We let l be the number of training samples, and denote m as the number of testing samples, $\hat{y}_i$ as the prediction value of y_i , and $\overline{y} = \frac{1}{m}\sum_{i=1}^{m} y_i$ as the average value of $y_1, y_2, \cdots y_m$.

4.1. Artificial datasets. We first evaluate it on two artificial data sets such as those in [9, 10]. We first consider the following function

$$y = \frac{\sin(x)}{x}, \quad x \sim U[-4\pi, 4\pi]. \tag{26}$$

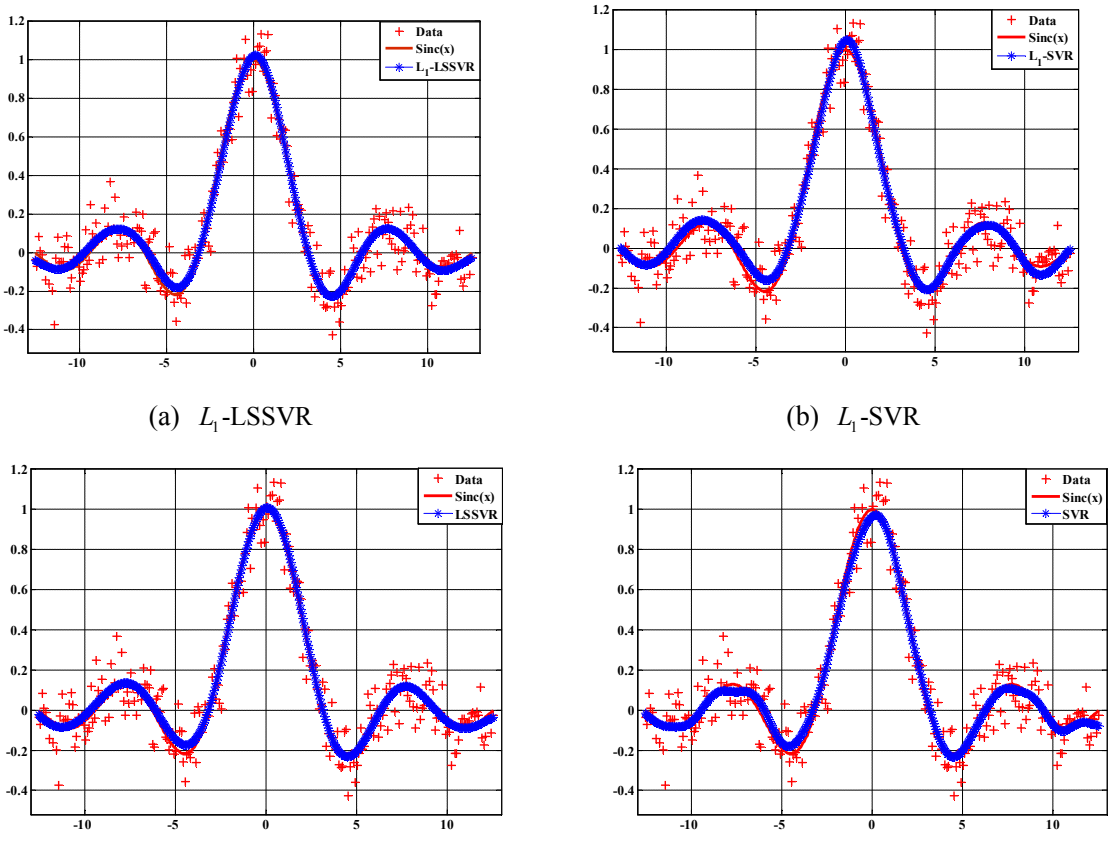
To reflect the regression performance of our L_1-LSSVR effectively, training data samples are polluted by uniformly distributed noise. In practice, we use the following training samples

(x_i, y_i)

$$y_i = \frac{\sin(x_i)}{x_i} + \varsigma_i, \quad x_i \sim U[-4\pi, 4\pi], \quad \varsigma_i \sim N(0, 0.1^2), \tag{27}$$

where $U[0,0.1]$ represents uniformly random variables in $[0,0.1]$. Our data sets consist of 252 training samples and 503 test samples.

Figure 1(a)-(d) shows the estimated functions obtained by our L_1-LSSVR, L_1-SVR, LSSVR, and SVR. Note that the regression perform of L_1-LSSVR is so well as other methods. Table 2 lists corresponding performance criteria results to give a clearer view of the relative performance of these four methods. Note that in Table 2, our L_1-LSSVR derives the small error sum of squares (SSE) and normalized mean square error (NMSE) and the large R^2. This indicates that statistical information in the training data set is captured well by our L_1-LSSVR and with fairly small regression error. Furthermore, we observe that the training speed of L_1-LSSVR is much faster than L_1-SVR, since L_1-LSSVR applies the linear equality constraints and ADMM algorithm.



(a) L_1-LSSVR (b) L_1-SVR

(c) LSSVR (d) SVR

FIGURE 1. Prediction of L_1-LSSVR, L_1-SVR, LSSVR, and SVR of function $\frac{\sin x}{x}$.

4.2 UCI dataset. To further test the feature selection and regression performance, we consider five real-world data sets, including Bankruptcy Prediction, Auto price, and Boston Housing. Bankruptcy Prediction data set consists of 500 samples with 41 attributes [24]. Auto price data set and Boston Housing data set can be downloaded from the website of the UC Irvine (UCI) machine learning repository benchmark data sets. The specifications of the data sets are listed in Table 3.

Table 4 lists the feature selection and regression results of our L_1-LSSVR, L_1-SVR, LSSVR, and SVR on these data sets. Here, Gaussian kernel is employed, and three comparison criteria number of selected features, NMSE and R^2 are considered. From Table 4, we easily observe that our L_1-LSSVR selects the fewer

features and gets small NMSE and large R^2. This indicates that very few selected features capture useful information in data on their own. From Table 4, we find that the training speed of our L_1-LSSVR is faster than L_1-SVR and SVR and slower than LSSVR. Thus, it can be seen that our L_1-LSSVR is a faster algorithm than L_1-SVR in training time. The best parameters selected by L_1-LSSVR and L_1-SVR algorithms are listed in Table 5.

TABLE 1 Performance metrics and their calculations

Metrics	Calculation
SSE	$SSE = \sum_{i=1}^{m} (y_i - \hat{y}_i)^2$
SST	$SST = \sum_{i=1}^{m} (y_i - \bar{y})^2$
SSR	$SSR = \sum_{i=1}^{m} (\hat{y}_i - \bar{y})^2$
NMSE	$NMSE = SSE / SST = \frac{\sum_{i=1}^{m} (y_i - \hat{y}_i)^2}{\sum_{i=1}^{m} (y_i - \bar{y})^2}$
R^2	$R^2 = SSR / SST = \frac{\sum_{i=1}^{m} (\hat{y}_i - \bar{y})^2}{\sum_{i=1}^{m} (y_i - \bar{y})^2}$
MAPE	$MAPE = \frac{\sum_{i=1}^{m} \lvert y_i - \hat{y}_i \rvert / y_i}{m} \times 100$

TABLE 2 Comparison results for L_1-LSSVR, L_1-SVR, LSSVR, and SVR in artificial data sets

Data set	Regressor	SSE	NMSE	R^2	CPU Sec.
(27)	L_1-LSSVR	0.2051	0.0038	0.9928	0.9100
	L_1-SVR	0.4392	0.0081	0.9763	2.0285
	LSSVR	**0.1788**	**0.0033**	**0.9977**	**0.0187**
	SVR	0.3455	0.0064	0.9228	1.6128

TABLE 3. Specification of real-world regression cases.

Data set	Training samples	Testing samples	No. of features
Bankruptcy Prediction	200	300	41
Auto price	80	79	15
Boston Housing	300	206	13

TABLE 4. Comparison of L_1-LSSVR, L_1-SVR, LSSVR, and SVR for five benchmark data sets.

Data set	Regressor	No. of selected features	NMSE	R^2	CPU Sec.
Bankruptcy Prediction	L_1-LSSVR	**11**	**0.3987**	0.9421	0.1785
	L_1-SVR	35	1.1973	0.9777	0.7557
	LSSVR	41	0.6116	**0.9941**	**0.0094**
	SVR	41	1.5084	0.9900	8.3281

Auto price	L_1-LSSVR	6	0.3360	0.7473	0.1401
	L_1-SVR	**5**	0.4114	**0.8672**	0.1697
	LSSVR	15	0.2229	0.8058	**0.0078**
	SVR	15	**0.2059**	0.7854	0.2819
Boston Housing	L_1-LSSVR	**11**	1.8217	0.9481	0.2944
	L_1-SVR	12	1.7061	**0.8873**	5.0612
	LSSVR	13	1.9016	0.9770	**0.0141**
	SVR	13	**1.5186**	0.9612	0.6189

5. Conclusion. We have proposed a new feature selection in regression called L_1- norm least squares support vector regression(L_1-LSSVR). Using $L1$-norm gives our L_1-LSSVR a reliable ability in select useful features. In addition, our L_1-LSSVR runs much faster than L_1-SVR due to the employment of ADMM algorithm, which decomposes a difficult problem into a sequence of simpler ones. Comparison of our L_1-LSSVR , L_1-SVR and SVR for several data sets indicates the superiority of our L_1-LSSVR in terms of feature selection and speed.

Acknowledgements

This work is supported by the National Natural Science Foundation of China (No.11201426, No.11071252, No.11161045 , and No.11426200), the Zhejiang Provincial Natural Science Foundation of China (No.LQ12A01020, No.LQ13F030010, No.LQ14G010004, and No.LY15F030013), Ministry of Education, Humanities and Social Sciences Research Project (No.13YJC910011), China Postdoctoral Science Foundation(No.2015M571848), and Zhejiang Provincial University Students' Science and Technology Innovation Activities Program (Xinmiao Talents Program) (No.2014R403063).

REFERENCES:

[1] Drucker H., Burges C. J. C., Kaufman L., Smola A., Vapnik V., Support Vector Regression Machines, *Bell Labs and Monmouth University*, 1997.

[2] Burges C, A tutorial on support vector machines for pattern recognition， *Data Min Knowl Discov* ,vol.2, pp.121-167, 1998.

[3] Bi, J. and Bennett. K.P., A geometric approach to support vector regression, *Neurocomputing*, vol.55, no.1-2, pp.79-108,2003.

[4] Smola, A. and Scholkopf, B., A tutorial on support vector regression, *Statistic Computing*, vol.14, no.3, pp.199-222,2004.

[5] C.L. Huang and C.Y. Tsai, A hybrid SOFM-SVR with a filter-based feature selection for stock market forecasting", *Expert Systems with Application*, vol.36, pp.1529C1539, 2009.

[6] J.B. Yang and C.J. Ong, Feature selection using probabilistic prediction of support vector regression, *IEEE TRANSACTIONS ON NEURAL NETWORKS*, vol.22, pp.954C962, 2011.

[7] Y.F. Ye, H. Cao, L. Bai, Z. Wang, Y.H. Shao, Exploring determinants of inflation in China based on L_1-ε -twin support vector regression, *Procedia Computer Science*, vol.17, pp.514-522,2013.

[8] X. Peng, D. Xu, "A local information-based feature-selection algorithm for data regression", *Pattern Recognition*, vol.46, pp.2519-2530, 2013.

[9] Y.F. Ye, Y.X. Jiang, Y.H. Shao, and C.N. Li, Financial conditions index construction through weighted lp-norm support vector regression, *Journal of Advanced Computational Intelligence and Intelligent Informatics*, vol.19, pp.397C406, 2015.

[10] Y.F. Ye, Y.H. Shao, and C.N. Li, "Wavelet Lp-norm support vector regression with feature selection"， *Journal of Advanced Computational Intelligence and Intelligent Informatics*, vol.19, pp.407C416, 2015.

[11] R. Tibshirani, "Regression shrinkage and selection via the lasso， *Journal of the Royal Statistical Society, Series B (Methodological)*, vol.58, no.1, pp.207-288, 1996.

[12] L. Meier, S. van de Geer, and P. Buhlmann, The group lasso for logistic regression, *Journal of the Royal Statistical Society. Series B (Statistical Methodology)*, vol.70, no.1, pp.53-71, 2008.

[13] Suykens J.A.K., Lukas L., Van Dooren P., De Moor B., and Vandewalle J., Least squares support vector machine classifiers: a large scale algorithm, *In Proceedings of European Conference of Circuit Theory Design*, 1999.

[14] Boyd S., Parikh N., Chu E., Peleato B., and Eckstein J., Distributed optimization and statistical learning via the alternating direction method of multipliers, *Foundations and Trends in Machine Learning*, vol.3, pp.1-122, 2010.
[15] Bioucas-Dias J.M. and Figueiredo M. A. T., Alternating direction algorithm for constrained sparse regression: application to hyperspectral unmixing, *Hyperspectral Image and Signal Processing: Evolution in Re- mote Sensing, 2010 2nd Workshop on. IEEE*, pp. 1-4, 2010.
[16] J.A.K. Suykens, J.D. Brabanter, L. Lukas, and J. Vandewalle, Weighted least squares support vector machines: robustness and sparse approximation, *Neurocomputing*, vol.48, pp.85-105, 2002.
[17] Y.H. Shao, C.H. Zhang, Z.M. Yang, L. Jing, N.Y. Deng, An -twin support vector machine for regression, *Neural Computing and Applications*, vol.23,pp.175-185,2013.
[18] Y.F. Ye, Y.X. Jiang, Y.H. Shao, and C.N. Li., Financial conditions index construction through weighted lp-norm support vector regression, *Journal of Advanced Computational Intelligence and Intelligent Informatics*, vol.19, pp.397-406, 2015.
[19] Y.F. Ye, Y.H. Shao, and C.N. Li., Wavelet lp-norm support vector regression with feature selection, *Journal of Advanced Computational Intelligence and Intelligent Informatics*, vol.19, pp.407-416, 2015.
[20] R.J. Hyndman, A.B. Koehler, Another look at measures of forecast accuracy, *International Journal of Forecasting*, vol.22, pp.679-688, 2006.
[21] Y.H. Shao, C.H. Zhang, Z.M. Yang, L. Jing, N.Y. Deng, An twin support vector machine for regression, *Neural Computing and Applications*, vol.23, pp.175-185,2013.
[22] Y.F. Ye, Y.H. Shao, W.J. Chen, Comparing inflation forecasts using an ε -wavelet twin support vector regression, *Journal of Information and Computational Science*, vol.10, pp.2041-2049,2013.
[23] O.L. Mangasarian and E.W. Wild, Feature selection for nonlinear kernel support vector machines, *In IEEE seventh international conference on data mining*, 2007.
[24] Q. Yu, Y. Miche, and E.a. Séverin, Bankruptcy prediction using extreme learning machine and financial expertise, *Neurocomputing*, vol.128, pp.296-302, 2014.

Housing Market Hedonic Price Analysis Based on Boosting Regression Tree

Guangtong Gu[1,2] and Bing Xu [2]

1. School of Science
Zhejiang A & F University
Hangzhou, Zhejiang, China
guguangtong@163.com

2. Research Institute of econometrics and statistics
Zhejiang Gongshang University
Hangzhou, Zhejiang, China
bingxu@zjgsu.edu.cn

ABSTRACT. *Housing prices is the focus of the community issues of common concern, explore housing prices constitute very important. Based in Beijing, Shanghai, Guangzhou three cities the purchase price of new real estate market data, and select architectural features, 19 features variable neighborhood property characteristics, location characteristics under rates established classical line hedonic price model, the three characteristics of the housing factors prices were compared. Further based on gradient boosting regression tree of data mining methods, analyze and compare for the new housing hedonic price modeling from Beijing, Shanghai and Guangzhou. And order influence importance of the characteristic variable to the housing price, and visualize of the main characteristic variables impacted on the housing price path and decision rules.*
Keywords: Data mining; Residential hedonic price; Boosting regression tree

1. **Introduction.** Housing is a necessity place for every resident to live and work. Since the reform of housing system in China, Commodity housing has achieved rapid development, the rapid expansion of the scale of investment, and gradually become the pillar and leading industry of China's economy. For a long time, the fluctuation of housing price is always affecting the residents' living quality and the sustainable and stable development of the national economy. Therefore, the research on the constitution factors of housing price has become the hot spot which the society pays attention.

Each set of housing is usually composed of different characteristics, such as the structure of the building type, size, location, environment, etc. These characteristics have a direct or indirect effect on the housing price. In order to analyze the direction and extent of the impact of these characteristics on housing prices, from the micro perspective, the relevant research for new housing price characteristic factors of Beijing, Shanghai and Guangzhou is carried out in this paper. So as to effectively control the trend of housing price and its influencing factors. Our research has certain guiding role and reference value for the harmony and stability of the stable operation

of the economy and the stability of the residents.

Since the beginning of the last century 70's, foreign scholars have gradually accepted and adopted the hedonic price model to identify and measure the relationship between the characteristics of housing and the housing price. This kind of hedonic price theory assumes that the relationship between the house price p and the house characteristics x have the following function structure relations.

$$p=f^*(x) \tag{1}$$

The house characteristics x can be residential area, floor, residential green rate, property costs, distance from the city center, etc. For the theory and more results on this topic, we refer readers to [1-3] and the references therein. In the practical application, the hedonic price function $f^*(x)$ is replaced by the fitting equation $f(x)$ of historical data $\{p,x\}_1^n$.

Through the research on the existing literature, we find that the functional forms of hedonic price models are varied, and the common linear feature model, the logarithmic price model, the semi logarithmic price model and the semi parametric model. The heodnic price model based on box-cox transform, some consider the interaction effect or the nonlinear characteristic of the characteristic variables of the house. Such as, in the work of [4-6], respectively have tried to build hedonic price model of the residential market in Beijing city and Hangzhou City, an empirical study, to construct a polynomial model to reflect the nonlinear impact on prices from the housing characteristics. Previously residential feature data is difficult to obtain, but now just like Taobao shopping information, a variety of real estate information has been on the Internet. Have to admit that such a relatively perfect Internet platform, real estate prices and their characteristics of the data is not only comprehensive and high transparency. Such as Soufang.com Beijing residential houses covering 8971 detailed feature information, the number of second-hand housing estate is tens of thousands of, covering more than 200 cities in China. So the residential data is a big data, especially the new commercial housing data almost all the Internet, it is not a problem to obtain the data. Now the key technology is to build a suitable hedonic price model. With the development of machine learning data mining method, the model has been gradually liberated. Based on the boosting algorithm, using machine learning regression tree and cross validation (CV) method to new residential housing markets the research objects, we try to analyze the important factors affecting the housing prices in Beijing, Shanghai and Guangzhou, China.

2. Model and Method.

2.1 Hedonic price model. The theoretical basis of the hedonic price model is that housing is not only a kind of commodity, but also can be regarded as a combination of the characteristics of consumer utility, such as comfort, beauty and accessibility. But because the housing market is as a whole to trade, these characteristics of the price P is unable to show up in the market. It is to solve this problem, the references [3] to establish the hedonic price analysis of the empirical research framework. The basic

principle of this framework is that the difference of any kind of heterogeneous commodity is derived from the homogeneity of its own, so it can be decomposed into a set of characteristics which can be separately measured, and then the price of the commodity is decomposed into the price of each characteristic. On the housing, the housing characteristics can be divided into two parts: the structural characteristics of the building and the external features, which can be further decomposed into the characteristics of location and neighborhood characteristics, these characteristics may have a positive impact on prices may have a negative impact, which causes the housing price changes.

Typical housing characteristics can be divided into building structural features *S*, location features *L*, neighborhood features *N*, these features are not only qualitative and quantitative. A lot of studies suggest that the most frequent variables in models: Fangling, natural environment, sports facilities quality, education facilities, close to the CBD, adjacent to the subway, building area, in the work of [7-9],. Therefore, the characteristic price model can be expressed as:

$$P=f(S,\ L,\ N) \tag{2}$$

2.2 Gradient boosting machine learning. In the past, most of the literature is based on the assumption that the distribution of housing prices and residential characteristics, there are some literature from the perspective of the semi parametric density estimation, for example the work of [11]. But based on data mining and machine learning, this kind of problem is discussed. Usually data mining, machine learning technology, is based on data sets $\{x_i, y_i\}_1^n$ to train or fit the model *f(x)*, divided into two kinds of classification training and regression model training. The house price $Y = \{y_i\}_1^n$ or a natural logarithm $\log(Y) = \{\log(y_i)\}_1^n$ is a continuous variable. While residential characteristic variables can be continuous variables $x=(x_1, x_2, \ldots, x_p)$ and can also be classified variables or order variables. Therefore, the housing hedonic prices analysis should be used to carry out the regression training.

Under the gradient boosting framework, similar to the work of [12-13], a study on the relationship between housing price and housing characteristics can be given as follows:

$$\arg\min_f E_{Y,X}[\rho(y, f(x^T))] \tag{3}$$

In the above equation (3), the assumption that the loss function ρ is a differentiable function about the function *f(x)* is true. But in fact the equation (3) is unknown, and can be replaced by boosting algorithm that minimize $\sum_{i=1}^{n} \rho(y_i, f(x^T{}_i))$. Specific algorithm steps are as follows:

The first step, the initial estimate $\hat{f}^{[0]}$ for the n-length of the vector.

The second step, A training benchmark model that is the classical linear hedonic price model is constructed for each housing feature and housing price, estimated by the least square method. The least square is a form of punishment or no punishment.

The third step is to calculate the negative gradient $-\frac{\partial \rho}{\partial f}$ of the loss function ρ:

$$u^{[m]} = (-\frac{\partial}{\partial f}\rho(y_i, \hat{f}^{[m-1]}(x_i^T))) \qquad , i = 1,2,...,n \tag{4}$$

In the above equation (4), $m \geq 1$, m represents the first m step of the algorithm. $\hat{f}^{[0]}$ represents the fitting estimation for the second step model. Let the iteration step length $0 < l \leq 1$, So the iterative process is $\hat{f}^{[m]} = \hat{f}^{[m-1]} + l\,\hat{u}^{[m]}$.

The fourth step, repeat the third step, based on the residual method and the principle of cross validation method or AIC. to determine the optimal number of boosting steps m, marked as m_{opt}.

2.3. A regression tree algorithm based on gradient boosting. Based on the gradient boosting can model the regression tree model, the steps are as follows:

The first step is to calculate the negative gradient $-\frac{\partial \rho}{\partial f}$, marked as:

$$z_i = (-\frac{\partial}{\partial f}\rho(y_i, \hat{f}(x_i^T))) \qquad , i = 1,2,...,n \tag{5}$$

The second step is to randomly select a $p \times N$ dimension data set, and a regression tree with K nodes is fitted to the data set.

Third step, calculate the optimized forecast value $r_1, r_2, ..., r_k$ of the $1,2,...,K$ node:

$$r_k = \arg\min \sum_{x_i \in S_k} \rho(y_i, \hat{f}(x_i^T) + r) \tag{6}$$

In the above equation (6), S_k is a set of active feature variables under the first K nodes.

Fourth step, iteration $\hat{f}^{[m]}(x^T) = \hat{f}^{[m-1]}(x^T) + l\,r_K$, repeat third step above, the same as the choice of cross validation or AIC method to determine the optimal number of iterations m_{opt}. Finally, the regression tree model of gradient boosting is obtained, as shown in Figure 1.

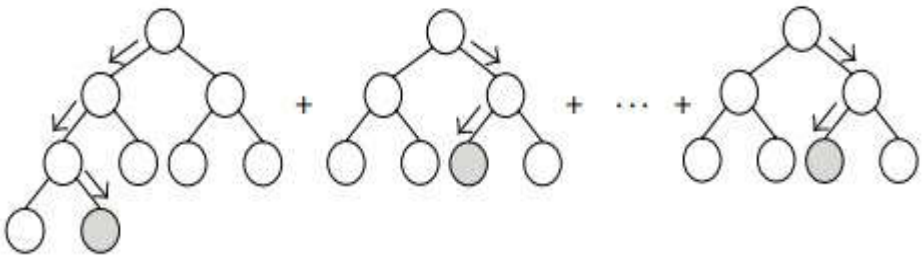


FIGURE1. Regression tree of gradient boosting

According to the work of [14] about the estimation method of boosting estimation, the important degree of residential characteristic variables to residential price can be obtained by the gradient boosting regression tree algorithm.

3. Data and Variable description. Beijing, Shanghai and Guangzhou are the three most influential cities in China. 2010 Chinese State Council approved and the highest three cities, which Beijing is located in the world's cities; Shanghai, Guangzhou positioning as an international metropolis. Because of its relatively advanced economy in China's cities, it is often used as a model for the analysis and prediction of urban economic indicators. A large number of populations caused by the impact of housing characteristics on the stability of prices in the three cities.

In view of these three cities has a strong representation. In this paper, we chose Beijing, Shanghai and Guangzhou to build a new housing community as the basic unit of analysis. The commercial housing community is built by a single real estate developer, with different infrastructure and public services. These regional real estate markets have started earlier, the market is mature, and the relevance and interaction of the market is strong. Through the authority of the real estate website home off, from the housing network, Sina Real estate website, Beijing City, Shanghai City, and Guangzhou City three cities in the first opening price data are collected. And the Internet electronic map (Baidu map) is used to measure the distance variables for the geographical location of the development of the geographical location, including longitude, latitude. The central city of the three cities are selected as the Tiananmen of Beijing, Shanghai people's Square, Guangzhou Zhongshan Park respectively. Before the model is estimated, the data are pre processed to remove the abnormal value, and the effective residential sample is 253. The economic development, cultural atmosphere, and natural environment of the region are analyzed, and the advantages and limitations of several special diagnostic variables in the domestic and foreign literature are compared. Based on the characteristics of the market, the 19 characteristics of the real estate market are selected, including architectural features, location characteristics, and three categories of neighborhood characteristics. The variables definition are as follows: first opening price y, main city zone x_1,vice city x_2, primary and middle school x_3, university x_4, kindergarten x_5, integrated shopping mall x_6, bank x_7, hospital x_8, recreation and entertainment x_9, restaurant x_{10}, decoration x_{11}, the subway x_{12}, volume ratio x_{13}, greening rate x_{14}, property charges x_{15}, area covered

x_{16}, built-up area x_{17}, average area of house x_{18}, away from the city centre (CBD) km x_{19}. The meaning of some of the variables and the definition are shown in Table 1.

TABLE 1. Quantification of residential characteristic variables

Variables	Variable definition
main city zone x_1	If in the main urban area is equal to 1, otherwise it is equal to 0.
primary and middle school x_3, university x_4, kindergarten x_5	If there is a kindergarten, primary and secondary school, and the university is equal to 1, otherwise it is equal to 0.
integrated shopping mall x_6	If there is a large mall in the vicinity of the 3km is equal to 1, otherwise it is equal to 0.
bank x_7	If there is a bank business hall in the vicinity of the 1km is equal to 1, otherwise it is equal to 0.
hospital x_8	If there is a hospital in the vicinity of the 3km is equal to 1, otherwise it is equal to 0.
recreation and entertainment x_9	If the area of the 3km has a place of entertainment is equal to 1, otherwise it is equal to 0.
restaurant x_{10}	If there is a restaurant in the vicinity of the 1000m is equal to 1, otherwise it is equal to 0.
decoration x_{11}	If the hardcover is equal to 1, otherwise it is equal to 0.
the subway x_{12}	If there is a metro area in the vicinity of the 1000m is equal to 1, otherwise it is 0.

4. Modeling analysis.

4.1. Descriptive statistical analysis. This paper analyzes the data of new housing prices and the characteristics of variable data in Beijing, Shanghai and Guangzhou. As shown in table 2.

Table 2 show the average price of housing and property charges in Shanghai are the highest in three cities, and the distance from the CBD is the shortest. The average house price of Guangzhou is the lowest in Beijing and Shanghai, but the distance from CBD to is about 1.5 kilometers away from CBD and more than 5.2 kilometers away from Beijing. Volume rate, also known as gross floor area, is the ratio of the total construction area and the area of land area. The analysis shows that the volume ratio of Beijing is 2.200, Shanghai is 2.156, and Guangzhou is 3.670. Beijing's new residential green rate is about to 70%, and 2 times in Shanghai and Guangzhou. Floor area and building area both are the largest in Guangzhou, Shanghai is the smallest. Shanghai's new residential average size of the house is higher than the other two cities.

TABLE 2. Comparative analysis of market segments

Characteristic variable	Beijing	Shanghai	Guangzhou
Average price *(**unit:** Yuan/ m^2)*	32585.76	46197.65	23420.48

volume ratio x_{13}	2.1998	2.1595	3.6702
greening rate x_{14}	0.6984	0.3578	0.3635
property charges x_{15} *(**unit:** Yuan/ m^2 / month)*	3.554	4.3536	3.0381
area covered x_{16} *(unit:m^2)*	134741.99	90548.31	186175.06
built-up area x_{17} *(unit:m^2)*	258408.47	243269.43	575778.04
average area of house x_{18} *(unit:m^2)*	114.59	152.81	105.14
CBD x_{19} *(unit:km^2)*	24.209	15.521	17.06

4.2. Construction of classic log linear hedonic price model. First, this paper takes the new residential sales price as the dependent variable, the 19 characteristic variables as independent variables, and to build a log linear feature price model. And then use the stepwise regression method to eliminate the variables that are not significant. The parameter estimation and test results are shown in Table 3.

TABLE 3. Parameter estimation of the new housing price log linear model

Model	Beijing	Shanghai	Guangzhou
	Coefficient *(standard error)*	Coefficient *(standard error)*	Coefficient *(standard error)*
constant	9.954** *(0.117)*	9.626** *(0.165)*	9.843** *(0.587)*
main city zone x_1	0.394** *(0.062)*	0.216* *(0.082)*	0.394** *(0.062)*
hospital x_8	0.231** *(0.058)*	-	-
recreation entertainment x_9	-	0.194** *(0.059)*	0.207* *(0.155)*
decoration x_{11}	0.182** *(0.058)*	0.241** *(0.058)*	-
the subway x_{12}	-	0.119* *(0.054)*	-
greening rate x_{14}	0.064** *(0.023)*	0.982* *(0.376)*	-
property charges x_{15}	-	0.043** *(0.011)*	-
average area of house x_{18}	0.001** *(0.000)*	0.002** *(0.000)*	-
CBD x_{19}	-0.015** *(0.002)*	-0.019** *(0.003)*	-0.104** *(0.005)*

*Note: * indicates significant levels of 0.05, * * indicates a significant level of 0.01.*

From table 3, we can see that the impact of Beijing's new residential average price is the number of kilometers away from the city center, the main city, hospitals, family size, decoration, green rate, etc. And the parameter estimation coefficient of the significant characteristic variable is in line with the economic significance. Shanghai new housing prices are mainly affected by the main city, leisure and entertainment facilities, decoration, the subway, green rate, property costs, family size, the number of kilometers away from the city center and other characteristics of these eight variables. New housing prices in Guangzhou are mainly influenced by the main urban areas, recreational facilities and CBD of the three characteristic variables. Clearly in the market segments, based on the classic logarithmic hedonic price model, the common factors that affect the residential characteristics of the newly built residential buildings are the CBD distance and the main urban area. The coefficient of distance from the city center (CBD) is large. The impact of the house price is deep, and its coefficient is negative. We can know the distance from the city center and the price of real estate. Whether it is located in the main city of real estate prices have a greater impact. The main city is a city of political and cultural center. Its influence is higher, compared with the natural and vice city will have a higher price difference.

4.3. Boosting regression tree analysis. Through the analysis of the 4.2 section based on the three cities, the paper finds that The market is divided into a very small number will lead to the vary greatly between the characteristics of the residential market. At the same time, it is also suspected that the limitations of the distribution assumption on the model and the distribution of different models are not appropriate. As is known to all, the three cities house prices of Beijing, Shanghai and Guangzhou are typical representative of high housing prices with obvious similarities in China. Next, this paper based on data driven machine learning method, from the perspective of the merger of these three cities to build a model. To explore the influencing factors of housing price in China's real estate market, especially to measure the relative importance degree.

Based on the gradient boosting regression tree algorithm, the distribution of the loss function is 90% off, the number of iterations is 1000, the depth of the tree is 5, the learning rate is 0.01, the sampling rate is 50%, the 10-folds cross validation is used to obtain the iterative number of the algorithm and the variation of the regression tree is shown in Figure 2.

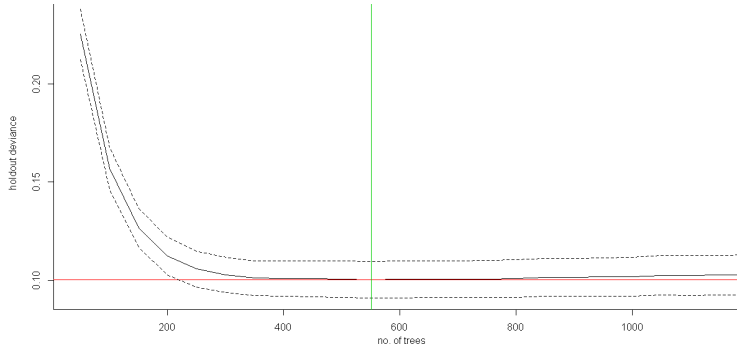


FIGURE 2. 10-folds cross validation regression tree iteration number

From Figure 2 we can see that the algorithm iteration number is stable at 550. In addition, the risk of the model based on the training data is estimated to be 0.0434, and the test data is 0.1627, the corresponding standard error is 0.0048 and 0.0245 respectively, which show that the accuracy of the boosting regression tree is very high in the sample and out the sample. The importance of variables in new house price of three cities are sorted, see table 4.

TABLE 4. Ranking of the importance of residential characteristic variables

Variable	x_{19}	x_{15}	x_1	x_{18}	x_2	x_{17}	x_{13}	x_{16}	x_4	x_6
Importance (%)	28.6869	15.3482	14.3232	11.8131	8.6060	3.6690	3.3681	3.3656	2.7199	2.4620
Variable	x_{14}	x_9	x_{11}	x_5	x_{12}	x_8	x_3	x_7	x_{10}	
Importance (%)	2.1152	1.1266	0.9771	0.6488	0.3788	0.2206	0.0910	0.0798	0.0000	

From table 4, the main influence factors on the new housing price sorted in order from big to small are CBD, property costs, the main city , the average size, Vice City, construction area, floor area, floor area, University, integrated shopping malls, and green rate, etc. However, banks, restaurants and other characteristics of the impact of residential prices are relatively small, especially if there is a restaurant on the impact of residential prices almost 0. Further analysis on the contribution of residential property to the housing price (See Figure 3.), we can see that the effect of residential characteristic variables on the housing price is almost non-linear. So the classic linear hedonic model is not suitable for the model.

From the common effect of residential characteristics on the impact of residential price, the interaction between the features is not particularly evident. The interactions between the main city x_1 and CBD x_{19} on the impact of housing prices are relatively obvious. The relationship between the three can be seen from the following three-dimensional visualization (See Figure 4.).

In this paper, we construct a gradient boosting regression tree model, as shown in Figure 5. The graph gives the characteristic variable decision tree rules and the influence path of the house price.

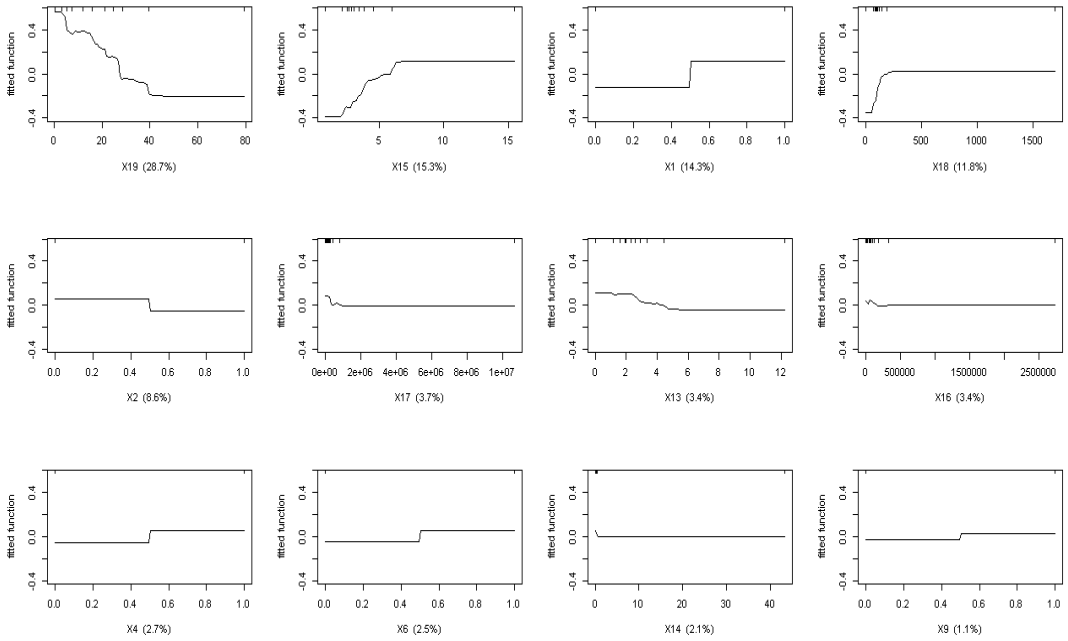


FIGURE 3. Influence of the characteristic variables (>1%) on the residential price

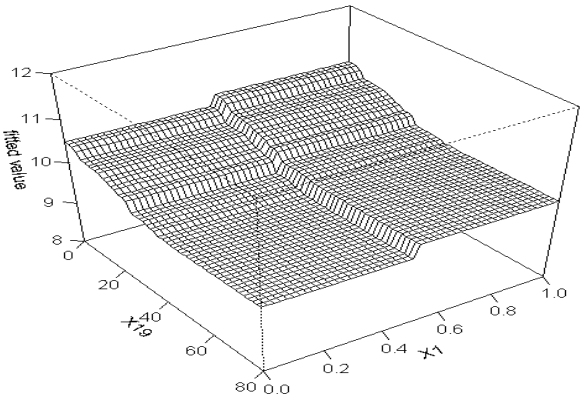


FIGURE 4. Interaction impacts between CBD and main city to house price

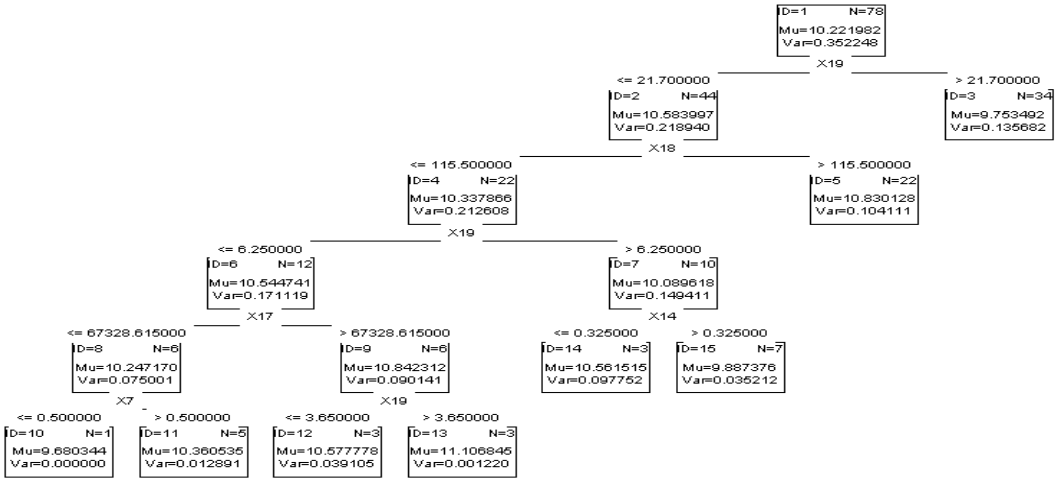


FIGURE 5. Gradient boosting regression tree model

5. **Conclusions.**

This paper selects three new housing markets in Beijing, Shanghai and Guangzhou as the research object. Based on the comparison of the traditional new residential price log linear hedonic price model and the gradient boosting regression tree algorithm to modeling analysis, the paper finds that the latter is more reasonable and rich in information, and the accuracy is high, the characteristic variables are more likely to be measured. And can get the characteristics of the price of residential variable decision rules.

Through the above modeling and analysis, we can further know the following conclusions: (1) in the location characteristics, the division of administrative areas of housing has a significant impact, and the main urban housing prices are higher than the sub-district and the commercial center of population density and land prices result in high prices. CBD and the main sub district are the significant impact factors in the new housing prices of the three cities. (2) In architectural features, the impact of green rate is very significant. Green rate is higher, the higher the residential price. Green rate is lower, the lower the residential price. At the same time, the sizes of the area and property costs also have a certain impact. These characteristics are mainly related to the life style and habits of the people. (3) In the neighborhood characteristics, impact on residential prices by the surrounding entertainment facilities, school district room, such as the impact of a certain proportion of kindergarten. But the banks and the role of the restaurant are not significantly reflected. This is likely due to the three cities in the more developed economies, the more complete urban facilities, banks and restaurants more than a large number of. This paper based on the gradient boosting regression tree data mining method in the residential hedonic price modeling effect is obvious. With the advent of the Internet and the era of big data, real estate is not easy to get the micro data as before. Based on similar data mining, machine learning method to construct the housing hedonic price model of the housing price index, it is more meaningful. The related research and the empirical analysis are worth to be further discussed. The advantages of the housing price index can be a reference for the residents, government statistics department or industry organizations to study and observe the housing price trend.

Acknowledgment. This work is partially supported by the National Statistical Science Program of China (No. 2013LY123), the Zhejiang Provincial Department of education project of China (No. Y201223259) and the Natural Science Foundation of China (No. FX2014035). The authors also gratefully acknowledge the helpful comments and suggestions of the reviewers, which have improved the presentation.

REFERENCES

[1] Lancaster, K, Change and innovation in the technology of consumption. *American Economic Review*, vol.56, no.2, pp.14-23, 1966.

[2] Griliches, Z, Price indexes and quality change: studies in new methods of measurement. *Journal of the Royal Statistical Society,* vol.136, no.1, pp. 275-281, 1971.

[3] Rosen, S, Hedonic prices and implicit markets: product differentiation in pure competition.

Journal of Political Economy, vol.82, no.1, pp. 34—55, 1974.

[4] Wen Haizhen and Jia Shenghua, Market Segment and Hedonic Price Analysis of Urban Housing. *Journal of Zhejiang University(Humanities and Social Sciences)*,vol.36, no.2, pp.155-161,2006.

[5] Lu Yu, Zheng and Liu, The Spatial Variation and Affecting Factors Of The Housing Price Gradients——The Case of Beijing. *Economic Geography*, vol.28, no.3, pp.406-410, 2008.

[6] Wen H Z, Xiao-Qing B U and Qin Z F, The Spatial Effect of Urban Lakes on Housing Prices——The Case of the West Lake in Hangzhou. *Economic Geography,* vol.32, no.11, pp.58-64, 2012.

[7] Mccord J, Mccord M and Mccluskey W, Effect of public green space on residential property values in Belfast metropolitan area. *Journal of Financial Management of Property and Construction*, vol.19,no.21,pp.117-137, 2014.

[8] Shi Y and Muxiu L I, The Analysis of the Housing Price Gradient and Its Impact Factors of Shanghai City. *Acta Geographica Sinica*, vol.61, no.6, pp.604-612, 2006.

[9] Weicher, John, C., Zerbst, and Robert, The externalities of neighborhood parks: an empirical investigation. *Land Economics*, vol.49, no.1, pp.99, 1973.

[10] Potepan, Explaining Intermetropolitan Variation in Housing Prices Rents and Land Prices. *Real Estate Economic*, vol. 1, no.24,pp.219-245, 1996.

[11] Wang Y, The Research of Application of Semi Parameter Regression Model to Price Index of Housing for Sale. *Statistical Research*, no.4:pp. 25-29, 2005.

[12] Hofner B, Mayr A and Robinzonov N, Model-based boosting in R: a hands-on tutorial using the R package mboost. *Computational Statistics*, vol. 29, no. 12, pp.3-35, 2014.

[13] Li, Q. and Mao, Y. A review of boosting methods for imbalanced data classification. *Pattern Analysis and Applications,* vol.17, no.4, pp.679-693, 2014.

[14] J.H. Friedman, Greedy Function Approximation: A Gradient Boosting Machine. *Annals of Statistics*, vol. 29, no. 5, pp.1189-1232, 2001.

The Importance of the Balance between Leading Players and Supporting Staffs in a Team: A Simulation Using Agent–Based Model "Die Mannschaft"

Nathamon Tayutivuthikul, Komsan Suriya and Siriporn Srichoochart
Faculty of Economics and Social Research Institute,
Chiang Mai University
Chiang Mai 50200, Thailand
Email: suriyakomsan@gmail.com

ABSTRACT. *This study extends the study of Tayutivuthikul and Suriya (2015) and uses the agent-based simulation "Die Mannschaft" to simulate football matches in order to answer whether the addition of attackers can raise the performance of a team who work under the O-ring theory. The motivation comes from the conclusion of the previously mentioned work that the quality of the attackers determines the success of a team. Therefore, the addtion of the scorers should make the team more successful. However, the results show that this is not true. The formation of 4:3:3 with the emphasis on the forwarders loses to the formation of 4:4:2 with less number of forwarders but more balance in the team setting especially between the scoring and supporting positions. This finding reveals that an optimal team should have a good combination between the leading players and supporting stafffs. Less supports will undermine the performance of the team even though the team is equipped with good leading players.*

Keywords: Team combination, O-ring theory, Simulation, Agent-based simulation, Optimization

1. Introduction. A series of the finding of the optimal combination of a team begins from the work of Kiatkarun and Suriya (2013) who conduct an experiment to find out the determinance of a good team under O-ring and Foolproof theories. Then Kreinovich, Sudtasan and Suriya (2014) find the outcome of the different distribution of human capital in a team by a simulation called "Fighter Ant Algorithm". The work of Suriya et al (2015) especially Vladik Kreinovich who is the main contributor of this work adds that the diversity of team members is beneficial for a team and give an example of a research group. This series of research still continues and challenges the field of team management and managerial economics.

The recent work of Tayutivuthikul and Suriya (2015) creates an agent-based simulation called "Die Mannschaft" to simulate football game that mimics the working under O-ring theory (Kramer, 1993). It finds that the, under the limited capital, the emphasis on the forwarders determines the success of a team. Therefore, it is curious whether the addition of more forwarders will make the team even better or not.

This study also applies the Die Mannschaft model to simualte the football matches between a team with more forwarders but less supporting staffs (the formation of 4:3:3 which means 4 defenders, 3 midfielders and 3 forwarders) and a terma with less forwarders but more supporting staffs ((the formation of 4:4:2 which means 4 defenders, 4 midfielders and 2 forwarders). It hypothesizes that the formation of 4:3:3 should win.

2. Theory and conceptual framework. In brief, Kramer's O-ring theory indicates that a team whose works of each staff are linked together as steps on a manufacturing belt will perform well when there is no mistake made by each staff. The more mistake, the worse

performance of the team. Considering a Cobb-Douglas production function with the adaptation to explain this theory by Kramer (1993) with an example shown in Suriya (2010):

$$Q = K^{\alpha}\left(\prod_{i=1}^{N} q_i\right)\cdot N \cdot B$$

when K = Capital
q_i = Pprobability of a labor who successfully completes a task
N = Number of processes in a production line
B = Average working efficiency of workers

The new production function mostly depends on q_i as it is shown as belows:

Example 1: there are 5 workers and q_i of each person is 0.99. The result will be shown as $Q_1 = 0.95 \cdot K^{\alpha} \cdot N \cdot B$

Example 2: there are 5 laborers. q_i of 4 laborers is 0.99 and q_i of the remainder is 0.50. the result will be shown as $Q_2 = 0.48 \cdot K^{\alpha} \cdot N \cdot B$

Example 3: there are 5 laborers and their q_i are 0.05. The result will be shown as $Q_3 = 0.03 \cdot K^{\alpha} \cdot N \cdot B$

Example 4: supposing that q_i of one of laborers is zero, the result will be illustrated as $Q_4 = 0$

Observing that the outcome of first example completely contrast from the result of the second one.

$$\frac{Q_2}{Q_1} = \frac{0.48}{0.95} = 0.51\,\text{times} \quad \text{and} \quad \frac{Q_3}{Q_1} = \frac{0.03}{0.93} = 0.03\,\text{times}$$

An above equation illustrates that only one inefficient laborer in the excellent team can decrease the production to fourty nine percentages (the number of a production decline from 100 to 51). Also, supposing that the team consist of the inefficient laborers, the production will be reduce to ninety seven percentages (the number of a production decline from 100 to 3).

This example illustrates that a mistake made by just a member in a team will worsen the team's performance drastically. Therefore, the best choice is to put all the high-quality members into the team to make sure that the team performs excellently.

However, due to the limited capital that restricts a team to acquire the best member into it, it must compensate the good and bad members in the combination of a team. To answer this question of how to allocate the resource to make a good combination of a team, Tayutivuthikul and Suriya (2015) simulate football matches using the formation of 4:4:2 for both sides and vary the quality of each position. They discover that the emphasis at the forwarders makes the performance of a team better than the focus on other positions.

The results are interesting and bring a further research question what would happen if a team adds more forwarders. It should win over another team with less forwarders. However, this hypothesis may not be obvious when that team must trade-off between the forwarders and midfielders who act like supporting staffs.

3. Methodology and the Die Mannschaft model. The "Die Mannschaft" model is a kind of agent-based simulation. It simulates the sequential working process under the O-ring theory

by modeling the football game. The word “Die Mannschaft” which is German means “The Team”. It is also the nickname of the national football team of Germany.
Similar to the work of Tayutivuthikul and Suriya (2015), the model divides players into two teams, red and blue. Each team contains 11 persons. There are three functions in the team; they consist of strikers, midfielders and defenders. A simulator can assign any number 0 to 11 to each function, e.g. 4 defenders with 4 midfielders and 2 strikers. This is concerned the 4:4:2 formation in football. When there are 4 defenders, 3 midfielders and 3 strikers, this is called the 4:3:3 formation.

The determinant of winner is the score. When a team scores more than another team, then the team is the winner. The score can be draw when both teams get the equal scores. It simulates the game for 1,000 times per each setting to ensure that the simulation finds the real winner.

4. The simulation. Underlying assumptions of these simulations are as follows:

1) The Red play with four defenders, three midfielders and three forwards (The formation of 4:3:3 in football strategy) while the Blue, play with four defenders, four midfielders and two forwards (The formation of 4:4:2 in football strategy).
2) The endowment of each team equals to 30 points.
3) The trade-offs among different formations in the 4:4:2 strategy are assigned as shown in Table 1 and the formation of 4:3:3 are shown in Table 2.

Table 1: Settings of the formation of the endowment allocation under the formation of 4:4:2

	Uniform	Dominant forwards	Dominant midfielders	Dominant defenders
Defender 1	3	1	1	5
Defender 2	3	1	1	5
Defender 3	3	3	1	5
Defender 4	3	3	1	5
Midfielder 1	3	3	5	1
Midfielder 2	3	3	5	1
Midfielder 3	3	3	5	1
Midfielder 4	3	3	5	1
Forward 1	3	5	3	3
Forward 2	3	5	3	3
Summation of the endowment	30	30	30	30

Source: Assignment by authors.

Table 2: Settings of the formation of the endowment allocation under the formation of 4:3:3

	Uniform	Dominant forwards	Dominant midfielders	Dominant defenders
Defender 1	3	1	1	5
Defender 2	3	1	1	5
Defender 3	3	1	1	5
Defender 4	3	3	3	5
Midfielder 1	3	3	5	1

Midfielder 2	3	3	5	1
Midfielder 3	3	3	5	1
Forward 1	3	5	3	1
Forward 2	3	5	3	3
Forward 3	3	5	3	3
Summation of the endowment	30	30	30	30

Source: Assignment by authors.

The simulation results are displayed in 2 tables. Table 3 focuses on the Red's view and Table 4 focuses on the Blue view. As the results in Tayutivuthikul and Suriya (2015) show that there is no first mover's advantage. Therefore, this study does not vary the player who starts the match. Then the Red starts all matches.

Table 3: Simulation results when Red team starts the match and the results focus on Red team's formation

Red team's formation	Blue team's formation	Matches	Red wins	Blue wins	Tie	Difference	Prob. Red wins	Prob. Blue wins
Uniform	Uniform	1,000	37.10	45.50	17.40	-8.4000	**0.35**	0.47
Uniform	Dominant forwards	1,000	31.50	51.00	17.50	-19.5000		
Uniform	Dominant midfielders	1,000	35.90	42.50	21.60	-6.6000		
Uniform	Dominant defenders	1,000	34.30	47.70	18.00	-13.4000		
Dominant forwards	Uniform	1,000	36.00	48.20	15.80	-12.2000	**0.37**	0.46
Dominant forwards	Dominant forwards	1,000	35.00	47.00	18.00	-12.0000		
Dominant forwards	Dominant midfielders	1,000	38.60	44.20	17.20	-5.6000		
Dominant forwards	Dominant defenders	1,000	39.30	45.00	15.70	-5.7000		
Dominant midfielders	Uniform	1,000	35.70	47.60	16.70	-11.9000	**0.35**	0.48
Dominant midfielders	Dominant forwards	1,000	33.10	53.50	13.40	-20.4000		
Dominant midfielders	Dominant midfielders	1,000	36.00	45.70	18.30	-9.7000		
Dominant midfielders	Dominant defenders	1,000	34.40	47.30	18.30	-12.9000		
Dominant defenders	Uniform	1,000	38.30	43.60	18.10	-5.3000	**0.36**	0.45
Dominant defenders	Dominant forwards	1,000	33.20	48.50	18.30	-15.3000		
Dominant defenders	Dominant midfielders	1,000	40.00	41.30	18.70	-1.3000		
Dominant defenders	Dominant defenders	1,000	34.70	47.10	18.20	-12.4000		

Source: Calculation by authors.

On the Red's view, there is no formation that the Red overcomes the Blue. The results are even worse than the formation 4:4:2. These results lead do not confirm that the additional forward in the formation of 4:3:3 is better than the balanced formation between the supporting staffs and the strikers in the 4:4:2.

Table 4: Simulation results when Red team starts the match and the results focus on Blue team's formation

Blue team's formation	Red team's formation	Matches	Red wins	Blue wins	Tie	Difference	Prob. Red wins	Prob. Blue wins
Uniform	Uniform	1,000	37.10	45.50	17.40	-8.4000	0.37	**0.46**
Uniform	Dominant forwards	1,000	36.00	48.20	15.80	-12.2000		
Uniform	Dominant midfielders	1,000	35.70	47.60	16.70	-11.9000		
Uniform	Dominant defenders	1,000	38.30	43.60	18.10	-5.3000		
Dominant forwards	Uniform	1,000	31.50	51.00	17.50	-19.5000	0.33	**0.50**
Dominant forwards	Dominant forwards	1,000	35.00	47.00	18.00	-12.0000		
Dominant forwards	Dominant midfielders	1,000	33.10	53.50	13.40	-20.4000		
Dominant forwards	Dominant defenders	1,000	33.20	48.50	18.30	-15.3000		
Dominant midfielders	Uniform	1,000	35.90	42.50	21.60	-6.6000	0.38	**0.43**
Dominant midfielders	Dominant forwards	1,000	38.60	44.20	17.20	-5.6000		
Dominant midfielders	Dominant midfielders	1,000	36.00	45.70	18.30	-9.7000		
Dominant midfielders	Dominant defenders	1,000	40.00	41.30	18.70	-1.3000		
Dominant defenders	Uniform	1,000	34.30	47.70	18.00	-13.4000	0.36	**0.47**
Dominant defenders	Dominant forwards	1,000	39.30	45.00	15.70	-5.7000		
Dominant defenders	Dominant midfielders	1,000	34.40	47.30	18.30	-12.9000		
Dominant defenders	Dominant defenders	1,000	34.70	47.10	18.20	-12.4000		

Source: Calculation by authors.

On the Blue's view, it is also clear that no matter the Red plays any formation, the chance of the Blue to win exceeds that of the Red. The results are better than the previous ones when the Red plays with the 4:4:2 formations.

5. Discussion. The results discovered in this study emphasize the role of supporting staffs. When the work of Tayutivuthikul and Suriya (2015) may mislead the conclusion that the more attacking, the more chance to win the game. This may lead a team to add more strikers while reducing the supporting staffs in the midfield. The results should have shown the positive outcomes when a team plays like that, but the simulation reveals the contradictory outcomes such that the formation of 4:3:3, with an addition of a forward and a reduction of a midfieder, is inferior to the formation of 4:4:2.

Therefore, the results in this study destroy the believe from the work of Tayutivuthikul and Suriya (2015) that a team should not place too much attention to the quality and quantity of the strikers, even though the strikers are key players to lead the team to fulfill the main objective of the organization. A team should never underestimate the role of supporting staffs. It is clear that when there are less supporting staffs in a team, the strikers are not sufficiently and effectively supported to score the goal, regardless of how many and how good of the strikers. This should be a caution of all teams and organizations in order to set an optimal combination of a team.

6. Conclusions. This paper extends the work of Tayutivuthikul and Suriya (2015) and uses the agent-based simulation "Die Mannschaft" to mimic football game in order to find a good combination

of a team. The findings reveal the importance of the supporting staffs rather than the leading players. The study convinces a team not to overlook the supporting roles. A team cannot win the game even though it has more forwards with high quality but not enough supporting teammates that pass the ball to them efficiently. The team should not underestimate the supporting staffs and replace them by more strikers. This is a big illusion in any organization that aims at making more profit by adding more strikers into the team while reducing the supporting staffs that work behind the strikers.

For the conclusion, an optimal team in the O-Ring process should have a balance between the leading staffs who score and fulfill the main objective of the organization and the supporting staffs. The number of supporting staffs should be enough to ensure that the process flows to the strikers smoothly and efficiently. Attaking formation is good but not the best when a team overlooks the roles of supporting staffs.

REFERENCES

[1] Kiatkarun, Tanita and Komsan Suriya, Mechanism design for increase of team performance: An economic experiment using O-Ring and Foolproof theories, *The Empirical Econometrics and Quantitative Economics Letters,* vol. 2, no.2 June 2013, pp. 57 – 70, 2013.

[2] Kreinovich, Vladik, Tatcha Sudtasan and Komsan Suriya, Simulation using fighter ants algorithm with an application on efficient team building. *International Journal of Intelligent Technologies and Applied Statistics,* vol.**7**, no.2, pp. 47-57, 2014.

[3] Kremer, Michael, The O-ring theory of economic development. *The Quarterly Journal of Economics (August 1993)*, vol. 108, no. 3, pp. 551-575, 1993.

[4] Suriya, Komsan, *Advanced Development Economics: Theories for Doing Research.* Chiang Mai: Faculty of Economics, Chiang Mai University, 2010.

[5] Suriya, Komsan, Tatcha Sudtasan, Tonghui Wang, Octavio Lerma and Vladik Kreinovich. Diversity is beneficial for a research group: One more quantitative argument, *Journal of Uncertain Systems,* vol. 9, no.2, pp. 144 - 147, 2015.

[6] Tayutivuthikul, Nathamon and Komsan Suriya. Simulation of optimal team combination under o-ring theory using agent–based model "Die Mannschaft," *International Journal of Intelligent Technologies and Applied Statistics,* vol. 8, no.2, pp. 139 – 152, 2015.

Analysis of Influence Factors of Non-Performing Loans and Path Based on the Dynamic Control Theory[1]

Wang zhenLei[1], Qin Song[2,3]
[1] HangZhou DianZi University
HangZhou, P.R.China
[2]HuaZhou University of Science and Technology
WuHan, P.R.China
[2] TaiZhou University
TaiZhou, P.R.China

ABSTRACT.*With non-performing loans as the object of the research, it leaded the ability of managing bank loans into the model in ZengShiHong(2004). It set up an influence factors of non-performing loans' model based on the dynamic control theory, analyzed different pathof non-performing loans basing on changing of different influence factors. It obtained some conclusions. Firstly, non-performing loans decreased with increasing of the ability of controlling risk before and after releasing loans, vice versa. Secondly, non-performing loans decreased with increasing of macro-economy, vice versa.*
Keywords: Dynamic control theory, Non-performing loans, Hamilton function

1.Introduction. On June 7th, 2013, the People's Bank of China released the report which pointed out that the balance of non-performing loans of Chinese banking financial institutions rebounded for the first time after the year of 2005.Credit risk has emerged. As of the end of 2012, the balance of non-performing loans was1070billion yuan and it was 23.4 billionyuan more than the beginning of the year. Non-performing loan rate was 1.56% in 2012. In this case, how toestablish early warningmodels to recognize as the factors that influencednon-performing loans and take effective measures to prevent, control and manage the banks' credit assets has been the new issue whichis widespread concerned in the academic circle and practice circle.

Foreign scholars mainly focused on the formation mechanism and the influence factors of non-performing loans for the study of bad loans. Houben, A., Kakes, J., G., Band, Shinasi, D., O., &Hartmann, P., thought that the vulnerability of financial markets was the source of non-performing loans. NkusuMwanza (2011)studied of the 3 major branches of non-performing loans in detail.The first branch was concerned with explaining the non-performing loans' differences in the different countries and different banks and the position of non-performing loans in the macro-economic operation, management quality and policy choice. Dash and Kabra (2010) gave a more detailed overview of the non-performing loans and analysedthe different types of non-performing loans including commercial loans, consumer loans and credit loans with data of 9 banks in Greece in September, 2003. Louzis, Vouldis and Metaxas (2010) found that the quality of banks' management and macroeconomic performance were suitable to explain the non-performing loans, especially mortgage non-performing loans to the extent of macroeconomic which was minimal impact. They also found a positive correlation between NPL and the actual borrowing rate, that is, with the increasing in non-performing loans, the real interest rate rising. Through the analysis of the characteristics of the banks, the low efficiency management level and the higher cost-income ratio were positively correlated with

[1]Grant from:ZheJiangPhilosophy and Social Science Planning Project(14NDJC026YB); Chinese Postdoctoral Science Foundation(No.2013M542029); ZheJiangPhilosophy and Social Science Key Research Base: The Research Center of Information Technology & Economic and Social Development Project(14XXHJD08YB); The Research Base of ZheJiang Statistics Science Project(2015); TaiZhouPhilosophy and Social Science Planning Project(12GHY01)

the non-performing loans.The relationship between non-performing loans and macro financial conditions was analyzed in second branchesand the probability of non-performing loans to the crisis was positively affected. Kaminsky and Reinhart (1999) found that the increasing in large non-performing loansindicated that the economic crisis emerged. But there were some scholars opposing. Duttagupta and Cashin (2008) found that the negative correlation between non-performing loans and economic crisis, that is to say, when non-performing loans increased, the bank wouldincreasedthe power of the control of non-performing loans again which would reduce the probability of occurrence of the crisis. Although there was no direct relationship between the crisis probability and bad loans, scholars (Klingebiel, 1996; Pazarbasioglu, Drees, 1998; Kaminsky) studied of high non-performing loans as a part of direct or indirect variables which helped to predict the crisis.The third branch analyzed panel data from non-performing loans. Brooks, Dicks and Pradhan (1994) focused on the rising in the inflation rate for the role of a pledge of non-performing loans. Rinaldi and Sanchis-Arellano (2006) analyzed the situation in which the family had a non-performing loan (data from the panel data of 7 euro zone countries). Jappelli, Pagano and Marco (2008) analyzed consumer credit and pledge loans (data from 11 euro zone countries) and found that the debt-to-incomeand non-performing loan were positive correlation. That is to say, with the increasing in the proportion of debt-to-income, non-performing loans increased. Rinaldi and Sanchis-Arellano (2006) pointed out, in the short term, housing prices had a negative correlation with NPL.When housing prices were falling, non-performing loans were rising because of the role of a buffer in the unexpectedthat is to say stock price, or the purchase of a buffer that can be used to reduce the credit risk caused by the shortage of stock price volatility. That is to say, the purchase price increased, the purchase amount was reduced. Originally, more money purchasing houseswas invested in the stock market or production which leaded to the reduction of non-performing loans. Some scholars studied the financial supervision, the bank's own characteristic indexes of non-performing loans to the valuesincluding the relations between the capital adequacy ratio, asset profit rate, loan loss provision coverage, equity structure and non-performing loans.

Domestic scholars mainlystudiedon policy initiatives to decrease the non-performing loans, non-performing loan recovery rate and non-performing loans and bank efficiency relations, etc.. Some scholars used statistical methodsto study the recovery rate of non-performing loans with the perspective of regional, industry and enterprise type. Chen MuZi(2011) established non-performing loan recovery rate model based on the logistic model and generalized beta regression method to study of non-performing loans zero recovery rate dynamic changes of influence factors at the time span which was from 2001 to 2008. Wang Bo(2011) established a single family of non-performing loan recovery rate forecast model and studied factors that affected the recovery rate of non-performing loans, including the risk exposure scale, region, industry, security and five classification. Wang DongHao(2010) studied the recovery rate of non-performing loans structure characteristics of different size of small and medium enterprises. And the relationship between the productivity and the efficiency of non-performing loans and the factors of the banking industry had been studied. Yang PengPeng(2008) used Granger causality test method to test the assumption that the relationship between the commercial banks' non-performing loans and the efficiency. Wang Bing (2011) used SBM directional distance function and Luenberger productivity index to measure the efficiency and total factor productivity growth of

11listed commercial banks in China from2003 to 2009. The results showed thatthe efficiency of joint-stock commercial banks was better than commercial banks, non-interest income and non-performing loans were the main sources of Bank inefficiency.

Comparing of domestic and foreign scholars research literature, there are some differences as follows. Firstly, it is the study of the breadth and depth of the gap. Foreign scholars mainly deeply analyzed the causes of non-performing loans and the influence factors. Scholars respectively analyzed the form of influencing in the macro including economic growth rate, inflation rate and unemployment rateand micro,mainly from the bank's own characteristic index value, such as correlation of capital adequacy ratio, asset profit rate, loan loss provision coverage, equity structure etc. Even some scholars had introduced the financial regulatory indicators into the bank's non-performing loans, including the level of capital requirements, government supervision, market standards and regulatory authorities. However, most of the research is on the "ex-post behavior". Secondly, it is the gap of research methods. Because of the limitation of the integrity, richness and continuity of the micro and macro data, the domestic scholars' researches on the non-performing loans were more inclined to qualitative analysis or the specific application of a theory.

Based on the above analysis, this paper studies the factors affecting the rate of non-performing loans of financial institutions and introduces the variables that reflect the bank’ loan management ability and macro economy by dynamic control theory model. The organization of this paper is as follows. In section 2,we introduce the construction of the model variable selection and the utility function. In section 3, we present the construction of the dynamic control model. In section 4 we report the model path analysis. In section 5 we leave some concluding remarks.

2.Variable selection and construction of utility function

2.1 Variable selection. Banks with higher profitability have less pressure on the creation of income, and there is no need to set more constraints on credit products to control the risk of the product. At the same time, banks with lower profitability will face more high levels of problem loans than banks with higher profitability. Poor management implies high operating costs and low credit quality customers which also lead to high capital losses.Basing on theory, the greater the size of bank assets, the stronger the ability to resist risks, the quicker asset size growth rate and the more effective measures are to resist risks. By the concept of non-performing loans, non-performing loans is the sum of substandard, doubtful and loss class loan. If banksimprove the power of non-performing loan collection efforts, the probability of changing substandard and doubtful (or even loss class loan) into good loans will be increased. Thereby, that will increase the total social utility. So this paper considers the abilities of lenders’ research, risk control and non-performing loans collection efforts.

In order to increase the inputs of production, enterprises purchase equipment, inventory, production lines and other items. The price of goods directly determines the actual purchasing power of enterprise loans. If the price increases, the same amount of purchasing power will decline and company need much more money to buy good. So thatthe burden of the enterprise's financial is burdened and it is easy to lead to the possibility of heavy burden on the enterprise and non-performing loans. House price is an important part of the price index and the price of all kinds of goods is one of the components of the price index. The change of the price of house and the price of the other items will affect the non-performing loans, so the price index is one of the

macro economic factors that affect the change of non-performing loans.
Whether personal loans or business loans, loan interest are required to pay the bank. Because the loan principal is unchanged, the change in the interest rate will directly affect the amount of interest paid. In the short term, if interest rates rise, the loan interest payments increased. Once the amount of interest is much more than the borrower's ability to pay, it is easy to produce non-performing loans. And the increasing in non-performing loans, banks or financial institutions are bound to raise interest rates in order to control non-performing loans continuing to increase. From a long term, increasing of interest rates will reduce the number of borrowers and affect the profitability of banks or financial institutions. So interest rate is one of the factors that affect the change of non-performing loans.

If the economic situation was in the ascendant, enterpriseswill increase investment in order to be adapt to rising momentum. In the short term, the main source ofenterprises' investment is banks' loans which will be used to expand production. Due to the economic upward, good sales momentum and increasing profits, enterprises can repay the loans on time and the probability of non-performing loans will be reduced. If the economy shows a downward trend, that will weaken the momentum of business and operating income, reduce other basic expenses and increase the burden on business. In order to maintain corporate survival, enterprises will reduce expenses by layoffs. In the long run, if the economy continues downward, conditions of enterprises will deteriorate which will increase the probabilities of changing corporate loans into non-performing loans. So this paper considers the economic growth rate as one of the factors that affect the change of non-performing loans.

The exchange rate is more complex than other factors. On the one hand, the increasing in exchange rate will weaken the competitiveness of export companiesand affect their ability to repay (Fofack, 2005), on the other hand, that can improve the borrower's ability to borrow money from foreign financial institutions. For export enterprises, when the exchange rate falls, the part of the business earning is far less than that of the exchange rate increasing, on the production of the same product exports. When the exchange rate falls, the purchase of the same product used in the currency is much higher than that of the exchange rate increasing. From a long-term point of view, when the exchange rate falls, the financial burden of import and export enterpriseswill lead to a large probability of non-performing loans. If the exchange rate rises, for export enterprises, the earn from production of the same product is higher than that of the exchange rate falling; and for the import business, the purchase of the same import products used by the local currency is much lower than that of the exchange rate falling. From the perspective of external debt, if the exchange rate rises, enterpriseincreasesforeign debtvaluingin the local currency, the burden on enterprises and the possibility of business losses.If the exchange rate falls, enterprisereduces the value of foreign debt, the burden on enterprises and the possibility of loss. So the exchange rate is also one of the factors that affect the change of bad loans.

2.2 **construction of utility function**

Assuming L is total loans and N is the amount of non-performing loans. On the one hand, the L makes the enterprise produce more products and provide more serviceswhich will help to increase the total social utility. On the other hand, to a certain country, organization or region, the existence of N is a "financial pollutant"which will weaken the social utility. The utility function is constructed as follows (CengShiHong, 2004).

$$M = M(L),\ M' > 0, M'' < 0 \quad (1)$$
$$Q = Q(N),\ Q' < 0, Q'' < 0 \quad (2)$$

Assuming functional relationship of M and Q is as follows,

$M = M(L) = (uL^{\theta})^{\frac{1}{n}}$, that is to say $M^n(L) = [(uL^{\theta})^{\frac{1}{n}}]^n = uL^{\theta}$ (3)

$Q = Q(N) = -vN^m,\ v > 0$ (4)

The total utility function is $U = U(M(L), Q(N))$. For simple, it used exponential weighting utility function.

$U = U(M(L), Q(N)) = uL^{\theta} - vN^m,\ 0 < \theta < 1, u > 0, m > 1$ (5)

1. $\frac{\partial U}{\partial L} = u\theta L^{\theta-1} > 0$ and $\frac{\partial^2 U}{\partial L^2} = u\theta(\theta-1)L^{\theta-2} < 0$. It suggested thatmarginal utility of L is greater than zeroand marginal utility is decreasing.

2. $\frac{\partial U}{\partial N} = -vmN^{m-1} < 0$ and $\frac{\partial^2 U}{\partial N^2} = -vm(m-1)N^{m-2} < 0$. It suggested thatmarginal utility of N is less than zeroand marginal utility is decreasing.

Considering research ability of loans, risk control, collection abilityon loan, economic growth rate, price index, loan interest rates, exchange rate and investment projects of enterprises income as the effect of changes in non-performing loans factors. Then the expression of the rate of non-performing loans versus time and several hypotheses, as follows:

$\dot{N} = \alpha L + \beta A + \gamma N + h\Delta GDP + l\Delta CPI + kD + fS + a\Delta E + b(i-r)$ (6)

Where A is research ability of loans, ΔGDP is the change of economic growth rate, ΔCPI is the change of price index(inflation or deflation), D is the change of trade, S is collection abilityon loan, ΔE is the change of exchange rate, i is loan interest rate and r is enterprises income. There are correlation analysis of non-performing loan rate and factors from ① to ⑨.

①. $\frac{\partial \dot{N}}{\partial L} = \alpha > 0$. If L increases, $\dot{N}$ increases. It is increase function.②. $\frac{\partial \dot{N}}{\partial A} = \beta < 0$. If A increases, $\dot{N}$ decreases.It is decrease function.③. $\frac{\partial \dot{N}}{\partial N} = \gamma < 0$. If N increases, $\dot{N}$ decreases.It is decrease function.④. $\frac{\partial \dot{N}}{\partial \Delta GDP} = h > 0$. Whether ΔGDP is positive growth or negative growth, $\dot{N}$ increases.It is increase function.⑤. $\frac{\partial \dot{N}}{\partial \Delta CPI} = l > 0$. If ΔCPI increases, $\dot{N}$ increases. It is increase function. ⑥. $\frac{\partial \dot{N}}{\partial D} = k > 0$. If D increases, $\dot{N}$ increases. It is increase function. ⑦. $\frac{\partial \dot{N}}{\partial S} = f < 0$. If S increases, $\dot{N}$ decreases.It is decrease function. ⑧. $\frac{\partial \dot{N}}{\partial \Delta E} = a > 0$. If ΔE increases, $\dot{N}$ increases. It is increase function.⑨. $\frac{\partial \dot{N}}{\partial (i-r)} = b > 0$. If $i-r$ increases, $\dot{N}$ increases. It is increase function.

3.Construction of non-performing loans rate model based on dynamic control

theory. $\max \int Udt = \int U(M(L),Q(N))dt = \int U(L,N)dt$ （7）

$U = U(M(L),Q(N)) = uL^{\theta} - vN^{m}$ （8）

s.t 1. $\dot{N} = \alpha L + \beta A + \gamma N + h\Delta GDP + l\Delta CPI + kD + fS + a\Delta E + b(i-r)$;

2. $0 < \theta < 1, u > 0, L > 0$, $\frac{\partial U}{\partial L} = u\theta L^{\theta-1} > 0$ and $\frac{\partial^2 U}{\partial L^2} = u\theta(\theta-1)L^{\theta-2} < 0$;

3. $N > 0, m > 1$, $\frac{\partial U}{\partial N} = -vmN^{m-1} < 0$ and $\frac{\partial^2 U}{\partial N^2} = -vm(m-1)N^{m-2} < 0$;

4. $\dot{L} = h_1\Delta GDP + k_1 D + fS + a_1\Delta E + b_1(i-r)$

Hamilton function is as follows,

$H = U(L,N) + \lambda_N(\alpha L + \beta A + \gamma N + h\Delta GDP + l\Delta CPI + kD + fS + a\Delta E + b(i-r))$

$+ \lambda_L(h_1\Delta GDP + k_1 D + fS + a_1\Delta E + b_1(i-r))$ （9）

To obtain the optimal solution, it must satisfy some conditions.

$-\frac{\partial H}{\partial L} = \dot{\lambda}_L \Rightarrow \dot{\lambda}_L = -(\frac{\partial U}{\partial L} + \alpha\lambda_N + \alpha_1\lambda_L) = -u\theta L^{\theta-1} - \alpha\lambda_N - \alpha_1\lambda_L$

$-\frac{\partial H}{\partial N} = \dot{\lambda}_N \Rightarrow \dot{\lambda}_N = -(\frac{\partial U}{\partial N} + \gamma\lambda_N) = vmN^{m-1} - \gamma\lambda_N$ （10）

Also $-\frac{\partial H}{\partial L} = \dot{\lambda}_L = 0 \Rightarrow \dot{\lambda}_L = -(\frac{\partial U}{\partial L} + \alpha\lambda_N + \alpha_1\lambda_L) = -u\theta L^{\theta-1} - \alpha\lambda_N - \alpha_1\lambda_L = 0$

$\Rightarrow -u\theta L^{\theta-1} - \alpha\lambda_N = \alpha_1\lambda_L$, then

$-u\theta(\theta-1)L^{\theta-2}\dot{L} - \alpha\dot{\lambda}_N = \alpha_1\dot{\lambda}_L = 0$, that is $u\theta(1-\theta)L^{\theta-2}\dot{L} = \alpha\dot{\lambda}_N$ （11）

Then,

$u\theta(1-\theta)L^{\theta-2}\dot{L} = \alpha(vmN^{m-1} - \gamma\lambda_N) \Rightarrow \dot{L} = \frac{\alpha(vmN^{m-1} - \gamma\lambda_N)}{u\theta(1-\theta)L^{\theta-2}}$ （12）

Because of $\frac{\partial H}{\partial L} = \frac{\partial U}{\partial L} + \alpha\lambda_N = u\theta L^{\theta-1} + \alpha\lambda_N = 0 \Rightarrow \lambda_N = -\frac{u\theta}{\alpha}L^{\theta-1}$ （13）

Then,

$\dot{L} = \frac{\alpha(vmN^{m-1} + \gamma\frac{u\theta}{\alpha}L^{\theta-1})}{u\theta(1-\theta)L^{\theta-2}} = \frac{\alpha vmN^{m-1} + \gamma u\theta L^{\theta-1}}{u\theta(1-\theta)L^{\theta-2}}$ （14）

Let the formula 14 equals zero,

$\frac{\alpha vmN^{m-1} + \gamma u\theta L^{\theta-1}}{u\theta(1-\theta)L^{\theta-2}} = 0 \Rightarrow \alpha vmN^{m-1} = -\gamma u\theta L^{\theta-1} \Rightarrow N^{m-1} = \frac{-\gamma u\theta L^{\theta-1}}{\alpha vm}$

$\Rightarrow N = (\frac{-\gamma u\theta}{\alpha vm})^{\frac{1}{m-1}} L^{\frac{\theta-1}{m-1}}$ （15）

The result is,

$$\begin{cases} \dot{N} = \alpha L + \beta A + \gamma N + h\Delta GDP + l\Delta CPI + kD + fS + a\Delta E + b(i-r) = 0 \\ \dot{L} = \frac{\alpha vmN^{m-1} + \gamma u\theta L^{\theta-1}}{u\theta(1-\theta)L^{\theta-2}} = 0 \end{cases}$$

$$\Rightarrow \begin{cases} N = -(\alpha L + \beta A + h\Delta GDP + l\Delta CPI + kD + fS + a\Delta E + b(i-r))/\gamma \\ N = (\frac{-\gamma u\theta}{\alpha vm})^{\frac{1}{m-1}} L^{\frac{\theta-1}{m-1}} \end{cases}$$ （16）

4.Path analysis. Here we discuss one situation which $N > 0$. According formula 16, we gets

$$N = -(\alpha L + \beta A + h\Delta GDP + l\Delta CPI + kD + fS + a\Delta E + b(i - r))/\gamma$$

Where $\alpha > 0, \gamma < 0$ and $-\frac{\alpha}{\gamma} > 0$.

For $N = (\frac{-\gamma u\theta}{\alpha v m})^{\frac{1}{m-1}} L^{\frac{\theta-1}{m-1}}$, $0 < \theta < 1, u > 0, m > 1, v > 0$, so $\frac{-\gamma u\theta}{\alpha v m} > 0$ and $\frac{\theta - 1}{m-1} < 0$.

Ⅰ： $\dot{N} < 0$， $\dot{L} > 0$ .On the areaof S_1, it will move to saddle point S_0;

Ⅱ： $\dot{N} > 0$， $\dot{L} > 0$ .On the area of S_2, it will stay away from the point S_0;

Ⅲ： $\dot{N} > 0$， $\dot{L} < 0$ .On the area of S_3, it will move to saddle point S_0;

Ⅳ: $\dot{N} < 0$， $\dot{L} < 0$ .On the area of S_4, it will stay away from the point S_0.

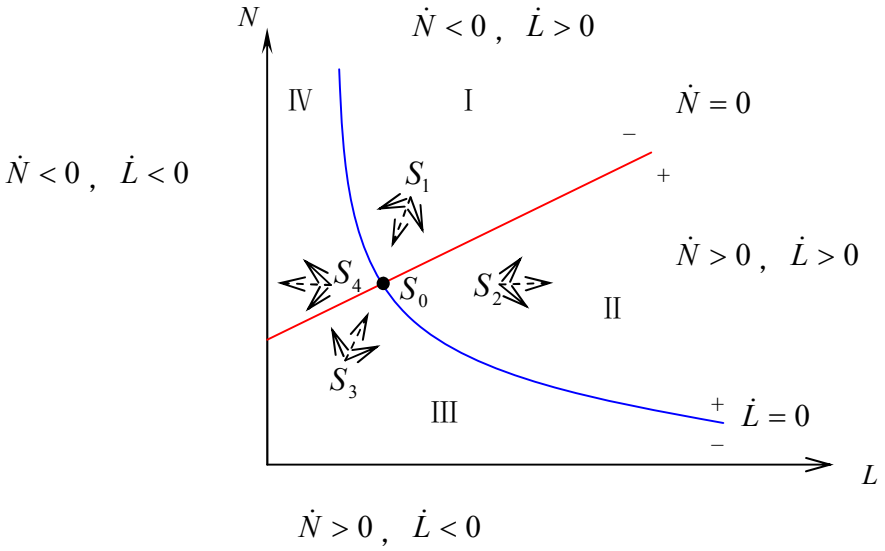


Fig.1non-performing and total loans

4.1 Analysis of the impact of different factors on the change of non-performing loans. When all parameters are invariant in line $\dot{L} = 0$, we alone analyze the impact of different factors on the change of non-performing loans in line $\dot{N} = 0$.

1. Assuming other parameters invariant, the intercept of line $\dot{N} = 0$ becomes small because of $\beta < 0, \gamma < 0$, $-\frac{\beta}{\gamma} < 0$. The line moves down and the equilibrium point of the line moves to S_1'. Non-performing loans decrease from N_0 to N_1 and total loans increase from L_0 to L_1.

If we increase A to $2A$ by introducing talent, better risk controlling,

$$N_1 - N_0 == -\frac{\alpha}{\gamma}(L_1 - L_0) - \frac{\beta}{\gamma}A$$

2. Assuming other parameters invariant except S increased, the intercept of line $\dot{N} = 0$ becomes small because of $f < 0, \gamma < 0$ and $-\frac{f}{\gamma} < 0$. The line moves down and

the equilibrium point of the line moves to S_1'. Non-performing loans decrease from N_0 to N_1 and total loans increase from L_0 to L_1.If we increase S to $2S$, we obtain that

$$N_1 - N_0 == -\frac{\alpha}{\gamma}(L_1 - L_0) - \frac{f}{\gamma}S$$

3. Assuming other parameters invariant except r increased or $i-r$ decreased, the intercept of line $\dot{N}=0$ becomes short because of $b>0, \gamma<0$, and $-\frac{b}{\gamma}>0$. The line moves down and the equilibrium point of the line moves to S_1'. Non-performing loans decrease from N_0 to N_1 and total loans increase from L_0 to L_1.If we increase r to $2r$, we obtain that

$$N_1 - N_0 == -\frac{\alpha}{\gamma}(L_1 - L_0) + \frac{b}{\gamma}r$$ .See Fig.2

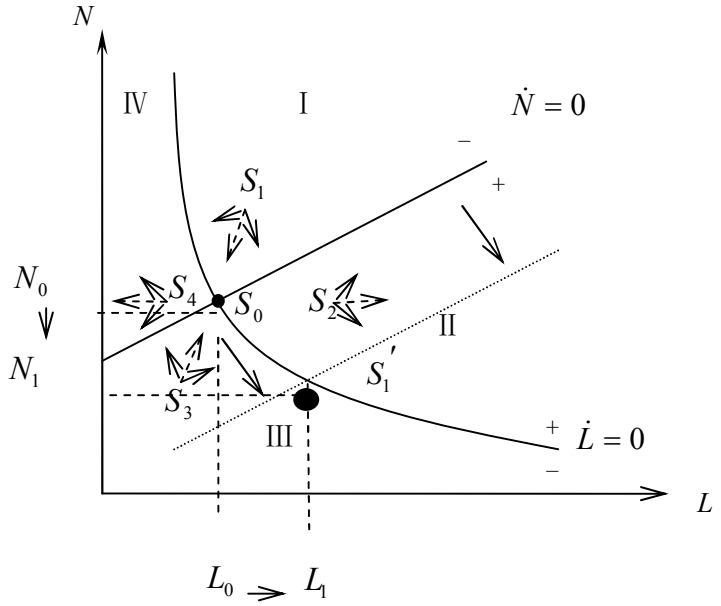


Fig.2the line of non-performing loan move down

4. Assuming other parameters invariant except A, S or $i-r$ decreased, the intercept of line $\dot{N}=0$ becomes long. The line moves up and the equilibrium point of the line moves to S_1''. Non-performing loans increase from N_0 to N_1' and total loans decrease from L_0 to L_1'.

See
Fig.3.

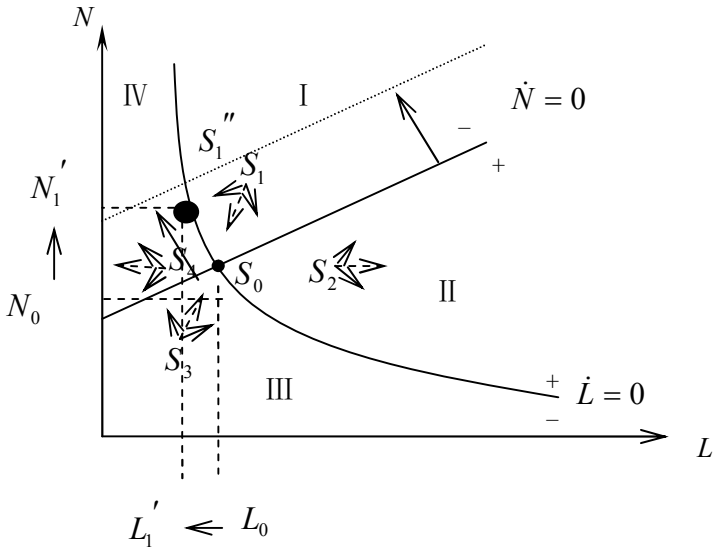


Fig.3the line of non-performing loan move up

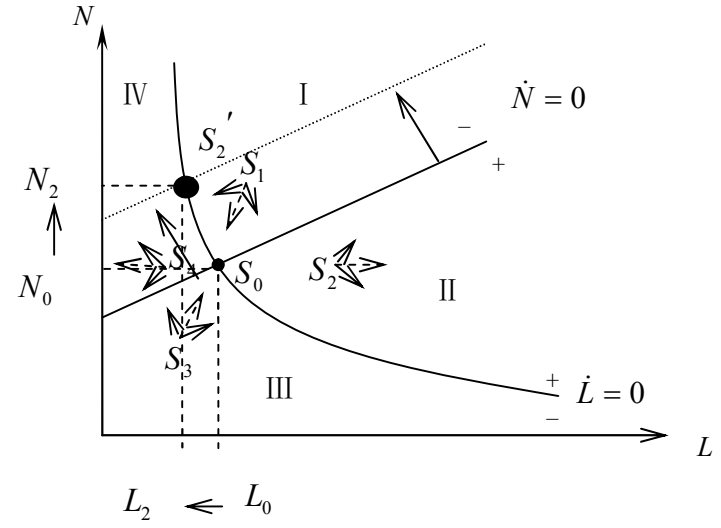


Fig.4the line of non-performing loan move up

5. Assuming ΔGDP increased, $h>0,\gamma<0$ and $-\frac{h}{\gamma}>0$; orassuming ΔCPI increased, $l>0,\gamma<0$ and $-\frac{l}{\gamma}>0$; orassuming D increased, $k>0,\gamma<0$ and $-\frac{k}{\gamma}>0$; orassuming ΔE increased, $a>0,\gamma<0$ and $-\frac{b}{\gamma}>0$. Above 4 cases, the intercept of line $\dot{N}=0$ becomes long. The line moves up and the equilibrium point of the line moves to S_2'. Non-performing loans increase from N_0 to N_2 and total loans decrease from L_0 to L_2. See Fig.4.

6. Assuming ΔGDP, ΔCPI, D or ΔE decreased, Above 4 cases, the intercept of

line $\dot{N}=0$ becomes short. The line moves down and the equilibrium point of the line moves to S_2''. Non-performing loans increase from N_0 to N_2' and total loans decrease from L_0 to L_2'. See Fig.5.

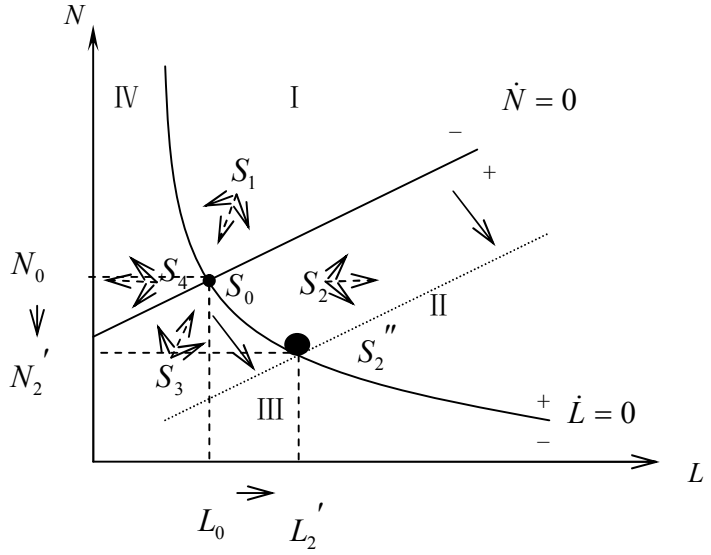


Fig.5the line of non-performing loan move down

4.2 Analysis of parameter θ and m in hyperbola $\dot{L}=0$.

When all parameters are invariant in line $\dot{N}=0$, we alone analyze the impact of different factors on the change of non-performing loans in hyperbola $\dot{L}=0$. We obtain $\frac{-\gamma u\theta}{\alpha v m}>0$ and $\frac{\theta-1}{m-1}<0$, then,

1. Assuming $\frac{\theta-1}{m-1}$ increasing, that is θ increased or m decreased. If θ increased or m decreased, the whole social utility increased. Above 2 cases, The hyperbola $\dot{L}=0$ moves down and the equilibrium point of the line moves to S_3'. Non-performing loans decrease from N_0 to N_3 and total loans decrease from L_0 to L_3. See Fig.6.

2. Assuming $\frac{\theta-1}{m-1}$ decreasing, that is θ decreased or m increased. If θ decreased or m increased, the whole social utility decreased. Above 2 cases, The hyperbola $\dot{L}=0$ moves up and the equilibrium point of the line moves to S_3''. Non-performing loans increase from N_0 to N_3' and total loans increase from L_0 to L_3'. See Fig.7.

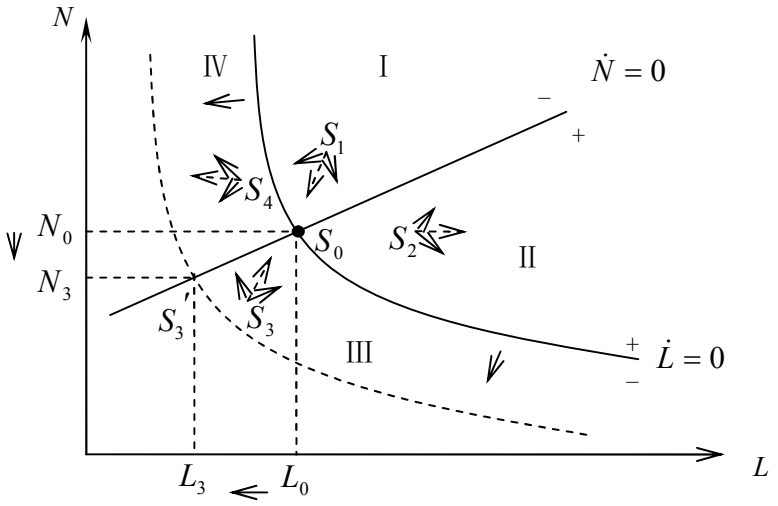


Fig.6 the hyperbola of total loans move down

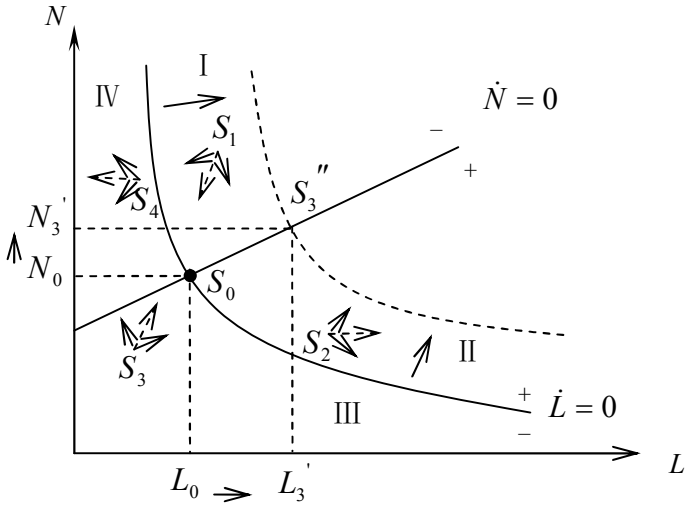


Fig.7 the hyperbola of total loans move up

5.Concluding remarks. In this paper we found thatif bank credit and loan risk control ability and management ability and loan collection efforts enhance, bank non-performing loans decreased significantly, and vice versa. Further to explain, in order to decrease the amount of non-performing, we should strength capacity management of bank loans. We also analyze the influence between macroeconomic and financing structure of loan enterprises. We found when the economic upturn, rising corporate loan proceeds, non-performing loans decreased, and vice versa.

This paper mainly analyzes the impact of various factors on the non-performing loans using the qualitative method bad loans. It is difficult to obtain some data which should take a longer period of time and more fundsinputting, we should take more energy to study the impact of various factors on non-performing loans using a quantitative

method.

REFERENCES

[1] Aver, B, An Empirical Analysis of Credit Risk Factors of the Slovenian Banking System, *Managing Global Transitions* 6, 317-334, 2008.

[2] Bucur, I. and Dragomirescu, S,The Influence of Macroeconomic Conditions on Credit Risk: Case of Romanian Banking System, *Studies and Scientific Researches*, Economics Edition, No. 19, 2014.

[3] Crouhy, M.D., Galai, D. and Mark, R,A Comparative Analysis of Current Credit Risk Models, *Journal of Banking and Finance* 24, pp. 59-117,2000.

[4] Castro, V,Macroeconomic determinants of the credit risk in the banking system:the case of GIPSI, *Economic Modeling* 31, pp. 672-683, 2013.

[5] Das, A. and Ghosh, S,Determinants of Credit Risk in Indian State-owned Banks: An Empirical Investigation, MPRA Paper No. 17301, 2007.

[6] Fama，E,Term Premiums and Default Premiums in Money Markets, *Journal of Financial Economics* 17, pp. 175-19, 1986..

[7] Fofack, H,Nonperforming Loans in Sub-Saharan Africa: Causal Analysis and Macroeconomic Implications, World Bank Policy Research Working Paper No. 3769, 2005.

[8] Gunsel, N,Micro and Macro Determinants of Bank Fragility in North Cyprus Economy, *African Journal of Business Management* 3, pp. 1323-1329, 2012.

[9] Jimenez, G. and Saurina，J,Credit Cycles, Credit Risk, and Prudential Regulation, *International Journal of Central Banking* 2, pp. 65-98, 2006.

[10] Jakubik, P,Macroeconomic Environment and Credit Risk, *Czech Journal of Economic and Finance* 57, pp. 50-78, 2007.

[11] Wang ZhenLei, A Statistical Research on Determiing Impacts on Non-Performing Loans Ratio In Commercial Banks [D]，*ZheJiangGongShang University*，2014.

[12] D.E.Allen,R.R.Boffey&R.J.Powell, The Impact Of Contagion On Non-Performing Loans:Evidence From Australia And Canada, *Journal Of Business And Policy Research, Vol.7, No.2, July Issue*, P13-24, 2012.

[13] MwanzaNkusu,Nonperforming Loans And Macrofinancial Vulnerabilities In Advanced Economies, IMF Working Paper, WP/11/161, 2011.

[14] Mark Tracey, The Impact Of Non-Performing Loans On Loan Growth: An Econometric Case Of Jamacia And Trinidad And Tobago, 2011.

[15] Louzis, P.,Vouldis,T.andMetaxas,L,Macroeconomic and bank-specific determinants of non-performing loans in Greece: a Comparative study of mortgage, business and consumer loan portfolios, *Journal of Banking and Finance* 36, pp. 1012-1027, 2012.

[16] Poudel, R.P.S,Macroeconomic determinants of credit risk in Nepalese banking industry", Proceedings of 21st International Business Research Conference, 2013.

[17] Salas, V. and Saurina, J,mCredit risk in two institutional regimes:Spanish commercial and savings banks, *Journal of Financial Services Research,* 22, pp. 203-224, 2002.

[18] Zribi, N. and Boujelbene, Y,The factors influencing bank credit risk: the case of Tunisia", *Journal of Accounting and Taxation* 3, pp. 70-78. 2011.

Author in brief:

Wang Zhen Lei, mainly engaged in quantitative economy and statistics on social development,
E-mail: wzhldkongjian@163.com.

X-EFFICIENCY OF BANKING SECTOR IN CHINA: NONPARAMETRIC STOCHASTIC FRONTIER ANALYSIS

Shen Zuiyi, Ying Jun,and Fu Cuilian
[1] School of Management
Zhejiang Ocean University, China

ABSTRACT.*The paper applies the nonparametric estimation method of stochastic frontier to analyze X-efficiency of the banking sector in China. For elasticity of input factors of banks, namely, allocation efficiency of X-efficiency of banks, the impacts of input factors to different bank profits have very big difference. the input factor of deposit is the bank of the input factor which be able to bring the biggest bank profits, on the contrary, the input factor of labor has the biggest negative impact on the bank profits. For technical efficiency of X-efficiency of banks, including efficiency of profits and efficiency of loans, the China Merchants Bank has the highest profit efficiency value while the efficiency of its loans is in a low level of the industry, on the contrary, Agricultural Development Bank has the highest efficiency value of the loans while its profit efficiency is the lowest. Based on the research results of the nonparametric estimation method, some suggestions are made for improving X-efficiency of the banking sector as references in the reform of Chinese banks.*

Key words: Chinese bank, X-efficiency, Nonparametric stochastic frontier , Elasticity of input factors

1. Introduction. Enhancing bank's efficiency is the basis of preventing financial crisis and bank's sustainable development, it is proved that X - efficiency ,measure the capacity of management to control cost and maximize the output , is one of the important deterministic factors to determine the operating performance of financial institutions. X efficiency includes technical efficiency and allocative efficiency. The improvement of Technical efficiency can reduce bank inputs through the effective management in a given output. The improvement of allocative efficiency can reduce the cost through reasonable allocation of input factors. According to the research of the U.S. banking sector(the Berger et.al.1998), efficiency loss caused by low x-efficiency was about 20% of the total cost. Therefore, calculating X-efficiency and further researching inputs on the efficiency of bank profit have important significance to improve the operation efficiency of Banks in our country. Traditional methods of technical efficiency measurement include parametric method and the non-parametric DEA based on radial technology distance function mainly. By means of the translogarithmic cost function, QiTianXiang et.al.(2009) makes an empirical verification for the efficiency of Chinese commercial Banks from 1995 to 2005,it showed that there were diseconomies of scale and negative effects of technological progress in the state-owned banks, which led to lower X -efficiency of Chinese commercial banking industry. Zhang jianhua (2003) used DEA method to study three kinds of X-efficiency of commercial bank during 1997-2001, found that the highest efficiency was ten joint-stock commercial banks while city commercial banks were the lowest. A defect in the parameter method is that it presupposes the functional form, which could lead to the deviation of efficiency. Non-parametric DEA method assumes that there is no random error term, namely, this method did not consider the data quality, luck, such as the influence of random factors on the efficiency. In this paper,

the nonparametric estimation method of stochastic frontier (Henderson2008)was used to measure X-efficiency of the banking sector in China, the advantage of the model lies on that it does not need concrete forms on frontier function, distribution of the random error term and inefficient item setting, it inherits the flexibility of DEA method and considers the existence of random error at the same time. Further, the elastic coefficient estimated by nonparametric model of stochastic frontier changed with time and the individual, maybe more matches the actual circumstances., brings obvious economic significance.

The rest of the paper is organized as follows: Section2 describes the survey data and determines the input and output variables. Section3 expounds the construction of the model and the estimation of its parameter. Section4 studies X-efficiency of our country banking with nonparametric stochastic frontier model, analyzes the differences of the elasticity between different types of banks and trend of elasticity change, according to the results of the analysis, puts forward policy Suggestions on improving the efficiency of Chinese banking. Section4 summarizes the model of the deficiencies and further study is pointed out.

2.Variable selection and data sources. The variable selection of input and output mainly reference the method provided by Yaoshujie et.al.(2004), the net value of fixed assets, labor input, equity and deposit amount were selected as four input variables of the bank, two output variables were the net profit and the volume of lending. Data obtained from the fifteen bank's balance sheet and income statement in China financial yearbook published by the national bureau of statistics during 2004 to 2013, and the bank annual report and the bank's official website. Fifteen banks including: three big state-owned commercial banks ,which are Industrial and Commercial Bank of China, China Construction Bank, Bank of China and ten joint-stock commercial banks, which are Bank of Communications, Citic Bank, Huaxia Bank, Minsheng Bank, Shenzhen Development Bank, Guangdong Development Bank, Pudong Development Bank, Everbright Bank, China Merchants Bank, Societe Generale, as well as two policy banks, which are the National Development Bank, Agricultural Development Bank. Since the country began to comprehensive reform of state-owned commercial banks in 2004, now let’s consider to measure the banking efficiency value since 2004.

3 Model structure and parameter estimation.

The specific expression of nonparametric stochastic frontier model is as follows:

$$y_{it} = f(x_{1it}, x_{2it}, x_{3it}, x_{4it}) + v_{it} - u_i \quad (1)$$

where $i = 1,...,15, t = 1,...,10$， y_{it} is the output of the ith bank in the tth year， x_{kit} is the kth input of ith bank in tth year $(k=1,...,4)$, $u_i \sim iid(\mu, \sigma_u^2), and\ u_i \geq 0$, $v_{it} \sim iid(0, \sigma_v^2)$, and for any i or j, u_i and v_{jt} is uncorrelated, $j = 1,2,...,15$. Due to the mean of u_i is

nonzero, the model (1) is revised to model (2) as follows: $y_{it} = m(x) + u_i + v_{it}$ (2) $m(x) = f(x) - \mu$, x denotes $x_{1it}, x_{2it}, x_{3it}, x_{4it}$, $u_i^* = \mu - u_i, u_i^* \sim iid\left(0, \sigma_u^2\right)$,let $u_i^* + v_{it} = \varepsilon_{it}$, ε_{it} is composite error of model (2), $\hat{\varepsilon}_{it} = y_{it} - \hat{m}*\left(x_{it}\right)$, $\hat{m}*\left(x_{it}\right)$ is estimated by least square kernel. $\hat{\bar{\varepsilon}}_i = \frac{1}{10}\sum_t \hat{\varepsilon}_{it}$, $\hat{\sigma}_\varepsilon{}^2 = 10\hat{\sigma}_u{}^2 + \hat{\sigma}_v{}^2 = \frac{10}{15}\sum_t \hat{\bar{\varepsilon}}_i^2$, $\hat{\sigma}_u{}^2 = \frac{\left(\hat{\sigma}_\varepsilon{}^2 - \hat{\sigma}_v{}^2\right)}{10}$, $\hat{\sigma}_v{}^2 = \frac{1}{15*9}\sum_i\sum_t\left(\hat{\varepsilon}_{it} - \hat{\bar{\varepsilon}}_i\right)^2$ $E(\varepsilon_{it}^2) = \mathrm{var}(\varepsilon_{it}) = \sigma_u^2 + \sigma_v^2$, hen $j \neq h$, $E(\varepsilon_{ij}\varepsilon_{ih}) = \mathrm{cov}\left(u_i^* + v_{ij}, u_i^* + v_{ih}\right) = \sigma_u^2$ $\varepsilon_i = [\varepsilon_{i1}, \varepsilon_{i2}, ..., \varepsilon_{i10}]'$, $V \equiv E(\varepsilon_i\varepsilon_i{}')$, $\Omega = I_{15} \otimes V$. Let $\delta(x) = \left(m(x), \beta(x)\right)'$ estimated by $\min\left(y - X\delta(x)\right)' W(x)\left(y - X\delta(x)\right)$ where $\beta(x)$ is made of $\beta_{kit} = \frac{\partial\hat{m}}{\partial x_{kit}}\left(x_{1it}, x_{2it}, x_{3it}, x_{4it}\right)$, $W(x) = \sqrt{K(x)}\Omega^{-1}\sqrt{K(x)}$. X is made of $X_{it} = \left(1, \left(x_{kit} - x_k\right)\right)$, $K(x)$ is a 150×150 diagonal matrix made of $\hat{\delta}(x) = \left(X'\sqrt{K(x)}\hat{\Omega}^{-1}\sqrt{K(x)}X\right)^{-1} X'\sqrt{K(x)}\hat{\Omega}^{-1}\sqrt{K(x)}y$, $\hat{m}(x) = e'\hat{\delta}(x)$, $e = (1,0,0,0,0)'$ let $\hat{\theta} = \frac{\hat{\sigma}_u{}^2}{\hat{\sigma}_v{}^2 + 10\hat{\sigma}_u{}^2}$, $\hat{v}_{it} = y_{it} - \hat{m}\left(x_{it}\right)$(see Henderson Ullah,2005） . u_i^* in model(2) is estimated by $\hat{u}_i^* = \hat{\theta}\sum_t \hat{v}_{it}$,to standardize u_i^* ,namely $\hat{u}_i = \max\hat{u}_i^* - \hat{u}_i^*$, then the X-efficiency of nonparametric stochastic frontier model can be estimated by $T\hat{E}_i = \exp\left(-\hat{u}_i\right)$.when output y denotes net profits or lending of bank, model(2) named as profit model or loans model respectively, by writing and running MATLAB program, the elasticity and efficiency of the two models can be estimated.

4.Analysis of X-efficiency of banking.

4.1 Allocation efficiency of X-efficiency. The elastic coefficients of banks were difference and change with time. To analyze the influence of the change of inputs on banks' profits from 2004 to 2013 and find the cause of gap of banks' net income , the estimation result of elasticity of four inputs were collected in Table 1 through classification of the bank and year averageness of the elastic coefficient.

TABLE 1.Average elasticity of inputs of all kinds of bank

elasticity	Fixed assets	labor	capital	deposit
Nationalized	-0.8189	-1.8533	1.4849	1.6098

bank				
Joint-stock bank	0.0063	-0.7123	0.3803	1.3650
Policy bank	-0.1815	-0.6918	0.3317	1.5516
Banking industry	-0.1837	-0.9378	0.5948	1.4389

it can be found from the results of table one：The change of fixed assets investment and the profit of nationalized bank and policy bank present a reverse relation. To joint-stock bank shows a positive correlation. The input of labor and the profit of three types of bank all present inverse relationships.

The input of both fixed assets investment and labor are the most sensitive to the profits of nationalized bank than the other banks, and the sensitivity of the labor should be greater than the sensitivity of fixed assets investment. This may be that nationalized banks have a large number of redundant personnel and the more idle fixed assets. Therefore, than the other types of bank, nationalized banks should pay more attention to the management of fixed assets, reduce unnecessary costs, control the cost of labor, prune away some of our surplus staff, implement better strategies to improve their profits, It has substantial significance for nationalized banks.

To equity investment, there is a same change trend between the investment and net profit of bank. The increase in equity can enrich the bank capital ，enhance the strength of bank management, improve the ability to guard against financial risks. The size effect of deposit has the most impact on the change of profit of bank in all inputs. On the basis of an analysis of the source of funds, the deposit is the main source of funds for the loan. Chinese banks still rely on income from government-set interest rate differentials for the bulk of their profits. Compared to other sources of funding, the cost of savings is low. Expansion of the scale of deposit can be increasing the degree of self-sufficiency of funds, and increase bank profits. In this sense, deposit of bank determines operating profits. Even if higher deposit rates in the future, deposit interest rate and loan interest rate of bank always keep a balance, the deposit can bring profits to the bank as long as a moderate expansion of scale. Furthermore, the influence of annual deposits for bank profits was analyzed from the perspective of dynamic, the results was shown in Table 2.

TABLE 2 The average value of elasticity of annual deposits for profits

year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
elasticity	1.541	1.571	1.635	1.649	1.634	1.703	1.754	1.824	1.832	1.833

It can be found from Table 2, the elasticity of deposit showed a trend of rising from 2004 to 2013. Enlarge the scale of the deposits would bring higher returns to the bank. This phenomenon maybe caused by lower deposit interest rates of the bank and a widening spreads since 2004.

4.2 Technical efficiency of X-efficiency. Next to study the change of technical efficiency of 15 Banks. Profits model and loans model were set up respectively by taking profits and loans as explained variables. The relevant MATLAB programs were written and run to solve technical efficiency of 15 sample banks. The results of efficiency of profits and efficiency of loans of 15 Banks were shown in figure 1.

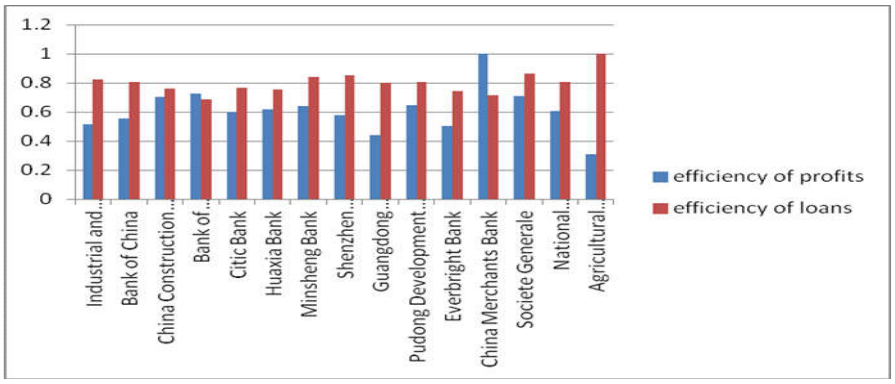


FIGURE 1. Technical efficiency of 15 sample banks

As can be seen from the figure 1, the sorting situation of efficiency of profits and loans of 15 Banks is completely different. The banks of efficiency value of profits, in descending order: China Merchants Bank, Bank of Communications, China Construction Bank, Societe Bank, Minsheng Bank, Everbright Bank, China Citic Bank, China Development Bank, China Bank, Pudong Development Bank, Shenzhen Development Bank, Huaxia Bank, Industrial and Commercial Bank, Guangdong Development bank, Agricultural Development Bank. The banks of efficiency value of loans, in descending order: Agricultural Development Bank, Pudong Development Bank, Minsheng Bank, China Development Bank, Industrial and Commercial Bank, Bank of Communications, China Construction Bank, Societe Bank, China Bank, Huaxia Bank, Shenzhen Development Bank, China Merchants Bank, Citic bank, Everbright Bank, Guangdong Development Bank. China Merchants Bank has the highest efficiency score of profits, but the efficiency of loans in a low level of the industry. For Agricultural Development Bank it was different, its efficiency score of loans was the highest, but the efficiency of profits was the lowest. As a joint-stock commercial bank, the company culture and enterprise system, cultural idea and management of China Merchants Bank were more advanced than other banks, while profit was the main purpose, and must self sustaining, the joint-stock commercial bank was more cautious in loans than other two kinds of bank. As a policy bank, the profitability of Agricultural Development Bank was bad, its own management consciousness is weak in the implementation of relevant national policies. To increase loans for government policy, policy banks had impulse of debt expansion than other two kinds of bank, and its profits efficiency is the lowest with large amounts of bad loans.

5. conclusions. In this paper, x-efficiency value of banking was estimated by using the nonparametric random effect model. some innovative method was explored in foundation of predecessors' research results. The model of the loan and profit was established and The change of the elastic coefficient of input factor which affect bank net profit was analyzed dynamically. Through the comparative analysis of the efficiency of loans and profits, some useful conclusions was obtained. The nonparametric stochastic frontier model in the paper is a model based on production frontier, in the later study, it can also be applied to the stochastic frontier model based

on cost cutting edge, calculate the cost efficiency, so as to provide the basis for cost control decisions.

REFERENCES

[1] Berger and Hannan,,The Efficiency Cost of Market power in the Banking industry,A Test of "Quiet Life" and related hypotheses, R*eview of Economics and Statistics* ,pp.80,1998..

[2] Zhang jianhua, X-efficiency Analysis of Commercial Banks in China.*„Journal of Financial Research* ,no.6*,* 2003. (in Chinese).

[3] Henderson, D.J.and A.Ullah,Nonparametric Estimation in a One-Way Error Component Model: Monte Carlo Analysis,University of California, Riverside, October 4,2008.

[4] Yaoshujie, Fenggenfu, Jiangchunxia. An Empirical Analysis of the Efficiency of Chinese Banking Industry, *Journal of Economic Studies*, no.8,2004 (in Chinese).

[5] QiTianXiang,Yangdaqiang, Commercial Bank Efficiency based on scale economies and technical progress,*Journal of guangdong finance academy*, vol24., no.1,2009, (in Chinese).

TheMacroeconomic Effect of Sudden Shock inMRS-DSGE models

Shangfeng Zhang[1], Yuying Wang[2], Liuyan Zhu[3] and Can Cheng[4]
College of Statistics and Mathematics
Zhejiang Gongshang University
18 Xuezheng Street, Xiasha Education Park, Hangzhou, Zhejiang 310018, China
[1]zhshangfeng@163.com
2yuyingwangde@163.com

ABSTRACT.*This article uses a two-state Markov regime switching dynamic stochastic general equilibrium model to study the macroeconomic effect of sudden shock.We model uncertainty events using a two-state Markov switching process. A sudden is characterized by the destruction of a portion of a temporary negative technology shock that reduces output. We show that The negativesudden shock to the productivity factor prompts firms to lower their output, consumption will also continue to decline because of the decrease of output.The rapid decline of technology weaken the impetus of continued investment, and the reduction of investment scale will lead to the shortage of employment increasement.*

Keywords: Sudden Shock,Markov regime switching model, dynamic stochastic general equilibrium model

1.Introduction. The effect of uncertainty on economic activity is a prevalent topic inboth economic policy and academic research.Economists and the financial press often discuss uncertainty about the future as an important driver of economic fluctuations, and a contributor in the Great Recession and subsequent slow recovery. For example, Diamond (2010) says, "What's critical right now is not the functioning of the labor market, but the limits on the demand for labor coming from the great caution on the side of both consumers and firms because of the great uncertainty of what's going to happen next." Recent research by Bloom (2009),Bloom,Foetotto, Jaimovich, Saporta-Eksten,andTerry (2011), Fernandez-Villaverde, Guerron-Quintana,Kuester, and Rubio-Ramirez (2011), Born and Pfeifer (2011), and Gilchrist, Sim, and Zakrajsek (2010) also suggests that uncertainty shocks can cause fluctuations in macroeconomic aggregates. However, most of these papers experience difficulty in generating business-cycle comovements among output, consumption,investment, and hours worked from changes in uncertainty. If uncertainty is a contributing factor in the Great Recession and persistently slow recovery,then increased uncertainty should reduce output and its components.In this paper, we show that If technology shock is positive,it causes a positive contraction for a long time in economic activity that includes labor, output , capital , consumption and investment.Ifsudden shock is negative,it does not make labor, output , capital ,

consumption and investment shows positive fluctuation, to the contrary, is negative.

2.Model Framework

Households. To get into the substantive questions as soon as possible, our description of the standard featuresof our prototype economy will be limited to fixing notation. FollowingAndreassen(2012) and Ireland(2004),There is a representative householdin the economy, whose preferences over stochastic sequences of consumption, c_t ; and work, n_t , are representable by a utility function:

$$\max E_0 \sum_{t=0}^{\infty} \beta^t \{ \frac{1}{1-\sigma} c_t^{1-\sigma} - \frac{1}{1+\phi} n_t^{1+\phi} \}$$

where $\beta \in (0,1)$ is the discount factor and E_0 is the conditional expectation operator. subject to its intertemporal household budget constraint each period:

$$w_t n_t + r_t^k k_{t-1} + \frac{R_t b_{t-1}}{\pi_t} = c_t + i_t + b_t$$

where i_t is investment, R_t is the risk-free gross interest rate, b_t is the holding of an uncontingentbond that pays 1 unit of consumption good at time t+1, w_t is the wage, n_t is labor, r_t^k is the rentalrate of capital, and k_t is capital,gross inflation as $\pi_t = p_t / p_{t-1}$. Asset markets are complete and we could have also included in thebudget constraint the whole set of Arrowsecurities. Since we have a representative household, thisis not necessary because the net supply of any security must be equal to zero. The uncontingentbond is all weneed to derive a pricing kernel for the economy. Capital is accumulated accordingto the law of motion:

$$k_t = i_t + (1-\delta) k_{t-1}$$

where δ is the depreciation rate.Using a Lagrangian approach, household optimization implies the following first-order conditions:

$$c_t: \frac{1}{c_t^{\sigma}} = \lambda_t \quad (1)$$

$$n_t: \ n_t^{\phi} = \lambda_t w_t \quad (2)$$

$$b_t: \ \beta E_t \lambda_{t+1} \frac{R_{t+1}}{\pi_{t+1}} = \lambda_t \quad (3)$$

$$k_t: \beta E_t \lambda_{t+1} ((1-\delta) + r_{t+1}^k) = \lambda_t \quad (4)$$

Using the stochastic discount factor, we can eliminate λ_t and simplify Equations (1)

- (4) as follows:

$$c_t^{\sigma} n_t^{\phi} = w_t \quad (5)$$

$$\beta E_t\left(\frac{c_t^{\sigma}}{c_{t+1}^{\sigma}} \frac{R_{t+1}}{\pi_{t+1}}\right) = 1 \quad (6)$$

$$\beta E_t \frac{c_t^{\sigma}}{c_{t+1}^{\sigma}}[(1-\delta) + r_{t+1}^{k}] = 1 \quad (7)$$

Firms. Firms, which are owned by the households, produce differentiated goods in a perfect competitive market. Firms labor, n_t , and rents capital, k_t , from the households to produce its output, y_t , according to a Cobb-Douglas production function：

$$y_t = Z_t k_{t-1}^{\alpha} n_t^{1-\alpha}$$

where $0 \le \alpha \le 1$. The productivity factor, Z_t ,comprises the typical technology shock, z_t , that follows a first-order autoregressive process and an additional component related to the sudden shock variable,

$$\ln(Z_t / Z) = \ln(z_t / z) + \varsigma \ln(D_t / D) \quad (8)$$

where D_t is the "sudden shock" variable, which is discussed in more detail in the next section.

Firms then chooses the combination of labor and capital that minimizes its production costs, $w_t n_t + r_t^k k_{t-1}$, given its production function. Solving firms cost minimization problem yields the following factor demand equations:

$$w_t = (1-\alpha)\frac{y_t}{n_t}$$

$$r_t^k = \alpha \frac{y_t}{k_{t-1}}$$

Monetary Policy. We assume a cashless economy where the monetary authority sets the nominal interest rate to stabilize inflation π_t , outputand the sudden shock variable. Following Bin Liu(2010),WeipingZhang(2012) and Benjaminand Michael (2011), monetary policy adjusts the nominal interest rate in accordance with the following rule:

$$R_t = R_{ss}\left(\frac{R_{t-1}}{R_{ss}}\right)^{\rho_R}\left(\frac{\pi_t}{\pi_{ss}}\right)^{\rho_\pi}\left(\frac{y_t}{y_{ss}}\right)^{\rho_y}\left(\frac{D_t}{D}\right)^{\rho_D} \exp(\varepsilon_t^R)$$

where ε_t^R is a discretionary monetary policy shock which is normally distributed with a zero mean and variance of σ_ε^2.

Markets clear

$$n_t = \int_0^1 n_t(i)di$$

$$k_t = \int_0^1 k_t(i)di$$

$$y_t = c_t + i_t$$

3. The Sudden Shock. We consider two crucial characteristics of a natural sudden like Hurricane Katrina. First, a sudden temporarily disrupts production, which we model as a transitory negative technology shock in Equation 8. Because a sudden is an infrequent event, the sudden shock is modeled as a two-state Markov switching process. The negative shocks to the capital stock and to technology are specified as functions of the two-state sudden variable.

The sudden shock variable, D_t, can take on one of two states. State 1 is the "normal" or "nonsudden" state, whereas state 2 is defined as a "sudden." The two states evolve according to a transition matrix with the calibrated probabilities,

$$\begin{pmatrix} p_{11} & 1-p_{22} \\ 1-p_{11} & p_{22} \end{pmatrix} = \begin{pmatrix} 0.98 & 0.98 \\ 0.02 & 0.02 \end{pmatrix}$$

where $p_{ij} = prob(D_t = D^j \,|\, D_{t-1} = D^i)$. For the given probability values, there is a 2% probability a sudden will occur, regardless of the sudden variable's state in the previous period.

To map the regime-shifting framework onto the canonical difference-equation structure of the model, a log-linearized version of the Markov-switching process is expressed in the following form:

$$\widehat{D}_{t+1} = \rho_D \widehat{D}_t + \varepsilon_{D_{t+1}}$$

It is convenient to define the baseline steady state as the unconditional expected value of the sudden shock:

$$\ln(D) = \frac{1-p_{22}}{2-p_{11}-p_{22}}\ln(D^1) + \frac{1-p_{11}}{2-p_{11}-p_{22}}\ln(D^2)$$

When D_t, is in state 1, its logarithmic deviation from the baseline steady state is

$$\widehat{D}^1 \equiv \ln(D^1) - \ln(D) = \frac{1-p_{11}}{2-p_{11}-p_{22}}(\ln(D^1) - \ln(D^2))$$

and when D_t, is in state 2, it is

$$\widehat{D}^2 \equiv \ln(D^2) - \ln(D) = \frac{1-p_{22}}{2-p_{11}-p_{22}}(\ln(D^2) - \ln(D^1))$$

A useful property of a two-state Markov-switching process is that the conditional probabilities implicit in the expectation term in Equation 8can be represented as a first-order autoregressive process. it is straightforward to show that the autoregressive coefficient defined as $E_t(\widehat{D}_{t+1}\left|\widehat{D}_t\right.)/\widehat{D}_t$, is independent of the present state and is equal to $\left(p_{11}+p_{22}-1\right)$. For the linearly approximated simulations, this expression defines the value for ρ_D.The sequence of disturbances placed into the model is calculated as

$$\varepsilon_{D_t}=\widehat{D}_t-E_{t-1}(\widehat{D}_t)=\widehat{D}_t-(1-p_{11}-p_{22})\widehat{D}_{t-1}$$

4.Calibration and Results. The sudden shock variable is calibrated to reflect the magnitude of Hurricane Katrina's economic impact. First, the ratio D^2/D^1 is set to 1.004, providing a baseline magnitude for the shock's impact. The effect of $\widehat{D}_t$ on capital and technology are calibrated to generate specific impulse responses consistent with the effect of Hurricane Katrina. In particular, the sudden variable's effect on the capital stock and technology are calibrated such that both the capital stock and output decline by 0.7 in the flexible price and wage equilibrium when the economyis in the "sudden" state. In terms of Equations 8, this requires that we set $\varsigma=-0.58$.

We set the depreciation rate of capita δ to 0.025 and the share of capital in the production process α to 0.6. The discount factor β = 0.96, is a default choice. The steady-state gross inflation rate, π, is set equal to 1, a common value used in the literature.the central bank follows a Taylor rule with $\rho_R=0.7,\rho_\pi=1.2,\ \rho_y=0.4,\rho_D=0.5$

Table 1. Parameter calibration

Parameter	Description	Value
β	Discount factor	0.96
α	Capital's share in production	0.6
δ	Depreciation rate of physical capital	0.025
π	Gross steady-state inflation rate	1
R	Nominal interest rate	1.01
σ	Elasticity of intertemporal substitution	1.7
ϕ	Inverse of Frisch labor supply elasticity	2
n	Steady state labor supply	1/3
ρ_z	Autoregressive coefficient of technology shock	0.85
ρ_π	Central bank reaction coefficient on inflation	1.2
ρ_y	Central bank reaction coefficient on output growth	0.4
ρ_R	Central bank monetary growth smoothing coefficient	0.7
ρ_D	Central bank reaction coefficient onsudden shock	0.5

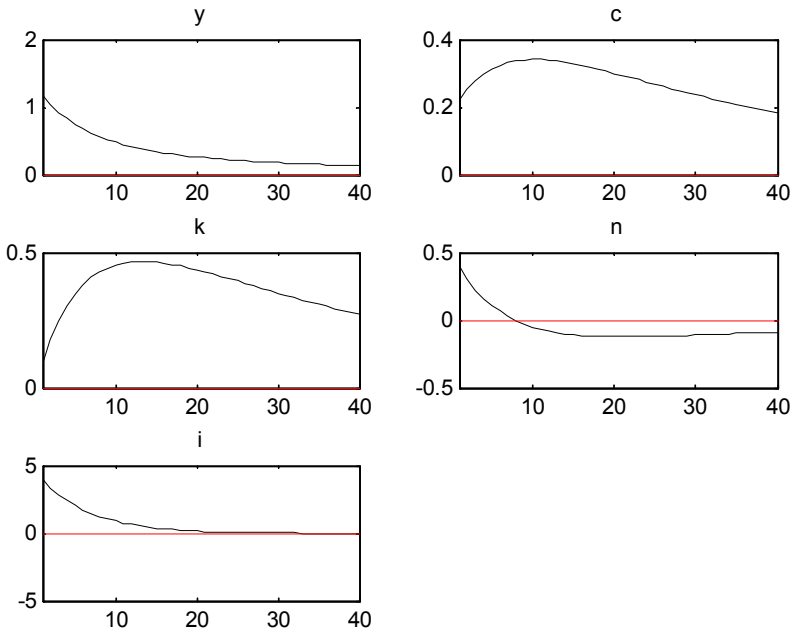


Figure 1.Impulse responses to technology shock

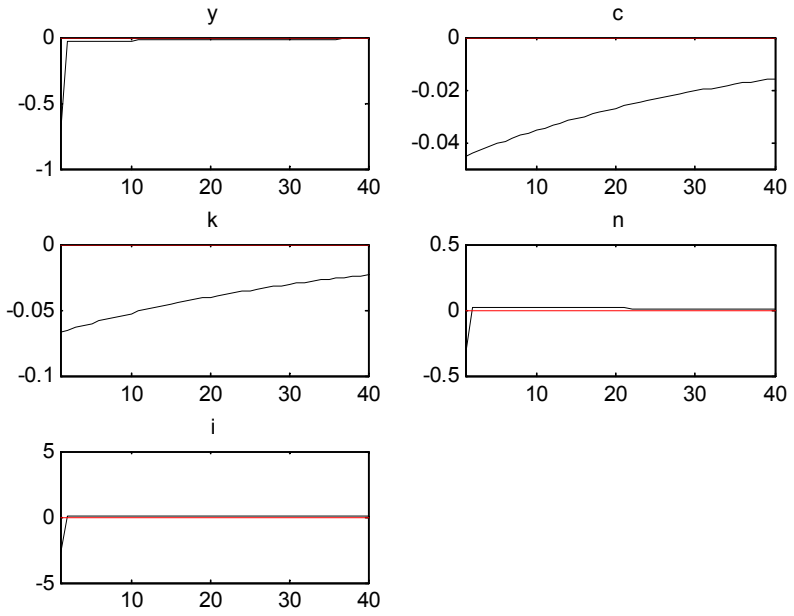


Figure 2.Impulse responses to sudden shock

Figure 1 suggested that technology shock causes a prolonged contraction in economic activity that includes labor, output, capital, consumption and investment.labor raise to 0.39, output improves 1.16 at impact, capital raise to 0.099, consumption raise to 0.22 and investment improves 3.96. The positive technology shock to the productivity factor prompts firms to improve their output,consumption will also continue to rise

because of the raise of output.The rapid rise of technology raise the impetus of continued investment, and the rise of investment scale will lead to the increase of employment increasement.

Figure 2 illustrates the effect of a sudden on the flexible model,it shows that sudden shock does not make labor, output, capital, consumption and investment shows positive fluctuation, to the contrary, is negative.We calibrate the shock to deliver a 0.7 fall in output, 0.045 fall in consumption,0.067 fall in capital,0.315 fall in labor and 2.69 fall in investment. The negative suddenshock to the productivity factor prompts firms to lower their output，consumption will also continue to decline because of the decrease of output.The rapid decline of technology weaken the impetus of continued investment, and the reduction of investment scale will lead to the shortage of employment increasement.

5. Conclusion. This paper examines thetwo-state Markov transmission mechanism of uncertainty to the macroeconomy in a standardrepresentative-agent general equilibrium model. Under reasonable assumptions, fluctuations in uncertaintycan generate business cycle-like comovements in labor, output , capital, consumption and investment. If technology shock is positive,it causes a positive contraction for a long time in economic activity that includes labor, output, capital, consumption and investment.Ifsudden shock is negative,it does not make labor, output, capital, consumption and investment shows positive fluctuation, to the contrary, is negative.

Acknowledgment. This paper is supported by Natural Science Foundation of China (71403247), Natural Science Foundation of Zhejiang Province (LQ13G030006), Philosophy Social Science Foundation of Zhejiang Province (14NDJC143YB), Humanities and Social Sciences Foundation of Ministry of Education (13YJC790213), the Postdoctoral Science Foundation of China (2013M531436), the Youth Fund Project of the Zhejiang Provincial Key Research Base for Humanities and Social Science Research (Statistics), the Youth Fund Project of Zhejiang Gongshang University, and the Innovation Post graduation Project of Zhejiang Gongshang University.

REFERENCES

[1] Andreassen M. M.,On the effects of rare suddens and uncertainty shocks for risk premia in non-linear DSGE models, *Review of Economic Dynamics*, vol.15, no.3, pp.295-316, 2012.

[2] Benjamin D. Keen and Michael R. Pakko, Monetary Policy and Natural Suddens in a DSGE Model, *Southern Economic Journal*, vol.77, no.4, pp. 973-990,2011.

[3] Bin Liu,*Dynamic Stochastic General Equilibrium Model and Its Application*, China Financial Publishing House,2010.

[4] Bloom, N.,The Impact of Uncertainty Shocks,*Econometrica*,vol.77, no.3 pp.623-685,2009.

[5] Bloom, N., M. Foetotto, N. Jaimovich, I. Saporta-Eksten, and S. Terry,Really Uncertain Business Cycles, *Working Paper*,2011.

[6] Diamond, P.,*National Public Radio Interview*, October 31, 2010.

[7] Fernandez-Villaverde, J., P. A. Guerron-Quintana, K. Kuester, and J. Rubio-Ramirez,Fiscal

Uncertainty and Economic Activity, *University of Pennsylvania Working Paper*,2011.

[8] Born, B., and J. Pfeifer,Policy Risk and the Business Cycle, *Working Paper*, 2011.

[9] Gilchrist,S.,J.W. Sim, and E. Zakraj_sek,Uncertainty, Financial Frictions, and InvestmentDynamics, *Working Paper*,2010.

[10] Ireland P N., Technology shocks in the new Keynesian model, *Review of Economics and Statistics*, vol.86, no.4 pp.923-936, 2004.

[11] Weiping Zhang,*MonetaryPolicy Theory-A Dynamic General Equilibrium Approach*, Peking University Press, 2012.

Modeling andSimulation ofFlexible ManufacturingSystemin VirtualRealityPlatform

Sinye Phoon[1], Hwa Jen Yap[2]andZahariTaha[31,2]DepartmentofMechanicalEngineering
CenterforProductDesignandManufactureUniversityofMalaya
JalanUniversiti,50603KualaLumpur,KualaLumpur,Malaysia[1]sinye.phoon@gmail.com[2]hjyap737@um.edu.my

[3]FacultyofManufacturingEngineeringInnovativeManufacturing,MechatronicsandSportsLab
UniversityMalaysiaPahang
PekanCampus,26600Pekan,Pahang,Malaysia[3]Ztr.motion@googleemail.com

ABSTRACT.*The adoption of virtual reality (VR) in manufacturing system simulations have proved its effectiveness in bridging the gap between different areas of expertise especially product design and manufacturing. In this paper, implementation of virtual reality in a cellular manufacturing system simulation is presented. By utilizing the feature of real-time interaction, the real-time control on the product travelling path based on user input is performed and the corresponding activities that are related to the change of travelling path is predicted in the virtual environment. Through the study, simulation of manufacturing system in virtual reality shows its potential as a powerful decision support system in process planning and scheduling.*
Keywords: VirtualReality,HumanMachineInterface,RealTime,ProcessPlanning

1. Introduction. The rapid development of computer technology has led the simulation method of complex manufacturing systems which are developed from 2D to 3D model and finally to virtual reality. The term virtual manufacturing has frequently appeared in recent studies as the result of increasing interest in using virtual reality for system simulation. It has generally been defined as a "system which abstract prototypes of manufacturing objects, processes, activities, and principles evolve in a computer-based environment to enhance one or more attributes of the manufacturing process". Application of virtual reality in manufacturing system is not limited to visualization purposes but also providing real time interaction and control with the virtual prototype, thus enhancing the overall manufacturing system quality from product design, manufacturing process, machining operation, facility layout and material handling system to all factory entities. Thus, it has great potential to be a decision supporting tool for manufacturing system planning and is expected to gain time-cost benefits from its application.

2. RelatedWork.A literature study and review covering more than 290 research papers throughout the year 2002 until 2012 has been conducted by Negahban and Smith [1]. The most important finding in this study was the significant growing trend of the simulation to be

used as a tool to solve different problems in manufacturing systems. In earlier researches, simulation is mainly used as a predicting and simple performance evaluation tool. As the development in computer science in the past decade has been rapidly growing, researchers have shown the interest of merging optimization and simulation for the search of optimal policy that is applied in manufacturing systems. From the observation of the current research trend, the application of simulation in manufacturing system design and operation is expected to continue growing and evolving in the future [1]. As the importance of simulation application in manufacturing system continues to grow, researchers has applied virtual reality for the purpose of simulating multiple manufacturing activities such as visualizing and analyzing current systems, improving and redesigning them, and searching for optimal solutions in emerging problems.

Generally, the application of virtual reality in manufacturing system can be classified into three main areas which are design, operation management and manufacturing process. This can further be divided into three different forms of VR systems according to the level of immersion such as non-immersive VR, semi-immersive VR and full-immersive VR [2]. Through the review on the application of VR systems in all areas, VR systems are not only limited to visualizing the possible problem in manufacturing design and product design, but also allowing real-time interaction in virtual environment to solve the problems effectively and efficiently [2].

The idea of adopting VR in manufacturing systems was further expanded by Menck et al. [3] through the suggestion of applying virtual reality as a collaboration tool for factory planning based on scenario technique. The study presented the idea of continuous VR system support throughout all phases of factory planning which enables the impact prediction of current decision on process planning in future development of the entire factory. Several researches have been conducted based on the idea of using VR system as a visualization tool in manufacturing systems [4-6]. VR has been used to build a die-casting virtual factory [4] where two different scheduling approaches were applied in the same virtual prototype platform under the same virtual environment, so that a comparison between two approaches could be observed and studied. Through the combination of VR system and discrete-event-simulation (DES) [5], the accuracy of system simulation in the virtual world has greatly improved which opens the door for analysis to be conducted in the virtual world for energy consumption, resource breakdowns and human performance analyses. VR systems appear to be a powerful tool to assist in the implementation of Value Stream Mapping (VSM) in United Stated-based small to medium enterprises (SME) company through visualization [6]. VR has also been used to build virtual process flow in both current and future state of VSM, where the time taken for each process is recorded in a VR platform and is used as the comparative variable to visualize the improvement of process planning through VSM.

As VR usage in simulating manufacturing systems is continuously expanding, a virtual factory framework has been developed which aims to achieve the sharing of resources, knowledge and information to support the design and management of the entire factory entities at all phases. The virtual factory concept has been applied in recent studies [7, 8], even though the proposed concept and model needs further development in order to deal with the complex manufacturing system network. However, the success of interoperability between software tools supporting the design, management and performance evaluation of manufacturing system through VR platform has been observed in the work.

One of the main benefits of using VR technology in manufacturing system simulation is the ability to visualize the virtual prototype of workplaces in its real operation environment

and real-time interaction within virtual environment, thus limiting the need of real mock up or real system testing which is time-cost effective and directly impacts the competitiveness of a company. As the virtual factory is able to simulate the real environment, the ergonomic study based on VR platform has been conducted [9-11]. In virtual prototypes of workplaces, the ergonomics and work safety of the product manufacturing process can be studied through the integration of VR hardware such as programmable hand tracking and gesture recognition gloves [9]. Similar work have been done [10] in order to study the assembly operation action performed by the operator, within an almost real assembly environment where every operation is based on operator reaction and is recorded and mapped as a standard assembly operation in the real workplace. An assembly test case was presented [11] where a prototype virtual experimentation environment has been created that uses a planning tool for assembly process by considering the ergonomic condition.

Application of VR in manufacturing has showed a potential to enhance manufacturing systems in a study by Yang et al. [12]. The VR simulation applies noise investigation, engineering change management and virtual cutting tool with chip formation simulation. By applying changes virtually, the negative impact of changes in real manufacturing systems can be minimized, resulting in an improved quality in planning and avoiding production shutdown. A recent study by Darmoul et al. [13] in year 2015 has performed the application of VR in robotic cell as well. The virtual environment for robotic cell was successfully used for layout planning and is a feasible solution to set up a real robotic work cell.

Through the reviews of previous work, the possibility of applying VR in different levels of manufacturing system design is high with current computer science and VR software applications and giving a positive result in achieving initial designed objective. This paper aims to study the possibility of applying a VR system in a robotic work cell and the effectiveness of the virtual robotic work cell to act as decision supporting tools in process planning.

3. Virtual Robotic Cell Development. This paper presents the idea of applying VR system for robotic cell. Through a scenario technique, the VR system is able to act as decision supporting tool for robotic cell

planning by selecting the suitable drop-pick position in terms of minimizing process cycle time and travel distance. There are two phases involved for the virtual environment creation. The first phase is the conception structural design and the second phase is the development of virtual models based on the initial structural design.

3.1. Conceptionstructuraldesign

Initial layout design has been proposed by adopting a small scaled real conveyor system mock up available in the lab which has a total of three suitable positions for the machine placement (in the simulation, dummy machines will be used) around the circular conveyor system and having two fixed machine placement in the middle of the loop which is located separately at both sides of a single gripper robotic arm. The complete structural design for the robotic layout is illustrated in Figure 1.

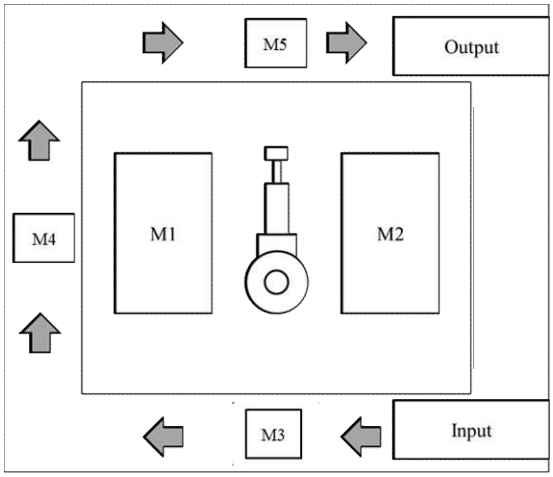


FIGURE1. Robotic Cell Layout

Few assumptions were made in proposing a simple robotic work cell:

1. One robot holds one part per time (single gripper robotic arm)
2. One machine involved per stage
3. Each machine can only hold one part
4. Each part only performs a maximum of three operations in the cell (the second operation is limited to M1 or M2)
5. No buffer for intermediate storage between the stages within the cell

3.2. Development of virtual model

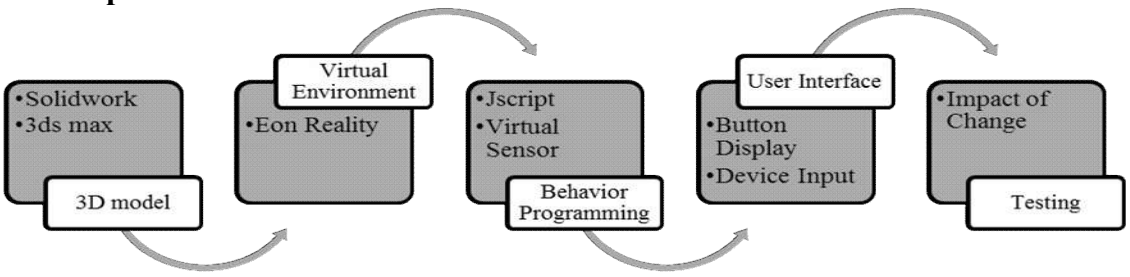


FIGURE2. Virtual robotic workcelldevelopment.

The stages to build the virtual robotic work cell are shown in Figure 2. The first stage is the CAD modeling, where the measurement of the real mock up conveyor system is recorded to assist in the CAD model through 3D modeling software (SolidWork). After the completion of the model, it is exported to the 3DS Max software for 3D model detailing. In the second stage, all 3D models will be transferred into a virtual environment through virtual reality software (EON Reality). The geometry of the 3D model will be redefined within the virtual environment. In the third stage, programming is required to simulate the desired motion for each part such as the continuous flow of parts and the KUKA robotic arm motion. To enhance the automation within the VR, virtual sensors have been set up to trigger reactions in related positions. The fourth stage is to create a user interface that enables real time interaction of the user with the simulation. The interface is buttons displayed on the screen which can sense the device input such as mouse and keyboard. The fifth stage is the most important stage for the

overall virtual robotic work cell. The user can have full real time interaction with the virtual object and visualize the impact of changes done to the system.

3.3. Architectureof virtualrobotic cell simulation

The simulation model is prepared in two main modes which are reading the machine sequence from the textfile at desired location or full user interaction. In the first mode,the s imulation window will read the textfile based on the given path, then the part will be initiated to move from the input porttoa desired M_i location (only machines arranged around the convey or loop can be selected).Once the partisin place,the stage2 operation M_{i+1} will be read from the textfile where the second operation is limited to machines within the loop(M_1 or M_2), thus the robot icarm will unload parts from $M_i$toM_{i+1}. Then, the operation duration will be displayed as a linear movement from the loading area of M_{i+1} to the unloading area of M_{i+1}. Once the part arrives at the unloading area,the third operation stage M_{i+2} reads from the file and thus the robot icarm will unload parts from M_{i+1} to M_{i+2}. After the part arrives at the final position, the part will move to the outputport. In the second mode,the same sequence and procedure occurs, but since full interaction with the user is not read from the computer and the simulation will not run automatically,the user need stoselect their next desired operation machine M_{i+1}as the part has reached the unloading area of the current machine.The full architecture is shown in Figure 3.

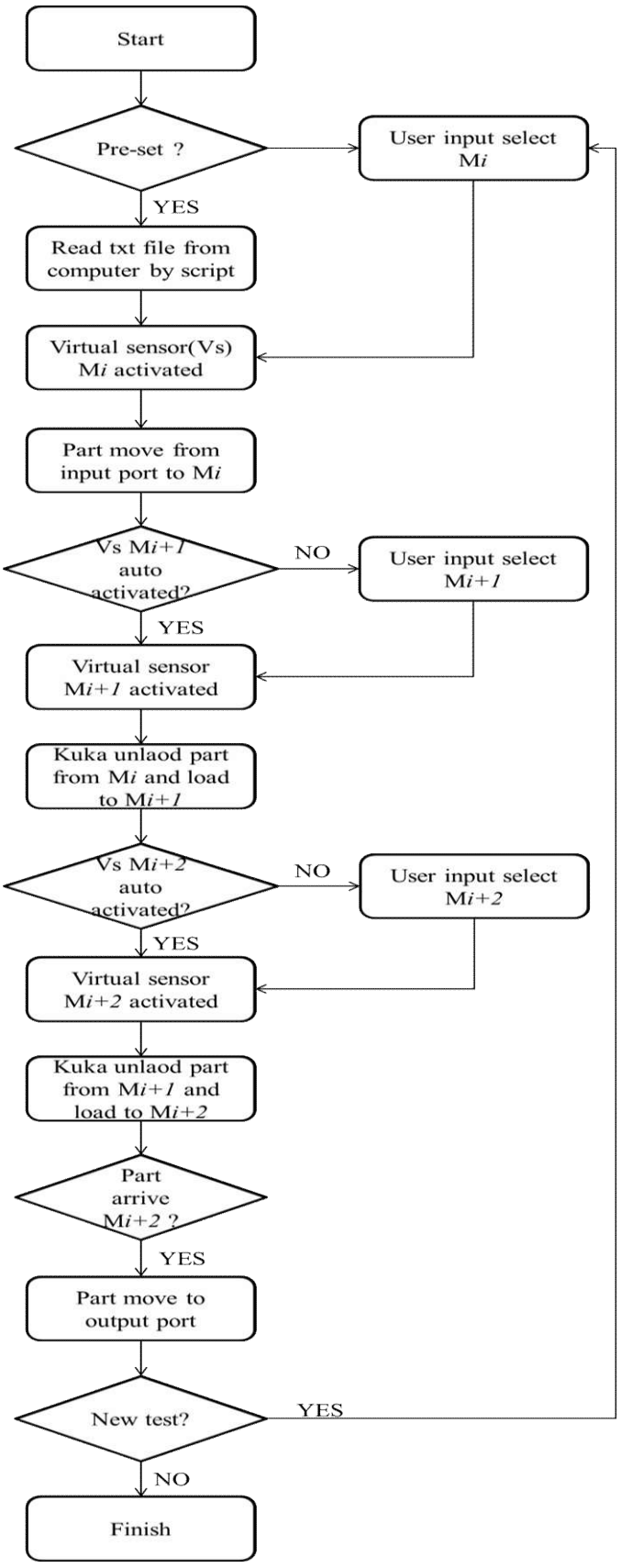


FIGURE3. Simulation architecture.

Inordertoobtainacomparativeresultforsupportingthedecisionmakinginproductionplanning,a distancecalculationscriptwasbuilt.Therewerefewassumptionsmade:

1. Thedistancecalculationis limited to thepart movingon the conveyor belt.
2. Thedistance ofapart movedbythe robotic arm is excluded.
3. Thepartstartsattheinput port andexits at the output port.
4. Thepartperforms 3 stages of machiningfor completingthe productioncyclebut thesameoperationcanonlybe performed once.

Thedistancecalculationalgorithm is shown in Figure 4.

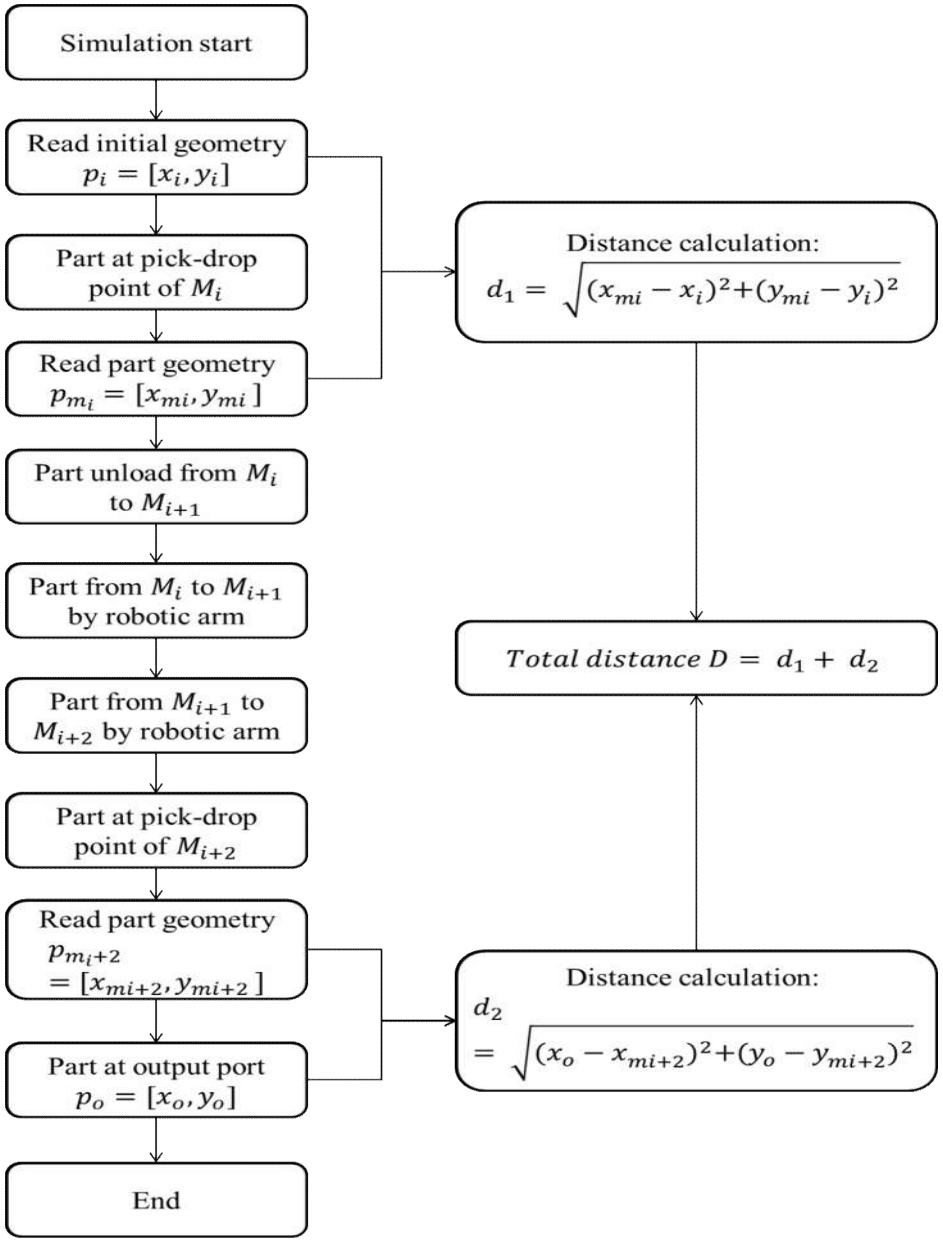


FIGURE 4. Distancecalculation algorithm

4. Simulation. Figure 5 shows the virtual layout of the proposed structural design and has simulated how parts are picked up, transferred to different stations and dropped by the robotic arm.

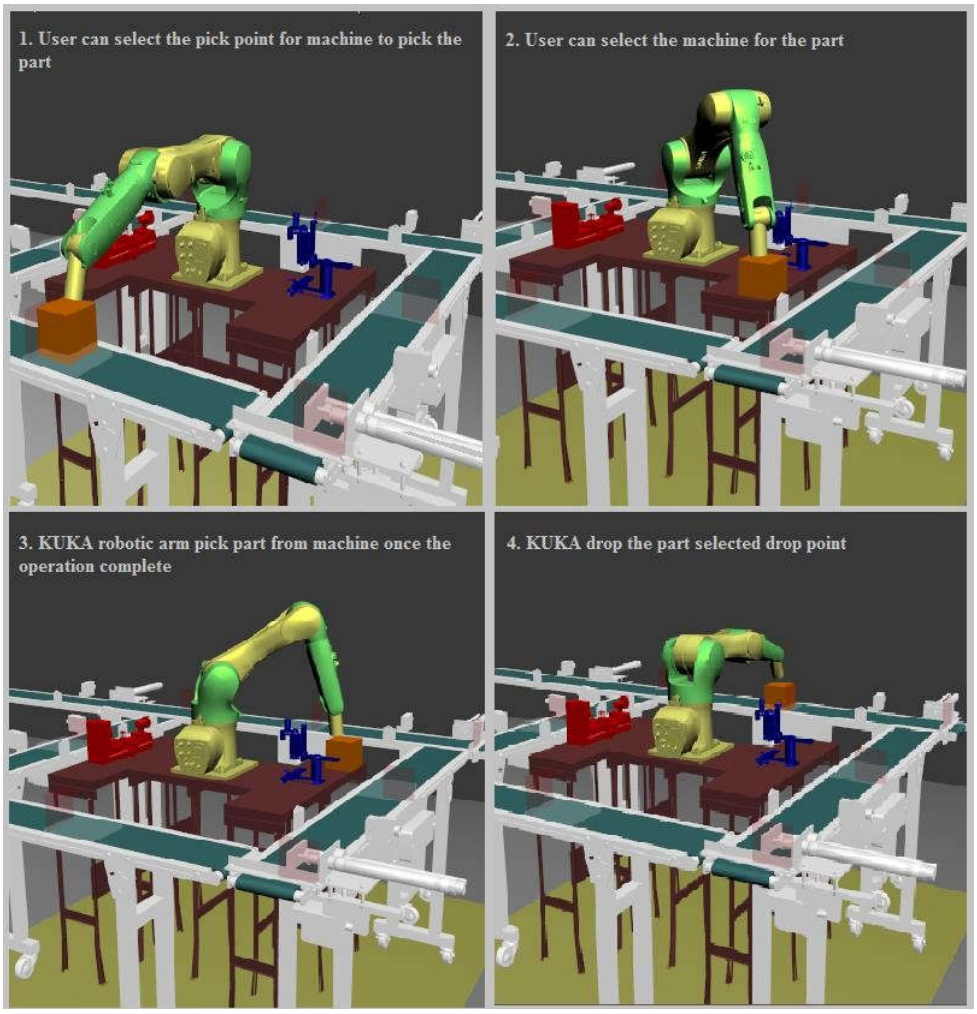


FIGURE5. Simulation of the virtual robotic workcell.

There is a choice of three different machine selections at the first stage, two machine selections at the second stage (however, since there is a distance of robotic movement while handling the part, the distance for selecting either M1 or M2 is assumed to be the same, which has less or negligible effects on the total travel) and two machine selections at third stage, which means there are a total of six sequences available for a part. The distance for each possibility will be taken. Since it is in virtual environment, the distance take is virtual unit that had been calibrated as 1mm in reality = 1 virtual unit. The data is shown in Table 1.

TABLE 1. Virtualdistance bydifferent routine

P =P(3)xP(1)xP(2)=3! X1! 2! =12				
Sequence	1st stage	2nd stage	3rd stage	Distance(virtual unit)
1	M3	M1	M4	2808.724
2	M3	M1	M5	1282.58
3	M4	M1	M3	5507.866
4	M4	M1	M5	2662.172
5	M5	M1	M3	6943.949
6	M5	M1	M4	5624.044

4.

Conclusions. Avirtualroboticworkcellhasbeendesignedanddevelopedbyintegrating3Dmodeling softwareandvirtualrealitysoftware.Thevirtualroboticworkcellallowsreal-timeinteractionwithvirtualobjectsthusallowingreal-timemodification.Changescanbedonedirectlytothesystemasthesimulationcontinuouslyrunsandtheimpactofchangescanbeobservedin thevirtualenvironmentwhichallowstheusertoevaluateontheselectedparttravellingpath.Throughthemultiplealternativetravellingpathtestedinthevirtualenvironment,userscan decidewhichisthemoresuitablepathbyconsideringenvironmentalissuesandfutureimpactoftheselection.VRsystemisagooddecisionsupportingtoolforprocessplanning,travellingpathplanningandjobsequencesplanning.Fromthestudy,themainadvantageofusingavirtualroboticworkcellistherepeatabilityfactorunderaconstantenvironment.Furthermore,testingthechangesinavirtualenvironmentcangreatlyreducecostbyavoidingrealmock ups and production shutdowns.

Acknowledgment. This work is supported by the Ministry of Education, Malaysia(FP026-2013) grant.

REFERENCES

[1] A. Negahban and J. S. Smith, Simulation for manufacturing system design and operation: Literature review and analysis, *Journal of Manufacturing Systems,* vol. 33, pp. 241-261, 2014.

[2] T.S. Mujber, T. Szecsi and M.S.J. Hashmi, Virtual reality applications in manufacturing processsimulation, *Journal of Materials Processing Technology*, vol. 155-156, pp. 1834-1838,2004.

[3] N. Menck, C. Weidig and J. C. Aurich, Virtual reality as a collaboration tool for factory planning based on scenario technique, *Procedia CIRP*, vol. 7, pp. 133-138, 2013.

[4] M. Bal and M. Hashemipour, Virtual factory approach for implementation of holonic control inindustrial applications: A case study in die-casting industry, *Robotics and Computer-Integrated Manufacturing* , vol. 25, pp. 570-581, 2009.

[5] U. Ghania, R. Monfared, and R. Harrison, Integration approach to virtual-driven discrete eventsimulation for manufacturing systems, *International Journal of Computer Integrated Manufacturing*, vol. 28, pp. 844-860, 2015

[6] S. Tyagi and S. Vadrevu, Immersive virtual reality to vindicate the application of value streammapping in an US-based SME, Int J Adv Manuf Technol, DOI 10.1007/s00170-015-7301-1, 2015.

[7] M. Colledani, G. Pedrielli, W. Terkaj and M. Urgo, Integrated virtual platform for manufacturing systems design, *Procedia CIRP*, vol. 7, pp. 425-430, 2013.

[8] B. Kadar, W. Terkaj and M. Sacco, Semantic virtual factory supporting interoperable modelling andevaluation of production systems, *CIRP Annals - Manufacturing Technology*, vol. 62, pp. 443-446, 2013.

[9] D. Grajewski, F. Górski, P. aw Zawadzki and A. Hamrol, Application of virtual reality techniques indesign of ergonomic manufacturing workplaces, *Procedia Computer Science*, vol. 25, pp. 289-301, 2013.

[10] Q. Yang, D.L. Wu, H.M. Zhu, J.S. Bao and Z.H. Wei, Assembly operation process planning bymapping a virtual assembly simulation to real operation, *Computers in Industry*, vol. 64, pp. 869-879, 2013.

[11] G. Chryssolouris, D. Mavrikios, D. Fragos and V. Karabatsou, A virtual reality-basedexperimentation environment for the verification of human-related factors in assembly processes,

[12] Robotics and Computer Integrated Manufacturing, vol. 16, pp. 267-276, 2000.

[13] X. Yang, R. C. Malak, C. Lauer, C. Weidig, H. Hagen, B. Hamann and J. C. Aurich, Virtual reality enhanced manufacturing system design, *Proceedings of DET*, pp. 125-133, 2011.

[14] S.Darmoul, M.H. Abidi, A. Ahmad, A. M. Al-Ahmari, S. M. Darwish and H.M.A. Hussein,Virtual reality for manufacturing: A robotic cell case study,*Industrial Engineering and Operation Management (IEOM)*, pp. 1-7, DOI 10.1109/IEOM.2015.7093880.

Modeling and Algorithm of Fuzzy Evaluation of Technical Standards Alliances Members---from the Perspective of Network Embeddedness

Jing Hu[1], Mingshun Song[1] and Yilin Wang[2]
[1] College of Economics and Management
China Jiliang University
No.258 Xueyuan Street, Xiasha Higher Education District, Hangzhou, 310018, P.R. China
hjcim, zyysh@163.com, smsqm@cjlu.edu.cn

[2] Zhongchao Ink Co., Ltd.
Shanghai, 201315, P.R.China
50487253@qq.com

ABSTRACT. *Under the background of the network, the enterprise obtained the alliance resources, such as technology, knowledge, and so on, as well as the continuously competitive advantages by "embedding" in the technology standard alliance. How to choose the alliance members has become an important link to decide that the technology standard alliance runs successfully. However, there existed a "paradox" for the embedded relationship of network, and if the membership was analyzed in isolation as leaving both resources and environment of organization, there would appear deviation. Only the network embeddedness is brought into the analytical framework to survey the member relationship of technological standard alliance, can the network "paradox" be solved.This paper establishes an evaluation model the technical standards alliances members based on fuzzy cognitive map (FCM). Firstly, by means of FCM causal relation reasoning and fuzzy measurement, the relationships and mutural influencement among evaluation criteria are depicted and reasoned. secondly, the non-linear Hebbian learning algorithm is integrated in the establishment of a fuzzy feedback system of knowledge transfer evaluation. Through the study and training of cognitive map, the dependency on the experts' opinions is avoided in the evaluation process. Finally, the effectiveness and rationality of the model are demonstrated through calculation examples.*

Keywords: Technical Standards Alliances, Alliances Members, Network Embeddednes, FCM

1. **Introduction.** Along with the development of the modern market economy, standards, as the new commanding height in international competition, have become an important means for the formulation of market rules. Against the backdrop of networked enterprises (the network development of enterprises and organizations and the networked technological innovation of enterprises), it is increasingly difficult for individual enterprises to grasp diverse knowledge and independently develop all technologies. As a matter of fact, it has become common sense of many enterprises to establish their own standards systems by setting up or jointing technical standards alliances. However their long-term development is

plagued by instability. Spekman, Dacni and Hitt as well as many other scholars, were convinced that the failure rate of enterprise alliances was 60%. Woodman even suggested it to be 70%. There is a general assumption among scholars that the selection of members is one of the most important factors resulting in such high failure rate.

The enterprise gains access to technology and knowledge, as well as other resources, by embedding in a technical standards alliance. However, the question of "What is the best embedding relationship" is in dispute: some studies have found that a higher level of network embeddedness means that strong embeddedness can enhance the performance of enterprises. Other empirical studies show that strong network embeddedness has a negative influence on enterprise performance. Uzzi pointed out that the relationship between network relationship strength and enterprise performance forms an inverted U shape. The ideal strength of network embedding exists in the intermediate state, which is neither too dense to dissolve the relationship, nor too loose to form a relationship. These contradictory views indicate that it is important to conduct in-depth research on alliance relationships.

Recent years have seen many studies of evaluation methods and models for enterprise alliance partnerships, including multi-objective programming (MOP), BP network programming, data envelopment analysis (DEA), analytic hierarchy process (AHP), direct choice analysis (DCA), cost analysis based on activities, the artificial neural network algorithm and the gray system algorithm. There are few evaluation models for a technical standards alliance, which mainly adopt AHP/ANP methods.

The technical standards alliance is a complex system. Considering the diversity of alliance members, functional integration, geographical dispersibility and organizational impermanence, the evaluation of its members is very difficult. Since it is difficult to obtain abundant historical data, and impossible to quantify the evaluation standards and attributes, the evaluation methods, to some extent, rely on the subjective evaluation of experts. In the existing evaluation model, AHP is a commonly applied method that can better resolve multi-objective decision making combining quantitative and qualitative approaches. Despite its advantage of high reliability and little error, it still neglects the mutual influence and interdependence of evaluation standards. ANP, as the extension of AHP, has taken into consideration the mutual influence of standards and attributes; however, it requires the establishment of a complicated judgment matrix. Consequently, the evaluation results are highly dependent on the determination of the network structure, thus reducing the reliability of the evaluation results. Therefore, there is a demand for a more effective modeling method to tackle the issues related to the selection of technical standards alliance partners.

The fuzzy cognitive map (FCM), proposed by Kosko, is a dynamic system analysis and modeling method based on Axelrod's cognitive map method and Zadeh's fuzzy set theory, and reasons according to the causal relationship. Currently, it has been widely applied to research on the social and behavioral sciences, stock exchanges and military policies. Compared to other evaluation methods, the advantage of FCM lies in its integration of the concepts of fuzzy logic and neural networks and the possession of intuitive expression ability and strong reasoning ability. Therefore, this paper applies the FCM method to the evaluation of technical standards alliance partners, so as to form a mapping relationship with the knowledge structure of the experts in this field. At the same time, the learning and

feedback mechanisms of FCM give the evaluation a progressive function, enabling the evaluation model to conform to the actual conditions of the technical standards alliance, and providing new thoughts for related research.

2. Member Evaluation Index System of Technical Standards Alliances. In the context of current networked enterprises, individual enterprises find it quite difficult to create standards exclusively due to a variety of limitations, and this is only possible for those with great power; therefore they would choose to participate in a technical standards alliance in an explicit or implicit manner. Both foreign and domestic scholars have offered descriptions of technical standards alliances from different perspectives, including organizational mechanisms, causes for the alliance and the type of the alliance. This research proposes that a technical standards alliance is a special strategic alliance that is formed by enterprises around key and core techniques, to share technical achievements and reduce costs for standardization, which means that it is a contractual alliance with a loose organizational mechanism. The nature of a technical standards alliance is a value network that accumulates numerous technical and social resources.

There are few studies on the factors for member selection in technical standards alliances by domestic and foreign scholars. By combining relevant theories and literature, and the author's long-term tracking and visiting of domestic technical standards alliances, this paper argues that the fundamental purpose for members to participate in a technical standards alliance is to be continually competitive by being "embedded" in this network, and to obtain alliance resources like techniques and knowledge. Therefore, reviewing membership from the perspective of network embeddedness is to adopt network embeddedness as the evaluation index of membership; this paper also proposes that membership is established on the basis of member selection and attempts to establish a member evaluation index system of technical standards alliances from the perspective of an "instinct factor" (member selection) and a "congenital factor" (network embeddedness).

Adopting Sierra and Cauley's 3C theory as a model, and taking references from the research achievements of Hua Jinke & Zeng Deming and Han Wenhui, this research combines the main purpose for establishing technical standards alliances, that is, achieving complementary resources, common technological progress and product and market development, and classifies members of technical standards alliances based on reputation, compatibility and technical standardization capacity. Among them, reputation includes brand reputation and product reputation; compatibility includes rules and regulations compatibility, strategic objectives and core values compatibility, etc; technical capability includes technology absorption capacity, technology management capability and technical innovation capability; market capabilities include marketing cognitive capability, marketing development capability and the suitability of marketing and R&D.

This research references McEvily and Marcus and Wang Jiong, and classifies network embeddedness into trust, information sharing and joint problem solving. Trust refers to alliance members not attacking each other; information sharing refers to alliance members sharing information with each other so as to promote the operation and innovation of other members, which is especially critical for technical standards alliances; joint problem

solving refers to network members sharing the responsibility of maintaining partnership and solving problems, which is also a necessary mechanism to design and promote a standards-linked technical standards alliance.

Based on the above analysis, this paper establishes a member evaluation index system of technical standards alliances shown in Table 1.

TABLE 1. Technical Standards Alliances Members Evaluation Index System Based on the Network Embeddedness

The Technical Standards Alliances Members Evaluation Index Based on the Network Embeddedness	Members Selection Index	Reputation (A)	Brand reputation (A_1)
			Product reputation (A_2)
		Compatibility (B)	Rules and regulations compatibility (B_1)
			Strategic objectives compatibility (B_2)
			Core values compatibility (B_3)
		Technical capability (C)	Technology absorption capacity (C_1)
			Technology management capability (C_2)
			Technical innovation capability (C_3)
		Market capabilities (D)	Marketing cognitive capability (D_1)
			Marketing development capability (D_2)
			Fit of marketing R&D. (D_3)
	Membership Index -Network Embeddedness (E)		Trust (E_1)
			Information sharing (E_2)
			Joint problem solving (E_3)

3. FCM model for Member Selection and Evaluation in Technical Standards Alliances

3.1 Reasoning process for fuzzy cognitive map. FCM is composed of concept nodes: C_i (i = 1, 2, ..., n, n is the number of concept nodes); each concept node represents a key element of the system, with a value $A_i \in [-1,1]$, i = 1,2, ..., n. A_i^k is the state value when C_i adopts the value at k round; W matrix is the adjacency matrix of interaction between concepts; F is the threshold function ensuring that each iteration output is within [0,1]. This research uses the following threshold function:

$$f(x) = tanh(x) = (1-e^{-x})(1+e^{-x})$$

Since the model being established is qualitative, the threshold function can be adopted to unify the input value at concept nodes. The hyperbolic tangent function $f(x) = tanh(x)$ is one of the commonly used threshold function and value of concept nodes can be negative; therefore, this paper adopts this threshold function.

Figure 1 is the reasoning process for fuzzy cognitive map.

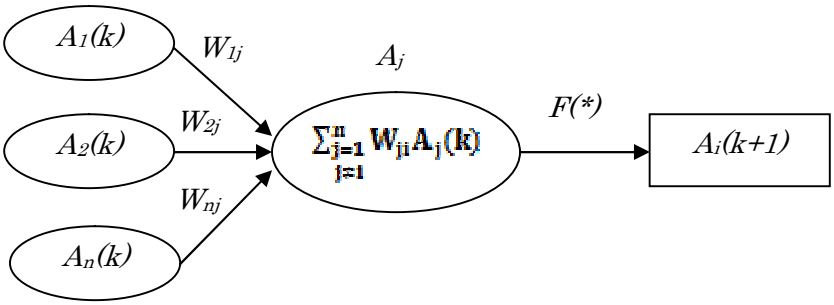


FIGURE1. FCM reasoning process

The interaction between certain specific concepts and other concepts can be calculated by the following iterative formula:

$$C^{(k+1)}=f(C^{(k)}W), \quad C^{(0)}=I_{n\times n} \tag{1}$$

At each step in the reasoning process, the state vector A_i^k in the previous step is multiplied by FCM adjacency matrix W; change the *f* to obtain A_i^{k+1}, which can be again input in the next step of reasoning. By a certain number of iterations, a stable state can be considered as reached when the state value of the concept node reaches one of the following states: (1)state value at a fixed value; (2) state value changing cyclically; (3) chaotic state, i.e., the state value is unpredictable and random.

As can be seen from the above reasoning, the fuzzy cognitive map has two significant drawbacks: strong dependency on expert opinion; and the final state may converge beyond the desired state. In order to enhance the effectiveness and robustness of the fuzzy cognitive map, it is necessary to update the weight matrix by using a learning algorithm, so that the final state can be converged within the desired steady state.

3.2 Weight learning algorithm. This research adopts the Papageorgiou Nonlinear Hebbian learning algorithm, which is based on the assumption that all the concept nodes in the FCM model can be excited in all iterations, and the state value changes. Therefore, the iteration formula modified by the Hebbian algorithm is:

$$A_i^{(k+1)} = f(A_i^{(k)} + \sum_{\substack{j=1 \\ j\neq i}}^{N} A_j^{(k)} W_{ji}^{(k)}) \tag{2}$$

$w_{ji}^{(k)}$ is the weight value of relationship between concept node C_j and C_i when the iteration becomes the k round. The calculation method is as follows:

$$W_{ji}^{(k)} = \gamma w_{ji}^{(k-1)} + \eta A_i^{(k-1)}(A_i^{(k-1)} - sgn(w_{ji}) w_{ji}^{(k-1)} A_i^{(k-1)}) \tag{3}$$

Where η is the learning rate parameter ($0 < \eta < 0.1$), the trial and error method is usually adopted to determine its value. γ ($0.9 < \gamma < 1$) is the weight attenuation factor. $sgn(w_{ij})$ is used to ensure that the appropriate weight symbol maintains its original physical meaning. $-sgn(w_{ji})\, w_{ji}^{(k-1)}(A^{(k-1)})^2$ is used to prevent the weight from increasing beyond the desired value.

In addition, decision makers also need to identify which concept nodes are for output, and represent their value by DOC. The identification of output concept nodes depends on the interest of decision makers. Generally, the non-linear Hebian learning algorithm

includes two termination conditions to minimize the following two standard functions by continuously updating the weight.

The first standard function is to check whether the output node DOC can meet the specialist's requirement: $$F_1 = |DOC_1 - T_1|$$

T_i is the average target value T of output node DOC; there are m nodes in a FCM. Therefore, the standard function is:

$$F_1 = \sqrt{\sum_{i=1}^{M} (DOC_i - T_i)^2} \quad (4)$$

The second is to minimize the change of values between two output nodes. The standard function F_2 is: $$F_2 = \left|DOC_i^{(k+1)} - DOC_i^{(k)}\right| < e \quad (5)$$

Therefore, the learning fuzzy cognitive map constantly updated by the weighted value, and thus the minimize standard function F_1 and F_2.

3.3 Calculating steps. First, obtain the partial weight vector by the characteristic root method after comparing the importance of the member evaluation index of technical standards alliances established in Table 1 in two;

Then depict the interaction between indexes by the fuzzy cognitive map, as there are mutual interactions between the various standards. The causality map is shown as Figure 2.

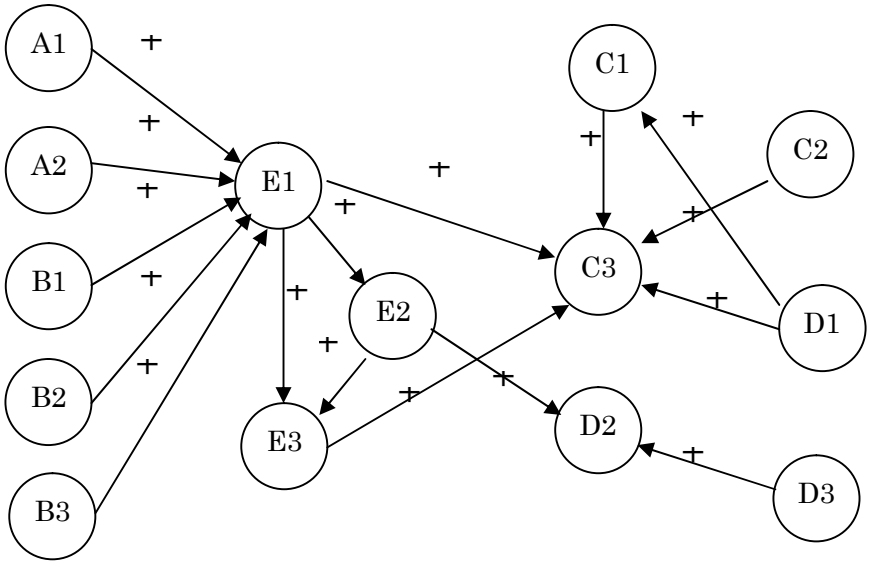


FIGURE 2. Causality Diagram of Technical Standards Alliances Partners Evaluation Index

In the cognitive map, each node represents the evaluation index of an alliance partner; weight value corresponding to directed arc between nodes $w_{ij} \in [-1,1]$ represents the causal relationship between nodes; "+" indicates positive effect, "-" indicates negative effect, and the absolute value reflects the degree of interaction between concepts. The larger the absolute value is, the more obvious the causal relationship between two nodes is. When building the fuzzy cognitive map, the relationship between standards is generally described by experts to determine whether the effect of one indicator on another is positive or negative.

The specific learning algorithm steps of fuzzy cognitive map are:

(1) Iterate k times according to the formula (1);

(2) Update the value of $A_i^{(k)}$ according to formula (2);

(3) Update the value of $w_{ji}^{(k)}$ according to formula (3);

(4)Calculate the two termination conditions based on formula (4) and (5) and stop the iterative process until both conditions are met.

(5) Return the final weight matrix W_{final}

4. Calculation Case Analysis. This paper chose the alliance for Zhejiang biology industry technical standards as the subject, and uses the above established evaluation model to evaluate the three alternative alliance members P_1, P_2 and P_3.

First, 14 indicators in Table 2 are compared by decision makers in groups of two, and the following judgment matrix is obtained. Then the local weight value by the characteristic root method is calculated, as shown in Table 2.

TABLE 2. Judging matrix of experts

	A1	A2	B1	B2	B3	C1	C2	C3	D1	D2	D3	E1	E2	E3	local weight
A1	1	1	3	2	1	1/3	1/3	1/5	1/2	1/3	1/4	1/5	1/4	1/4	0.1239
A2	1	1	3	2	1	1/3	1/3	1/5	1/2	1/3	1/4	1/5	1/4	1/4	0.1239
B1	1/3	1/3	1	1/2	1/3	1/6	1/6	1/9	1/4	1/6	1/8	1/9	1/8	1/8	0.0358
B2	1/2	1/2	2	1	1/2	1/4	1/4	1/7	1/3	1/4	1/5	1/7	1/5	1/5	0.0972
B3	1	1	3	2	1	2/3	2/3	1/3	3/4	2/3	1/2	1/3	1/2	1/2	1.0859
C1	3	3	6	4	3/2	1	1	1/2	3/2	1	3/4	3/5	3/4	3/4	0.2778
C2	3	3	6	4	3/2	1	1	1/2	3/2	1	3/4	3/5	3/4	3/4	0.2564
C3	5	5	9	7	3	2	2	1	5/2	5/3	5/4	2	5/4	5/4	0.4816
D1	2	2	4	3	4/3	2/3	2/3	2/5	1	1/2	1/3	2/5	1/2	1/2	0.1828
D2	3	3	6	4	3/2	1	1	3/5	2	1	1/2	3/5	3/4	3/4	0.3095
D3	4	4	8	5	2	4/3	4/3	4/5	3	2	1	4/5	1	1	0.3297
E1	5	5	9	7	3	5/3	5/3	1/2	5/2	5/3	5/4	1	2	2	0.5421
E2	4	4	8	5	2	4/3	4/3	4/5	2	4/3	1	1/2	1	1	0.3889
E3	4	4	8	5	2	4/3	4/3	4/5	2	4/3	1	1/2	1	1	0.3610

According to the fuzzy cognitive map, experts offer a weight value matrix:

TABLE 3. Weight matrix of experts

	A1	A2	B1	B2	B3	C1	C2	C3	D1	D2	D3	E1	E2	E3
A1	0	0	0	0	0	0	0	0	0	0	0	0.35	0	0
A2	0	0	0	0	0	0	0	0	0	0	0	0.35	0	0
B1	0	0	0	0	0	0	0	0	0	0	0	0.25	0	0
B2	0	0	0	0	0	0	0	0	0	0	0	0.35	0	0
B3	0	0	0	0	0	0	0	0	0	0	0	0.4	0	0
C1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0
C3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
D1	0	0	0	0	0	0.25	0	0.4	0	0	0	0	0	0
D2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
D3	0	0	0	0	0	0	0	0	0	0.3	0	0	0	0
E1	0	0	0	0	0	0	0	0.55	0	0	0	0	0.35	0.45
E2	0	0	0	0	0	0	0	0	0	0.35	0	0	0	0.35
E3	0	0	0	0	0	0	0	0.35	0	0	0	0	0	0

The nonlinear Hebbian learning algorithm learns the above weights, and identifies the learning rate η as 0.01, the attenuation factor γ as 0.95 by the trial and error method; the W matrix after being trained is:

TABLE 4. Weight matrix after training

	A1	A2	B1	B2	B3	C1	C2	C3	D1	D2	D3	E1	E2	E3
A1	0	0	0	0	0	0	0	0	0	0	0	0.1672	0	0
A2	0	0	0	0	0	0	0	0	0	0	0	0.2556	0	0
B1	0	0	0	0	0	0	0	0	0	0	0	0.2078	0	0
B2	0	0	0	0	0	0	0	0	0	0	0	0.0891	0	0
B3	0	0	0	0	0	0	0	0	0	0	0	0.5685	0	0
C1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C2	0	0	0	0	0	0	0	0.0518	0	0	0	0	0	0
C3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
D1	0	0	0	0	0	0.6449	0	0.3357	0	0	0	0	0	0
D2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
D3	0	0	0	0	0	0	0	0	0	0.2613	0	0	0	0
E1	0	0	0	0	0	0	0	0.5270	0	0	0	0	0.4850	0.4450
E2	0	0	0	0	0	0	0	0	0	0.1948	0	0	0	0.3705
E3	0	0	0	0	0	0	0	0.2658	0	0	0	0	0	0

Obtain the general weights by formula computation as shown in Table 5.

TABLE 5. Judging matrix Technical Standards Alliances Partners Evaluation Index

	A1	A2	B1	B2	B3	C1	C2	C3	D1	D2	D3	E1	E2	E3
Local weights	0.0270	0.0270	0.0078	0.0211	0.2362	0.0604	0.0558	0.1048	0.0398	0.0673	0.0717	0.1179	0.0846	0.0785
General weights	0.0129	0.0398	0.0053	0.0653	0.1826	0.0468	0.0355	0.0327	0.0824	0.0561	0.0783	0.1350	0.1046	0.1227

In the above table the partial weight and the overall weight of evaluation standards are compared, and it can be found that the reasoning of the evaluation index system by the fuzzy cognitive map reflects the interaction among indicators. Therefore, the weights of all evaluation indicators have changed, and those of B3(core values compatibility), D3(fit of marketing and R&D) and C2(technology management capability) are the most significant. It can be found by comparing the overall weights of each indicator that the D3(fit of marketing and R&D) indicator is the most important factor when selecting partners in alliance for technical standard, then E1(trust) and C2(technology management capability).

The member evaluation indicators of technical standards alliances established in Table 1 are all qualitative. Each indicator of the three alliance members is scored by experts; the evaluation statements set v = {very low, low, medium, very high, high}; the corresponding value v = {1, 2, 3, 4, 5,}; therefore, a score sheet of alliance partner candidates is obtained as shown in Table 6.

TABLE 6. Weight matrix after training

	A1	A2	B1	B2	B3	C1	C2	C3	D1	D2	D3	E1	E2	E3
P1	4	4	2	3	4	2	3	4	4	3	3	3	4	5
P2	4	3	2	3	3	4	4	5	5	3	4	3	2	4
P3	3	3	3	4	4	4	4	5	4	4	4	2	3	3

Make a comprehensive evaluation for each indicator of all candidate enterprises by the vector of overall weights in Table 3, and the evaluation results are shown in Table 7.

TABLE 7. the Evaluation Results of Alliance Partner Based on FCM

	P1	P2	P3
Evaluation Result of Local Weights	3.6079	3.4899	3.6437
Evaluation Result of General Weights	3.5375	3.6399	3.5917

The above table also shows the evaluation results according to the weighted value of indicators without FCM iteration; the order of the three companies is $P_3 > P_1 > P_2$, that is, the Union should take P_3 as the best candidate for its member, then P_1 and finally P_2. The result obtained by using the fuzzy evaluation model on the basis of fuzzy cognitive map is $P_2 > P_3 > P_1$; P_2 owns the highest score and should be given priority when absorbing enterprises as members of the alliance, while P_3 turns out to be the second, and thus the second candidate. The FCM method takes into account the interaction between all standards when evaluating members of an alliance for technical standards, and thus the results are different. It can be concluded from this that it is reasonable to establish a member evaluation model for alliances for closed-loop supply technical standards.

5. Conclusions. Using the network-based approach, the selection of alliance partners will exert certain impacts on the technical standards alliance. This paper is aimed at establishing the evaluation system for technical standards alliance partners from the perspective of

network embeddedness, highlighting the significance of the alliance member relationship to the development of the technical standards alliance, and driving the healthy and sustained growth of the technical standards alliance. The fuzzy cognitive map was adopted as the modeling instrument, so as to effectively express the evaluation system of alliance partners as a fuzzy system containing the mutual influence of each factor, and to verify the rationality and feasibility of this model through the analysis of examples of the computer software platform.

The main conclusions of this paper are listed as follows:

(1) According to this research, the influence of the selection of alliance partners in a technical standards alliance is established based on the relationship between specific situations and network embedding relationship. Therefore, the evaluation indicator system in this paper includes two dimensions, namely, the partner selection as the "innate factors," and network embedding as the additional factor influencing the technical standards alliance.

(2) In light of the qualitative evaluation standard with the feature of mutual influence and feedback, this paper sets up an evaluation model for a fuzzy cognitive map to integrate expert knowledge and intelligent computing, and make reasonable and scientific judgments and evaluations of the multi-objective evaluation covering a large number of qualitative indicators. Different from the AHP, this method takes into account the mutual influence and feedback relationship of indicators; as opposed to ANP, this method also avoids the complexity of establishing a multi-matrix.

(3) The fuzzy evaluation model in this paper combines the fuzzy cognitive map and the Hebbian learning algorithm, and sets up the complete FCM evaluation model supporting the adaptive behavior of expert knowledge. With the non-linear Hebbian learning algorithm training, it also acquires a more accurate weight matrix, thus overcoming the heavy reliance on expert opinions, and objectively reflecting the comprehensive advantage of a technical standards alliance partner.

Acknowledgment. This work is partially supported by Soft science project of Zhejiang Province—Research on risk prevention mechanism and countermeasure in Strategic Emerging Industries' Technical Standards Alliances: the Ecosystem Perspective [2015C35002]

REFERENCES

[1] C Jay Lambe, Robert E., Spekman, and Shelby, D. Hunt, Alliance competence, resources, and alliance success: Conceptualization, measurement and initial test, *Academy of Marketing Science*, vol.30, pp.141-158,2002.

[2] Capaldo A., Network structure and innovation: the leveraging of dual networks as a distinctive relational capability, *Strategic Management Journal*, vol.28, No.4, pp.585-608, 2012.

[3] Christoph,.D, and Jens G.; Multinational corporations, inter-organizational networks and subsidiary charter removals, *Journal of World Business*, vol.45, pp.206-216,2013.

[4] Daniel Tolstoy, and Henrik Agndal, Network resource combinations in the international venturing of small biotech firms, *Technovation*, vol.30, pp.24-36, 2011.

[5] Das, T. K. and Teng, B. S.; Between trust and control: developing confidence in partner cooperation in

alliances, *Academy of Management Review*, vol23, pp.491-512, 1998.

[6] Fang Fang, Wang Daoping and Zeng Mingde, Research on Path of Technical Standard Alliance's Enhancing the Dynamic Capability of High-tech Enterprises, *Modern Finance & Economics*, Vo1.26, No.10, pp.7-11, 2006.

[7] Hagedoorn, J., Understanding the cross-level embeddedness of interfirm partnership formation, *Academy of Management Review*, vol.31, pp.670-680. 2006.

[8] Holm, D. B., Erilisson, and K., Johanson, J,, Business networks and cooperation in international business relationships, *Journal of International Business Studies*, vol.27, pp.1033-1054, 2010

[9] Hou Jiyong, Liu Yi, and Li Xiyao, Research on knowledge management - based on enterprise network architecture, *Scientific Management Research*, vol.26, No.1, pp.74-77, 2012.

[10] McEvily, B., and Marcus, A,,; Embedded ties and the acquisition of competitive capabilities, S*trategic Management Journal*, vol.26, pp.1033-1055, 2005.

[11] McEvily, B., and Zaheer, A., Bridging ties: A source of firm heterogeneity in competitive capabilities, *Strategic Management Journal*, vol.20, pp.113-111, 1999.

[12] Minehart D., Neeman, Z., Termination & coordination in partnership, *Journal of Economics & Management*, vo.l8, pp.191-221, 2009.

[13] Powell, W., Neither market nor hierarchy: network forms of organization, *Research in Organizational Behavior*, vol.12, pp.295-336, 2011.

[14] Uzzi, B., The sources and consequences of embeddedness for the economic performance of organizations: the network effect, *American Sociological Review*, vol.61, pp.674-698, 1996.

[15] Williamson, O. E.; The Lens of Contract: Private Ordering, *American Economic Review*, vol.92, pp.438-443.2012.

[16] Zaheer, A., and Bell, G.; Benefiting from network position: firm capabilities, structural holes, and performance, *Strategic Management Journal*, vol26, 809-825, 2005.

[17] Zeng Mingde, Hua Jinke and Sun Yaowu, Selection of collaboration R&D partner -based on technology standards, *Science and Technology Management*, vol.11, pp.39-41, 2012.

[18] Zhang Yanfei, and Wu Wenhua, Research on the Ecology Characteristics of Technical Standard Alliances of Information Industry, *Science & Technology Progress and Policy*, vol.27, pp..88-92, 2010.

Does CSR influence the corporate value? Evidence from Chinese manufacturing enterprise.

Wentao Gu[1], Shumin Zhou[2] and Zhe Dong[3]
Research Institude of Econometrics and Statistics
Zhejiang Gongshang University
18, Xuezheng Street, Xiasha Education Park, Hangzhou, Zhejiang, P. R. C
[1]zjgsu-guwentao@hotmail. com
[2]Hoodeyn@163. com
[3]dz663266@163. com

ABSTRACT. *This paper is intended to explore the relations between corporate social responsibility(CSR) performance and the corporate value. Since there is no universal evaluation standard of CSR at our country, we establish a CSR index evaluation system based on the framework of ISO26000 and study the relationship between the index and corporate value. The index system is from a stakeholder perspective with the consideration of the particularity for Chinese corporation. In the empirical study, we select 122 listed manufacturing companies to carry out CSR performance evaluation and run multiple linear fixed effect panel models. The results shouw that the coefficient of CSR index is not significant. .*

Keywords: Corporate social responsibility, Factor analysis, Fixed effects model

1. **Introduction.** Nowadays, corporate social responsibility (CSR) has become the necessary requirements for corporations if they want sustainable development. But corporate needs to pay for CSR, which means increasing costs. Will the increased costs damage corporate value? How to weigh CSR and corporate value? These are exactly the research focus of this paper.

2. **Literature review and Proposed Hypothesis.** Abundant research existing on the relationship between enterprise value and the performance of CSR. The main conclusions of scholars can be divided into four categories: the first category is that the CSR positively affects the enterprise value. In the work of [1] , Lancaster studied more than 200 environmental information disclosure of the listed companies and the correlation with enterprise value, he concluded that the negative environmental events will damage enterprise value. Omaima used Egypt listed companies in [2] as the research object, and concluded that there has no significant positive correlation between companies voluntary information disclosure and enterprise value. Sandra A. Wad dock and Samuel B. GraveS (1997) proposed the company dominant costs (Explicit Cost: for example, the interest paid to a creditor) and hidden costs (Implicit Cost: the quality of the product Cost, environmental Cost) concept to explain this result. Companies which didn't engaged in CSR activities will make hidden costs increasing, then will produce more dominant costs, thus they will lose competitive advantage eventually.

The second category is that CSR is negatively related to the enterprise value. Aupperle et

a1. (1985) also think that CSR will waste capital and other resources.[3] Compared with the companies that don't engage in CSR activities, the company who engaged will at a competitive disadvantage.

The third category is that CSR has nothing to do with the enterprise value. Murray (2006) selected 100 British company with 10 years of data, and found that social responsibility and environmental information disclosure has no correlation with stock returns.

The last category is that CSR do have a certain influence on the stability of enterprise values in a time series view. Such as Cormier, etc. (2004) hold that investors tend to use CSR report, in order to better estimate the enterprise future earnings, reduce the uncertainty of potential; Capital market will respond according to CSR information, it provides the motivation to bear the social responsibility and do environmental protection; At the same time, the stock market will respond to corporate social responsibility report, thus affecting the long-term value of the stock. [4]

We hold the opinion that fulfilling CSR can help to increase the value of enterprise, but as corporations in our country just pay attention to CSR in recent years, the present CSR performance may effect enterprise value weakly. Therefore we put forward the following hypothesis:

Hypothesis. CSR can promote enterprise value weekly.

3. **Research contents and Methods.**

3. 1. **Construct the index system of CSR**

3. 1. 1. **Theoretical basis of constructing CSR.** Popular theories about CSR are the following three: triple bottom line, social contract theory and stakeholder theory. Triple bottom line was first put forward by British scholar John Elkington in 1997, and he thought CSR can be divided into economic responsibility, environmental responsibility, social responsibility. Social contract theory holds that the relationship between corporations and society is contractual. Society provides good living conditions for corporations so corporations should undertake corresponding responsibility for society. Corporations use authority granted by society to turn some resources into product or service and get revenue out of it. In return, corporations have obligation to repay the society. Stakeholder theory holds that CSR can be divided according to its stakeholders' benefits to determine their social responsibility, including corporations' responsibility for investors, creditors, employees, partners, customers, governments, society and improving ecological environment. The concept breaks the viewpoint of maximizing shareholder benefits in traditional literature.

3. 1. 2. **Popular CSR evaluation system.** The international popular evaluation index system of CSR includes social responsibility standard SA8000 (1997), the Dow Jones Sustainability Index DJSI (1999), and ISO26000 (2010). SA8000 taken from international labor standards through nine aspects(child labor, forced labor, health and safety, freedom of association and collective bargaining rights, punitive measures, discrimination, working hours, wages reward, management system)to evaluate the fulfillment of CSR. DJSI focus on the influence of corporations' development on economy, society, environment. IS026000 refers to 68 international conventions, statement and guidelines, including nine

aspects (management and organization, human right, labor, environment, equity management, consumer protection, community participation, social development, stakeholder cooperation.)

The fulfillment of CSR in China is still in the initial stage, and is mostly based on the existing foreign results. However, the emergence and development of Chinese corporations have their own characteristics in Chinese economic system, which is quite different from abroad. Therefore we establish a CSR evaluation system which is fitting for China firms. This evaluation system should be consistent with the concept of sustainable development, while conforming to the actual conditions of China.

We build our CSR index system mainly by the most widely used stakeholder theory. Based on the ISO26000 guidelines for social responsibility, combining with results of the empirical and normative research of listed company in China, we establish the evaluation index system of CSR for listed Chinese manufacturing corporations.

3. 1. 3. **Evaluation system of CSR.**

In this paper we hand-finish corporate social responsibility report or annual report to obtain both financial and nonfinancial information, either qualitative or quantitative.

We follow the principle of accessibility, scientific and comparability, establishing detailed evaluation index system of CSR by dividing into 10 first-grade indexes and 44 second-grade indexes. First-grade indexes included responsibility of information disclosure, fairness, protection of government rights, community, environment and sustainable development, protection of shareholders' rights, protection of suppliers' rights, protection of customers' rights, protection of employees' rights, and protection of creditors' rights. For details, please see the table 1 in the appendix.

We think the environmental protection and sustainable development performance is an important index of CSR, so we also decompose the CSR index into two categories: non-environmental protection and sustainable development performance index (NCEPPI), environmental protection and sustainable development performance index (CEPPI). Given the difference in data processing method of qualitative and quantitative indicators, we conduct two types of indexes segmentation. So this paper studies following four types of indexes: sustainable development qualitative indexes of non-environmental protection performance (NCEPPIX), sustainable development quantitative indexes of non-environmental protection performance (NCEPPIL), sustainable development qualitative indexes of environmental protection performance (CEPPIX), sustainable development quantitative indexes of environmental protection performance (CEPPIL).

Then, we need to determine the weight of indexes. Aa assignment method of factor analysis is a scientific and objective, based entirely on computation of the value of indexes to determine the weight of indexes, which can avoid subjective factors causing inaccurate results. So this paper use method of factor analysis to determine weight and calculate scores of every common factor, which is each factor in each observation's values.

3. 2. **Sample selection, data collection and processing.** We select listed manufacturing corporations to study the relationship between corporate values and CSR.Data used in this paper is from CSMAR database. Information of CSR is from sub-database of CSMAR

which called social responsibility research database of Chinese listed company. The whole sample has 309 manufacturing corporations from 2009 to 2014, however by deleting the corporations with incomplete quantitative environmental data, we finally get 122 sample (please see the table 2 in the appendix).

Due to the scarcity of Quantitative data for the environment responsibility, for 122 corporations we have the following imputation rules for missing data:

If the data of a corporate is not available in certain years but it has some data between 2009 to 2014, we use the average value for the imputation. If the variable has no data for all six years, we use the industrial average value of that specific year. If the industrial average data is not available, we will use the sample average value for this variable.

As for industry classification, we are based on SFC guidelines on Industrial Classification of Listed Companies in 2012. The involved industries of this paper are as follow (Table 3).

TABLE 3. The involved industries and simple code of this paper

Compute, communication and Other electronic equipment manufacturing industry	*Pharmaceutical manufacturing industry*	*Special equipment manufacturing industry*	*Auto manufacturing industry*	*Raw chemical materials and chemical products industry*	*Electric machinery and equipment manufacturing industry*
1	*2*	*3*	*4*	*5*	*6*
Wine, drinks and refined tea manufacturing industry	*Railway, shipping, aerospace and other transportation equipment manufacturing industry*	*Chemical fiber manufacturing industry*	*Culture, education, art, sports and recreation goods manufacturing industry*	*General equipment manufacturing industry*	*The food manufacturing industry*
7	*8*	*9*	*10*	*11*	*12*

Factor analysis is applied to the 44 indicate variables for the dimension reduction. After this work, we get the value of NCEPPIX, NCEPPIL, CEPPIX and CEPPIL. Factor analysis is also applied to four of them, and by the weighted average of the common factors we obtain the value of CSR index finally.

3. 3. **Establishment of testing model**

Nowadays, there are many representative viewpoints. We holds that corporate value is a reflection of the future profitability and development opportunities of corporations, which is the investment value. So we adopt the third point view and choose *Tobin's Q* value as our dependent variable.

In order to study the influence of CSR on corporate value, we need to control other factors that influence corporate value. According to previous research, we add a few important control variables.

Some scholars believe that capital structure will influence corporate value. And western financing structure theories argue that when the marginal debt of bankruptcy and agency cost equal to the marginal revenue of the tax shielding, it reaches the best capital structure and maximum corporate value. So debt asset ratio gets into the model as a control variable.

Corporate size also influences corporate value. Chinese scholars such as Fuyang Pan

(2004), Lijun Xia (2005) use this variable as a control variable in the study of corporate value.

TABLE 4. All variables names and meanings

Variable	*The meaning of variables*
Tobin's Q	Tobin's Q=market value/replacement cost, market value is indicated by market value of equity and book value of the debt. Because replacement cost of Chinese listed corporationsis difficult to obtain, we use assets at the end of the year replace it, this index reflecting investment value which is the market valuation on corporation growth of investors. The higher Tobin'sQ is, investors are more optimistic about corporation.
lev	Leverage ratio, which is also called corporate capital structure, indicated by debt asset ratio ;debt asset ratio = total debt/total asset.
lnsize	Corporate size, equal to the natural logarithm of total assets at the end of the year.
hert	Ownership concentration degree, indicated by the share proportion of the largest shareholder.
zind	Counterbalance degree of blockholders, equal to the sum of shareholders' shareholding ratio from top two shareholders to top five shareholders/the largest shareholder'shareholding ratio.
pss	The proportion of state-owned shares= the number of state-owned shares/total number of shares
idr	Ratio of independent directors=the number of independent directors/total number of directors
age	The average age of executives. Because one corporation has many executives, we use average.
eeb	Educational background of executives, 1=technical secondary school graduated or below, 2=unior college , 3=undergraduate, 4=graduate, 5=PHD. The bigger the number is, the hihger the diploma is. Because one corporation has many executives, we use average.
CSR	CSR is a composite indicator of corporate social responsibility.

Grossman and Hart (1980) hold that ownership concentration can help to supervise managers' action and then reduce agency costs. McConnell and Servaes (1990) find that major shareholders' shareholding ratio has positive correlation with Tobin's Q. [5] Xia Lijun (2005) do the work of [6] and argue that the sum of largest shareholder from the second one to the fifth one and the sum of largest shareholder from the sixth one to the eighth one can control the influence of shareholding ratio of other stakeholders on corporate value. Therefore, we use ownership concentration and degree of restriction to reflect shareholding structure.

We also consider the influence of state-owned shares ratio, Xu and Wang(1999) find that state-owned shares ratio has negative correlation with performance of corporation. The study of Chen Xiao and Jiang Dong (2000) show that state-owned shares ratio has negative correlation with performance of corporation. [7] Xu Xiaonian (1997) argue that the higher the state-owned shares ratio is, the worse the benefit is. [8]

Fosberg (1989) find that ratio of independent directors has positive correlation with Tobin's Q, no correlation with other performance indexes.

We believe that top management team characteristic might influence corporate value. Hambrick and Mason (1984) put forward " Upper Echelons Theory", which focuses on the influence of managers' personal characteristics (such as age, level of education, social background) on corporate organizational decision, because the different background will

give different reactions when facing with complex strategic choice. [9] Chen Weimin (2007) uses the sample data of Chinese listed corporations and finds that higher average age of executive team members is more beneficial to corporate performance. [10]

Thus we choose *lev, lnsize, hert, zind, pss, idr, age, eeb* as control variables. The difference of industry may influence the performance of corporate value, so we also set industry dummy variables to control industrial factors which may influence corporate value. Details are shown in Table 4.

$$Tobin'sQ_{i,t} = \alpha_i + \alpha_1 lev_{i,t} + \alpha_2 \ln size_{i,t} + \alpha_3 hert_{i,t} + \alpha_4 zind_{i,t} + \alpha_5 pss_{i,t} + \alpha_6 idr_{i,t} + \alpha_7 age_{i,t} + \alpha_8 eeb_{i,t} + \alpha_9 ind + \beta_1 CSR_{i,t} + \varepsilon_{i,t} \quad (1)$$

4. Results, discussion and implications

4. 1. **Basic descriptive statistics results.** Table 5 is the descriptive statistics results of the 122 listed companies in mainland China. The average of Tobin's Q is 1. 805133, it is close to 1. 78 which was calculated by Lang Xianping in 2002. The average lev of sample companies is approximately equal to 50%. Standard deviation of corporate size is big with the biggest scale of the enterprise is about 4843 times bigger than the smallest one. The average of corporate size is 19. 6 billion, that is, the size of selected manufacturing corporations is very large.

In the aspect of equity structure *(hert, zind, pss*), there is big span between maximum and minimum value, but standard deviation is small. The average of *hert* is 0. 3853228, which is less than 0. 5. The average of *zind* is 0. 556976, from the formula we can see that the sum of shareholders' shareholding ratio from top two to top five is half of the largest one. Average of *pss* of sample manufacturing corporations is less than 10%.

TABLE 5. Basic descriptive statistics results

Variable	*Obs*	*Mean*	*Std. Dev.*	*Min*	*Max*
Tobin's Q	704	1. 805133	1. 911742	0. 112823	33. 270070
lev	713	0. 478711	0. 190659	0. 056266	0. 963696
lnsize	713	22. 757050	1. 316623	18. 265860	26. 751230
size	713	19648618423	38662348693	85657087	414870673481
hert	713	0. 3853228	0. 15765630	0. 05350000	0. 86490000
zind	713	0. 556976	0. 563128	0. 012726	3. 695150
pss	713	0. 090556	0. 184092	0. 000000	0. 830294
idr	710	0. 371868	0. 060908	0. 250000	0. 666667
age	710	49. 604590	2. 692894	40. 307690	57. 842110
eeb	412	3. 651578	0. 467011	2. 500000	5. 000000
CSR	732	-0. 00000010708	0. 1286351	-0. 6097831	0. 7722819

The average age of executives of the 122 manufacturing enterprises is 50 years old, most of the executives are with a bachelor degree. The average salary of the top three executives differs greatly, some companies can pay tens of millions, but others just less than 300, 000.

The average of CSR is very small, and its standard deviation is 0. 1286351, there is tiny span between its maximum and minimum value.

According to the degree of economy development, China can be divided into four

economic regions: East, Northeast, Central and Western region. From table 6, we can see different regions have different performance in CSR. Northeast and Central regions have negative average scores of CSR, which shows these two regions are lacking of corporate social responsibility. In our study, sample enterprises in Eastern region have the highest scores, the phenomenon illustrates that manufacturing enterprises in the Eastern region pay more attention to CSR and CSR's information disclosure.

TABLE 6. Descriptive statistics results of CSR of different regions

Area	*Obs*	*Mean*	*Std. Dev.*	*Min*	*Max*
Northeast	30	-0. 038388	0. 063725	-0. 117937	0. 165959
East	474	0. 003183	0. 127315	-0. 609783	0. 678141
Western	132	0. 002989	0. 151374	-0. 464889	0. 772282
Central	96	-0. 007832	0. 114862	-0. 159163	0. 368011

4. 2. **The results of factor analysis.** We calculate average value of each index in 6 years to transform panel data into cross-section data and then use factor analysis to get the weight of each indicator. The steps are as follows:

Firstly, we do KMO and Barletts sphericity test. By observing the table 7, we know the sig value of Barletts sphericity test is 0. The result reject the null hypothesis, that means correlations exist among indicators. Although the result of KMO is not bigger than 0. 6, the value is still desirable. Therefore, we use factor analysis to calculate the value of NCEPPIX, NCEPPIL, CEPPIX , CEPPIL and the composite score of CSR.

TABLE 7. Test results of KMO and Bartlett

		NCEPPIX	*NCEPPIL*	*CEPPIX*	*CEPPIL*	*CSR*
Kaiser-Meyer-Olkin		0. 595	0. 564	0. 6	0. 54	0. 643
Bartlett sphericity test	*Approximate Chi-square*	779. 68	257. 863	54. 979	251. 808	38. 514
	df	231	36	10	28	6
	sig	0	0	0	0	0

Secondly, we calculate the common factor of each index and the corresponding variance contribution rate, we will take the latter one as weight of common factors. Variance contribution rate is shown in Table 8. Then according to the the factor score matrix, we calculate the scores of each common factor. Finally, we multiply each factor by the variance contribution rate, and do the sum work to get final scores.

TABLE 8. Variance contribution rate of each index

	NCEPPIX			*NCEPPIL*			*CEPPIX*			*CEPPIL*			*CSR*		
	Eigenvalue	*Variance(%)*	*Cumulation(%)*	*Eigenvalue*	*Variance(%)*	*Cumulation(%)*	*Eigenvalue*	*Variance(%)*	*Cumulation(%)*	*Eigenvalue*	*Variance(%)*	*Cumulation(%)*	*Eigenvalue*	*Variance(%)*	*Cumulation(%)*
1	2. 708	12. 309	12. 309	2. 258	25. 092	25. 092	1. 542	30. 832	30. 832	2. 259	28. 238	28. 238	1. 715	42. 865	42. 865
2	2. 217	10. 079	22. 388	1. 633	18. 148	43. 24	1. 346	26. 923	57. 755	1. 473	18. 418	46. 655			
3	1. 76	7. 998	30. 386	1. 309	14. 545	57. 784				1. 207	15. 092	61. 748			
4	1. 642	7. 465	37. 851	1. 029	11. 432	69. 216									
5	1. 638	7. 446	45. 298	1. 024	11. 379	80. 595									
6	1. 563	7. 104	52. 402												
7	1. 555	7. 067	59. 469												
8	1. 372	6. 236	65. 705												

Note: Extraction method is principal components analysis; the variance contribution rates we put in this table is after rotation.

4. 3. **Empirical results of panel regressions.** In this section, we use two linear fixed effect model. Hypothesis test results are shown in table 10.

In Model 1, we have no consideration of heteroscedasticity. In order to control the heteroscedasticity problem, our standard error of all regression coefficients are clustered in the company level, Model 2 in table 10 were on the basis of Model 1 by the cluster analysis.

As we can see from the table 10, after clustering, significance of each variable decrease. For example, before cluster analysis, coefficient of *lev i*s significantly positive in the 5% significance level, but after clustering, it isn't significant any more, but its direction of effect on enterprise value remain the same. It showed that enterprise's capital structure does affect the value of the firm to a certain extent, and debt financing can improve enterprise value. It is consistent with net income theory which is one of the traditional theory of capital structure.

Whether the cluster is handled or not, coefficient of *lnsize* is significantly negative. The result shows that bigger the enterprise scale is, lower enterprise value may be . In our sample enterprises, the smallest enterprise is 000536, its total assets is RMB 85657087. 26 in 2009, it is nearly one hundred million yuan. We already know from PART 4. 1 that the average value of *size* is about 19. 6 billion, that means that majority of the sample firms are very large. The estimate results remind us that when the enterprise scale increase to a certain degree, enterprise should stop the blind expansion, otherwise it will cut down the enterprise value, and eventually damage the interests of all parties.

Similar to the other scholars' research, equity structure has influence to the enterprise value. Without the clustering, ownership concentration degree and counterbalance degree of blockholders impacted on corporate value negatively and significantly. Although after clustering , their significance decreased, but the influence direction remains the same. *Hert* is the share proportion of the largest shareholder, it is on behalf of ownership concentration

degree. We found that the more concentrated the stake is, the lower the enterprise value is, such result is consistent with Zhongen Bai (2005). It may be that the higher the share proportion of the largest shareholder is, the more likely the largest shareholder abuse power for personal gains, and even damage the enterprise value. In our expectations, *zind* represents equity balance degree, it is conducive to improve enterprise value, after all the other big shareholders can restrain the first major shareholder to protect the interests of minority shareholders. It shows that our sample enterprises' value will be more likely to be damaged if equity balance degree is higher. The reason may be that several big shareholders have formed the community of interests, they will infringe the interests of other small and medium-sized shareholders for the benefit of themselves at the same time. In the two variables of equity, the former for violation of the enterprise value is more than the latter.

TABLE 10. The empirical results

	Model 1	**Model 2**
	63. 29285***	63. 29285***
	20. 00	2. 99
lev	1. 343221**	1. 34322
	2. 10	0. 95
lnsize	-2. 55387***	-2. 55387***
	-18. 37	-2. 94
hert	-10. 88153***	-0. 1088153
	-8. 53	-1. 51
zind	-0. 857497***	-0. 8574965
	-3. 18	-1. 14
pss	1. 085882***	1. 085882**
	3. 21	2. 11
idr	0. 4542109	0. 4542111
	0. 32	0. 27
age	0. 0285186	0. 0285186
	0. 77	0. 58
eeb	-0. 2806427	-0. 2806427
	-0. 98	-1. 18
CSR	0. 7967151	0. 7967152
	1. 63	1. 05
F	56. 78	6. 74
Prob > F	0	0
R2	0. 4596	0. 4596
obs	732	732

Note: each variable coefficient was in the first row, ***denote statistical significance at 1%, **denote statistical significance at 5%, *denote statistical significance at 10%;The value of the test statistics was in the second row.

We find that the coefficient of *pss* is significantly positive, so the higher the *pss i*s, the greater the enterprise value is, this is the opposite of previous research. Reason could be that compared to other industries, manufacturing enterprise needs the support of the government more. The higher *pss* is, then more the government will give policies and funds to support the development of it.

In our study, the *idr* for an enterprise to value the effect of a weak, mainly positive effect. *Age* is not significant and coefficient is small. We also found that the average education level of executives is inversely proportional to enterprise value, but not dramatically. It

showed that highly educated background is not the main factors of improving enterprise value and may damage corporate value.

After joining dummy variable of industry , we find that there exists multicollinearity problems, so we drop the variable of industry.

Now we check the index of CSR. Before cluster analysis, we can say it was significantly negative at around 10% significance level, however after clustering it is not significant. Although CSR is not significant, but we can find that coefficient of CSR is positive, that shows that the improvement of CSR is conducive to enterprise value.

5. **Conclusion.** We find that the effect of overall CSR index is non-significant but positive to the corporate value. Through undertaking responsibility of CSR, corporations can become the more competitive in the production markets and improve the corporate value. But nowadays ,CSR impact enterprise value weakly. Therefore, for the further economic development, Chinese policy makers should support more sustainable development of enterprises, such as tax reduction, industry subsidies, and so on.

The appendix.

TABLE 1. Corporate social responsibility index evaluation system

First-grade index	*Second-grade index*	*Point value*	*Explain and method of the assignment*	*Nature of indexes*
Responsibility of information disclosure	Establishment of CSR institutions	2	Establishing systematical and comprehensive CSR institution gets 2 points，establishing incomplete CSR institution gets 1 point, not establishing institution gets 0 point.	qualitative
Responsibility of information disclosure	Releasing social responsibility report	2	A、Releasing regular and consistent reports every year in many ways gets 2 points;B、Releasing noncontinuous reports or the less content gets 1 point ;C、Not releasing report gets 0 point.	qualitative
Responsibility of information disclosure	Whether disclosing negative information	2	Releasing negative information in the reports gets 2 points，otherwise getting 0 point. Negative information includes: irregularity, lawsuit , arbitration	qualitative
Impartial Responsibility	Protection of intellectual property	2	A、Actively promoting intellectual property strategy(such as holding a training programme)，the number of projects which are supported by country and patent applications which are submitted are large;B、Focusing on intellectual rights and disclosing the content of patent applications;C、Having related complain of intellectual property or not disclosing intellectual property protection. A gets 2 points. B gets 1 point. C get 0 point.	qualitative
Impartial Responsibility	Measures of anti-commercial bribery	2	A、Making many outstanding contributions in commercial bribe or signing anti-commercial bribe agreements;B Making some efforts for managing commercial bribe ； C、Commercial bribe existing. A gets 2 points. B gets 1 point. C get 0 point.	qualitative
Impartial Responsibility	Measures of anti-corruption	3	A、Establishing perfect system for anti-corruption and implementing strictly;B、Establishing incomplete system for anti-corruption but implementing strictly;C、Establishing system for anti-corruption but implementing loosely；D、Measure and system for anti-corruption not exist. A gets 3 points. B gets 2 points. C get 1 point. D get 0 point.	qualitative
The responsibility to protect the rights and interests of the government	Response to public policy	1	Disclosing information such as elected to government procurement list or sponsoring governmental activities gets 1 point. otherwise getting 0 point.	qualitative
Community responsibility	Donation	1	Having donation behavior(excluding education)gets 1 point. otherwise getting 0 point.	qualitative

Community responsibility	Contribution to employment	1	Providing the opportunities of employment for weak groups gets 1 point. Layoff gets 0 point.	qualitative
Community responsibility	Supporting the education and learning of community members(especially for vulnerable groups)	1	Providing the opportunities of employment especially for weak groups gets 1 point. Otherwise getting 0 point.	qualitative
Community responsibility	Encouraging employees actively participate in community and public welfare activities	2	A、Encouraging employees actively participate in public service activities and providing convenience；B、Allowing employees to participate in public service activities and occasionally organizing public service activities ;C、Not allowing or organizing public service activities. A gets 2 points. B gets 1 point. C get 0 point.	qualitative
Environmental and sustainable development	Emergency processing mechanisms for environmental incidents	2	A、Establishing mechanism of environment emergency accident and implementing strictly;B、Establishing mechanism of environment emergency accident but implementing loosely;C、Not establishing mechanism of environment emergency accident. A gets 2 points. B gets 1 point. C get 0 point.	qualitative
Environmental and sustainable development	Environment training	1	Existing gets 1 point, otherwise gets 0 point.	qualitative
Environmental and sustainable development	Optimization or using environmental friendly technology and energy saving equipment	1	Corporate which uses environmental technologies in process of producing gets 1 point, otherwise getting 0 point.	qualitative
Environmental and sustainable development	Whether having been certified environmental management system	2	Whether corporate is certified by ISO14000、ISO14001、GB/T24001 or QC080000. Whatever certification passed, getting 2 points. Otherwise gets 0 point.	qualitative
Environmental and sustainable development	Comprehensive utilization of resources	2	Disposing and comprehensive utilizing waste emissions, promoting resource recycling, relative investing. Corporate which does more than three items gets 2 points, between one to three getting 1 point, less one getting 0 point.	qualitative
Responsibility to protect stockholders' equity	Investors Relation Management	2	Reflecting corporation protects investors' right, enhancing the level of corporate governance of companies, receiving investors enthusiastically, holding shareholder meeting, doing webinars, arranging for shareholders to visit production line, increasing brand value. Corporation which does more than five items gets 2 points，between three to five gets 1 point，less two gets 0 point.	qualitative
Responsibility to protect suppliers' right	Supplier Relationship Management	2	Reflecting corporation protects suppliers' right, continuing to promote supplier's management system, dealing with complaints of suppliers, signing quality assurance agreement, introducing new suppliers, special researching to subcontractors、training the suppliers. Corporation which does more than five items gets 2 points, between three to five gets 1 point，less two gets 0 point.	qualitative
Protection of consumers' rights	Whether product quality having passed authoritative verification	2	Whether corporation is certified by ISO9000, ISO13485, CE(The European Union), FDA(United States), TUV(Germany) etc. Whatever certification passed, corporation can get 2 points. Otherwise getting 0 point.	qualitative
Protection of consumers' right	Product quality and security management	2	Passing rate of product qualification is 100%, holding train of quality management and auditing quality or quality improvement project , solving quality problem, quality re-visiting, investigating counterfeit infringing products, establishing strict quality management system, recalling defective products. Corporation which does more than five items gets 2 points, between three to five getting 1 point, less two getting 0 point.	qualitative
Protection of consumers' right	After-sales service and complaints mechanism	2	A、Establishing complete after sales service and complaints mechanism. and implementing strictly;B、Establishing incomplete after sales service or implementing loosely C、Having poor after-sales services or not disclosing. A gets 2 points. B gets 1 point. C gets 0 point.	qualitative
Protection of consumers' right	Customer relationship management	2	Reflecting the behaviors of protecting consumers' right such as review, VIP service, creating consumers' monthly analysis report, customer privacy management. Corporation which does more than five items gets 2 points，between three to five getting 1 point, less two getting 0 point.	qualitative

Protection of employees' rights and interests	Whether having passed occupational health and safety management system authentication	2	Whether corporation is certified by OHS18000, OHSAS18001, GB/T2800. Whatever certification passed, corporation can gets 2 points. Otherwise getting 0 point.	qualitative
Protection of employees' rights and interests	Caring physical and mental health of employees	2	Measuring the degree of corporation caring physical and mental health of employees. Such as improving work environment, occupational disease prevention, holding recreational and sports activities, medical checkup, donating for sick workers, buying serious illness mutual insurance for employees, holding mental health lectures etc. Corporation which does more than five items gets 2 points, between three to five getting 1 point, less three getting 0 point.	qualitative
Protection of employees' rights and interests	Safety production	2	Establishing complete safe production regulations, organizing safety training, dangerous job sites qualified rate reaching to 100%, safety inspections, eliminating hidden dangers, providing lash-up rescuing material etc. Corporation which does more than five items gets 2 points, between three to five getting 1 point, less two getting 0 point.	qualitative
Protection of employees' rights and interests	Training and development for employees	1	Caring about the employees' development, such as skill training (excluding quality management and safety production，because the above includes these)and career-development plan, or comprehensive evaluation of training more than 80 points, establishing or completing learning platform and opening experience exchange meeting, cultivating administration of cadre reserve, encouraging employees to participating continuing education. Corporation which does more than five items gets 2 points，between three to five getting 1 point, less two getting 0 point.	qualitative
Protection of employees' rights and interests	Employees' benefits	2	Visiting families of employees, distributing daily welfare and holiday welfare, helping the poor employees, involving in enterprise pension planning, stock option etc, Corporation which does more than five items gets 2 points，between three to five getting 1 point，less three getting 0 point.	qualitative
The responsibility to protect the rights and interests of the government	Net profit tax rate		Calculating formula is net profit tax rate=(Taxes payable /net profit)×100%，net profit is corporation itself has the ability of creating value. The index illustrates the proportions of give back to the community which from unit value. The index is higher better.	quantitative
Environmental and sustainable development	Million yuan of industrial output value of comprehensive energy consumption		Million yuan of industrial output value of comprehensive energy consumption is average consumption of per million yuan output value of energy in the reporting period. The index is lower better.	quantitative
Environmental and sustainable development	Carbon dioxide emissions		Reflecting corporate' efforts in reduction of air pollution unit: ton	quantitative
Environmental and sustainable development	Reduction of carbon dioxide emissions		Reflecting corporate' efforts in reduction of air pollution unit: ton	quantitative
Environmental and sustainable development	Reduction of sulfur dioxide emissions		Reflecting corporate' efforts in reduction of air pollution unit: ton	quantitative
Environmental and sustainable development	Emission of waste gas		The index illustrates that business activities impact on atmospheric environment. The index is lower better.	quantitative
Environmental and sustainable development	Emission of waste water		The index illustrates that business activities impact on water environment. The index is lower better.	quantitative
Environmental and sustainable development	Emission of waste solid		The index illustrates business activities impact on regional environment The index is lower better.	quantitative
Environmental and sustainable development	The quantity of saving the electricity consumption		The more corporation save，the better the work corporation does in energy conservation	quantitative
The responsibility to protect stockholders' equity	Rate of return on common stockholders' equity		Rate of return on common stockholders' equity is the ratio between annual net profit and net assets. The index illustrates the ability of unit shareholders' equity to create value and reflects profitability and utilization efficiency of condensate of net profit.	quantitative

			The index is higher better.	
The responsibility to protect stockholders' equity	The rate of dividend distribution		Rate of dividend distribution =dividends per share/earnings per share . The index illustrates the obligations of corporation to shareholders and the part of actual distribution from earnings per share. The index is higher better.	quantitative
the Responsibility to protect creditors' rights	Interest coverage ratio		Reflecting short-term payment ability, equaling to the ratio between earnings before interest and taxes and interest expenses. The bigger multiple is, the stronger the ability of payments of interest expense is.	quantitative
the Responsibility to protect creditors' rights	Shareholders ' equity ratio		Illustrating the ability of long-term solvency, equaling to the ratio between shareholders 'equity and total asset. the higher the ability to pay long-term debt and the shareholders 'equity ratio are , the lower financial risks and the property of debt ratio are.	quantitative
The responsibility to protect suppliers' right	Turnover ratio of account payable		Illustrating the ability of paying debt of payable account . The index is higher better.	quantitative
The responsibility to protect suppliers' right	Cash accounts payable ratio		Cash assets have strongly ability of cashing，including cash and bank deposits . The index illustrates corporation pays suppliers' security cash. The index is higher better.	quantitative
Protection of consumers' right	Ratio of profits to cost		Total profits /(operating costs+management costs + sales expense+finance charges). The index illustrates that when corporation setting prices, the more they think about the interests of consumers, the more they give consumers the space of benefit, and the setting price is closed to the cost that necessary for the process of production and sale, the index illustrates corporation takes social responsibility for custom . The index is lower better, worse the contrast.	quantitative
Protection of employees' rights and interests	Wages of employees		Measuring the level of employees' wages	quantitative

TABLE 2. The company code of 122 sample companies

000021	000028	000050	000063	000066	000100	000157	000338	000407	000422
000423	000425	000522	000527	000528	000536	000538	000550	000559	000568
000581	000623	000651	000666	000680	000725	000727	000768	000800	000822
000858	000912	000927	000930	000950	000952	000999	002001	002054	002064
002079	002092	002103	002161	002165	002172	002202	002287	002300	002304
002422	002423	002470	002498	002529	002584	002601	200771	300174	300181
600055	600056	600062	600063	600089	600096	600104	600151	600160	600161
600171	600184	600196	600197	600198	600218	600267	600298	600303	600329
600330	600367	600389	600435	600436	600486	600495	600498	600500	600517
600525	600557	600573	600596	600597	600600	600616	600618	600619	600685
600690	600702	600725	600741	600761	600765	600806	600815	600829	600835
600839	600867	600871	600875	600893	600973	600990	601038	601177	601727
601766	601989								

REFERENCES

[1] Lancaster, K. A. S, Valuation Analysis of Environmental Disclosures, *Working paper*, California Polytechnic State University, 1998.

[2] Omaima Hassan and David M. Power, The usefulness of accounting information; evidence from the Egyptian market, *Qualitative Research in Financial Markets*, vol. 1, issue. 3, pp. 125-141, 2009.

[3] Kenneth E. Aupperle, An Empirical Examination of the Relationship Between Corporate Social Responsibility and Profitability, *The Academy of Management Journal*, vol. 28, no. 2, pp. 446-463, 1985.

[4] Cormier. D, Irene. M. Gordon, M. Magnan. Corporate Environmental Disclosure: Contrasting Management's Perceptions with Reality, *Journal of Business Ethics*, vol. 49, no. 2, pp. 143-165, 2004.

[5] John J. McConnell, Henri Servaes, Additional evidence on equity ownership and corporate value, *Journal of Financial Economics* . vol. 27, issue 2, pp. 595-612, October 1990.

[6] Lijun Xia, Yiqiang Fang, The relation between government control, environmental governance and enterprise value: The empirical evidence from China's securities market, *Economic Research Journal*, vol. 5, pp. 40-51, 2005.

[7] Xiao Chen, Dong Jiang, The relation between diversity of equities, corporate performance and competitiveness of industry, *Economic Research Journal,* vol. 8, pp. 28-35, 2000.

[8] Xiaonian Xu, Give priority to Institutional investor as the main body when we set up the mechanism of corporate governance and capital market, *Reform*, vol. 5, pp. 28-30, 1997.

[9] Hambrick Donald C, Mason Phyllis A, Upper echelons: the organization as a reflection of its top managers, *Academy of Management Review*, vol. 9, no. 2, pp. 193-206, 1984.

[10] Weimin Chen, An Empirical Research on the Impact of TMT Demographic Characteristics on Firm Performance, *Journal of Nanjing University of Posts and Telecommunications(Social Science)*, vol. 1, pp. 23-27, 2007.

Explored Causality of Financial Investment in Sports Level and Health Care Expenditure

Tsung-Kuo Tien-Liu, Jung-Wen Wu
Center for General Education, National Chi Nan University, Taiwan
k900150@gmail.com
Sports Second Room, Kaohsiung Campous, Shih Chien University, Taiwan
archery@g2.use.edu.tw

ABSTRACT. *What is the relationship between government's financial investment in sports and health care expenditure? This study aimed to conduct an empirical research on the aforementioned questions by adopting a new measurement system. It assessed the relationship between government's financial investment in sports and health care expenditure by applying* ***time series,*** *quadratic regression* ***and*** *autoregressive. In this study, purposive sampling was used to recruit the research participants. Moreover, data (e.g., sports funding) published on government official websites (i.e., Sports Administration, Ministry of Education; Health Care Insurance Administration, Ministry of Health and Welfare) were collected in this study. The findings of this study were that reflect the effects of the government's financial investment in sports on health care expenditure after a five-year period. According to the findings, this study proposes the following recommendations for that the government should continue investing in sports activities and increase the amount of investment progressively.*

Keywords: Sports, Government's financial, Fuzzy membership functions, Quadratic regression, Financial investment.

1. Introduction

Sports Administration, Ministry of Education in Taiwan (abbreviation: SAME, 2014) have been indicated health care insurance for medical expenditures continuously increased every year (SAME, 2014). This phenomenon has been expensed heavily burden of government finances. Moreover, World Health Organization (abbreviation: WHO, 2012) considered that physical activity (PA) are effective in the prevention and treatment of risk factors. Hence, Prevention medicine may be reduced health care insurance for medical expenditures situation. So, People engaged in various physical activities and have a healthy physical, not only can reduce cardiovascular disease risk factors, prevention of cardiovascular diseases. Meanwhile, People participate to competitions moderate within the capacity of in various sports too. Therefore, government finance and physical fitness is important to coexisting whether applied to our health insurance payments, budget funding for sports condition an important issue.

2. Literature Review

Health systems worldwide was stressed with the need to control costs to maintain system viability that worsening economic conditions was the pressure to make structural changes are expected to continue growing(Diederich & Salzmann, 2015). Especially, since 1995, Taiwan's finance had increased health care expenditures, it produce long-term of payments imbalance as soon, was making the reserve fund surplus and deficit continue to become an important issue (Chin-Tung Hsiao., Chung-Shu Liu., Hsiu-Ching Liang., & Ching-Fang Wu, 2012). So, government struggled with dropping consumption of health care resources was important issue. Hence, government must invest more creativity that promoted physical activity ad that investment must be proportional to the burden disease attributable to an inactive and sedentary society (Barry, 2014, 8p).

WHO (2012) considered health have to highlight physical activity (PA) had been reduction weight, visceral fat accumulation; these are very effective in the prevention and treatment of cardio metabolic risk factors. These changes factors had often taken place independently of weight loss, but how much for the beneficial results were independent of weight loss and changes in body configuration was not entirely clear. So, healthy fitness and physical fitness showed important opinion (SAME, 2014) that exercise training has been effective in increasing high-density lipoprotein cholesterol (HDL), reduced declining triglyceride (TG) levels and blood pressure (BP)(WHO, 2012) and promoted mental health (Samadzadeh et al, 2011; Leeahtam, Sriboonjit, Sriboonchitta, Chaitip, Chaiboonsri, Peter, & Calkins, 2011). Hence, Government had raised medical service price so as to adjust the price distortion due to different environmental factors (Zeng, 2012).

There was evidence to support the effectiveness of workplace physical activity interventions for improving both health and work outcomes, including physical activity behaviour, fitness, body mass index, productivity, work attendance, and job stress (Barry, 2014). These physical activity interventions would decreased sitting time at work (Plotnikoff, Healy, Morgan, Gilson, Kennedy, 2014, 21p). In other hand, Milton, Smith and Bull (2014) suggested Implement policies that supported the integration of physical activity into the primary-care sector’s disease prevention and management strategies as well as in healthcare services to increase physical activity rates among practice populations (28p). However, sport active contributes positively to the development of confidence and social skills, social inclusion, community development, health and wellbeing, diversion from antisocial behaviour and improved self-esteem and health-related quality of life that additional benefits for human include improved fundamental movement skills and physical fitness (Salmon, Foreman, Eime, Brown, Hodge, Milton, 2014, 45p). According to the above

intervened in the affairs of its society for the fundamental reason that it enables it to set the nation's economic and political direction. More specifically, the State believes that by its various interventions it can improve the well-being of society (Hoye, Smith, Westerbeek, Stewart, Nicholson, 2006, 20p)

The meaning of these numbers can be found, Sports budget accounts for the proportion of total central government budget, showing signs of gradually reducing. Such as, Gudlaugsson colleagues (2013) studies indicated after exercise decrease have seen in weight, total fat mass, trunk fat mass, waist circumference, and blood pressure. The lack of central sports budget is a long question. In case of lack of resources, there will likely influence national sports promotion and marketing affairs (Wan-Chang Li & Shao-Hsi Chang, 2012), it showed more emphasis on short-term government effectiveness of the policy. However, there good health plan was the ability to reduce health insurance costs (Sebastian Bauhoff, 2012). In other words, sports funding support should be possible to influence national sports health plan, thereby affecting the lead health insurance expenses. The perspective of the proportion sports financial investment configuration has affected national health care expenditures. Therefore, let to national financial difficulties caused the economic recession. Hence, national care were expenditures showing huge growth rate, but national finance and competitive sport were taking forward the difficulties. Finally, for financial investment in sports should offered planning and utilization of effective proposals.

To overcome these issues, How to select the correct course place or environment style which were planning proposed analytical model of significance methods. How to promote national sports and exercise habits? It is important issues Government's budget will concern of subject. If Government did in the preparation of the project funding was not careful and not strict enough. Government improperly used generated resources situation not only wasted of national resources, but also produces other urgent crowding out effective of government affairs. Li, Blake, and Thomas (2013) study found that staging the Beijing Olympics brought economic benefits to the host economy. So, sports financial investment was also benefits for whole economy. Therefore, Government financial investment level was not only an investment of money, it should have led to the purpose of policy and administration direction. Through budget funding planning could understood Government policies and administration achieved the operational objectives. Substantial progress was the policy plan in the condition, due to implementation of the budget funding was presented by the measures taken to achieve the objectives.

3. Research Method

3.1. Population and Sample Selection

This study purpose validated methodology and used purposive random samples for analysis. This study had selected the official disclose in base data as sports funding level and health care expenditures national, these were public information (SAME, 2014; MHIA, 2014). The data collected official network and continuous fourteen groups which have center and local government. In addition, this studies of health care expenditures that were form NHIA, Ministry of Health and Welfare in Taiwan. The data base collected through official network and continuous fourteen groups.

3.2. Research Tool

The statistical methods applied to time series, quadratic regression and autoregressive. All data used the Statistical Package for the Minitab 16.0 and Microsoft Office Excel 2013 software to process the data analysis. And it used time series carried out for financial investment in sports and health care expenditures.

3.3. Target of the pattern.

The most important but have a good model, if an analyst wants to take an active role that the actual implementation of the process there are input sports financial rules to follow. If the lack of this in accordance with the organization's mission execution mode, you cannot assess past it that do anything. It is hardly whole system to guide activities, leading to decision-makers play a passive role. It is execution mode may be reduced to the arbitrary behavior of the health care expenditures.

System target modeled two senses. First, you can through the analyst's interpretation of the purpose of showing some blurred and then find out the explicit goal. Secondly, it can help policymakers that determine important decisions or control the implementation process. Major financial investment for sports has cause to the National Development Plan and social needs. It is requiring from a master limited financial resources, and the need to do properly deployment. It could be through this systematic overall planning, health care expenditures policy objectives of the implementation process that is more streamlined. Investment of sports finance improve plan that target of the pattern is very important. In this mode, the entire country is not only important to understand the direction of the national health policy and copying trends, consider sports finance and demographic indicators of change.

3.4. Dynamic Structure of Planning Model.

For sports funding are planning the scope of the proposal from the NHI cope with

the demand side of the supply side to explore. If planners begin that only from a single point of view, the overall sports funding allocation will not know enough. So far the planning and the actual situation is that resulting in over or under of estimate the situation. It will affect the efficiency that use of funds throughout the sport. (1) Sports of oversupply that will make financial investment wasted. (2) Sports equipment purchase too much, it will increased funding waste that (3).management and maintenance limited resources. (4) Health care expenditures planning. (5) Gymnasium, outdoor playground, sports venues and other related that charges often due to underestimation, using tough-type or primitive. That will wait for the construction was discovered that sufficient funding.

Therefore, sports finance and health care expenditures trend, to fully understand the supply side and the demand side, but it planner very important issue. The estimate of future supply and demand situation, the relevant information must be made according to a logical judgment, so as not to become subjective guess. Following on the prediction of meaning and ways of doing discussed. This is cited the Education Ministry of Sports Department budget and NHI expenditure budget for examples.

The study predicted used the moving average method has the advantage of doing simple calculations. The time series prediction comparatively good that no apparent long-term trends and seasonal changes. The disadvantage is that the moving average of the number of periods k decisions, often without objective criteria. And using the moving average method for rapid response to changes in the market is duller. Also use the moving average method that in practical applications, it is sometimes necessary to refer to the degree of importance of each period that given different weights to find k period moving average. For example: When the time series data before and after the strong correlation, we want to predict the next amount of information. It will find the latest information on a greatest impacting. So as a moving average, the most closing data should be given a greater weight. Now, we call that weight average methods. As for the size of the number of options, there are no objective criteria, depending on the subjective experience.

4. Empirical study

4.1. Data description for sports funding level and health care expenditure

This study used causality for quadratic regression analysis. According to Table 1 had been plot of the yearly expense of Taiwan 1999-2012 health care expenditure and sports funding. These dada exhibits several funding expenditures in the 14 years. First we inspected the tendency of NHIA health care expenditures in Table 1 We found the large fluctuations in the beginning and the end of the Taiwan medical expenditure index which showed there continued to increase rapidly variation in these periods in

Figure 1.

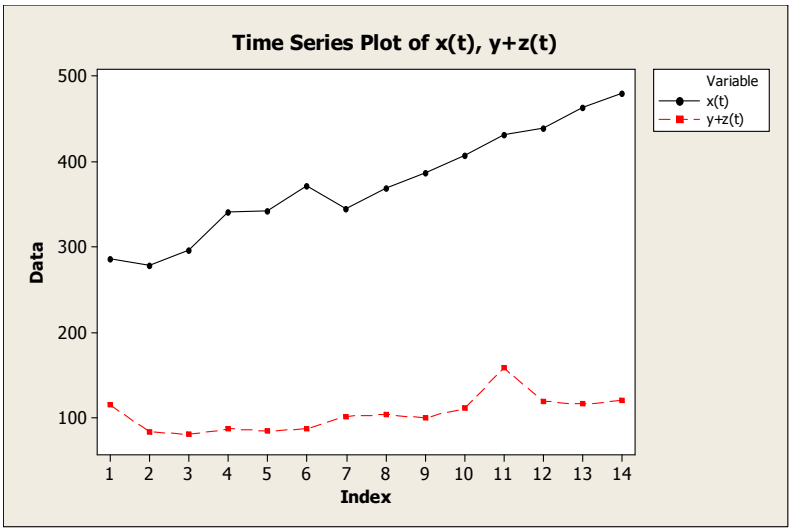


Figure 1 Time series plot of health care (x) and financial investment in sports financial trends(y+z)

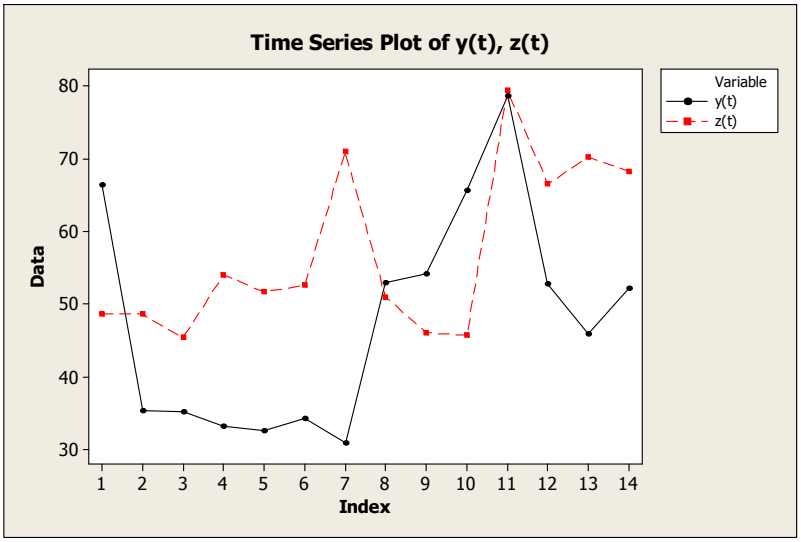


Figure 2 Time series plot of central sports(y) and Local government sports(z) financial investment trends

Table 1 The 1999-2012 health care and financial investment in sports for growth rate in Taiwan

No.	*Year*	*Medical expenses (X)*	*Central financial investment in sports (Y)*	*Local government Financial investment in sports (Z)*
1	1999	286.82	66.4	48.66
2	2000	278.36	35.35	48.66
3	2001	296.72	35.23	45.46
4	2002	341.34	33.25	54.02
5	2003	341.75	32.60	51.71
6	2004	371.49	34.36	52.59
7	2005	344.73	30.93	71.02
8	2006	369.29	52.98	50.97
9	2007	387.21	54.12	46.11
10	2008	406.71	65.70	45.70
11	2009	432.13	78.73	79.45
12	2010	439.39	52.78	66.55
13	2011	463.29	45.90	70.25
14	2012	479.59	52.15	68.22

UUnit: million

In addition, the Taiwan financial investment in sports was index which showed there slight variation in these periods in Table 1. And we inspected the tendency of central financial investment in sports and location government financial investment in sports. It found that mostly greater central financial investment in sports than location government budget funding, but there saw closer in 2006 and 2009 that organized and held the 2009 World Games in Kaohsiung in Figure 1. The purpose of this study was to examine the change point of financial investment in sports and health care's medical expenditure that was causality relationship.

4. 2. Polynomial regression analysis of causality for sports funding level and health care expenditure

According to Table 2, 3, 4 and Figure 3 that presented the backward five quadratic regression model explanatory power of 74.5%. In addition, quadratic regression model (F=13.87, p = 0.01) is well than linear regression model (F=1.12, p = 0.33).

Table 2 The regression equation is x(t+5), x(t+6) and x(t+7) of variance of the backward comparison

variance	*S*	*R-Sq*	*R-Sq(adj)*
t+5	27.1373	74.0%	65.3%
t+6	27.1623	75.8%	66.2%
t+7	24.2835	75.4%	63.0%

Not: financial investment = *x(t+5), x(t+6) and x(t+7)*

According to Table 2, 3, 4 and Figure 4 that presented the backward five quadratic regression model explanatory power of 75.8%. In addition, quadratic regression model (F=15.67, p = 0.01) is well than linear regression model (*F*=00.00, *p* = 0.96).

Table 3 Regression Analysis of variance for the backward form five to seven comparisons

variance	Source	*DF*	*SS*	*MS*	*F*	*P*
t+5	Regression	2	12547.5	6273.77	8.52	0.018
	Error	6	4418.6	736.43		
	Total	8	16966.1			
t+6	Regression	2	12547.5	5785.80	7.84	0.029
	Error	5	3689.0	737.79		
	Total	7	15260.6			
t+7	Regression	2	7211.26	3605.6	6.11	0.061
	Error	4	2358.76	589.69		
	Total	6	9570.02			

Not: financial investment = *x(t+5), x(t+6) and x(t+7)*

According to Table 2, 3, 4 and Figure 5 that presented the backward five quadratic regression model explanatory power of 75.4%. In addition, quadratic regression model (*F*=11.64, *p* = 0.03) is well than linear regression model (*F*=0.19, *p* = 0.68).

Table 4 Sequential analysis of variance for the backward from five to seven comparisons

variance	*Source*	*DF*	*SS*	*F*	*P*
t+5	Linear	1	2335.9	1.12	0.326
	Quadratic	1	10211.6	13.87	0.010
t+6	Linear	1	8.2	0.00	0.957
	Quadratic	1	11563.4	15.67	0.011
t+7	Linear	1	349.17	0.19	0.682
	Quadratic	1	6862.09	11.64	0.027

Not: financial investment = *x(t+5), x(t+6) and x(t+7)*

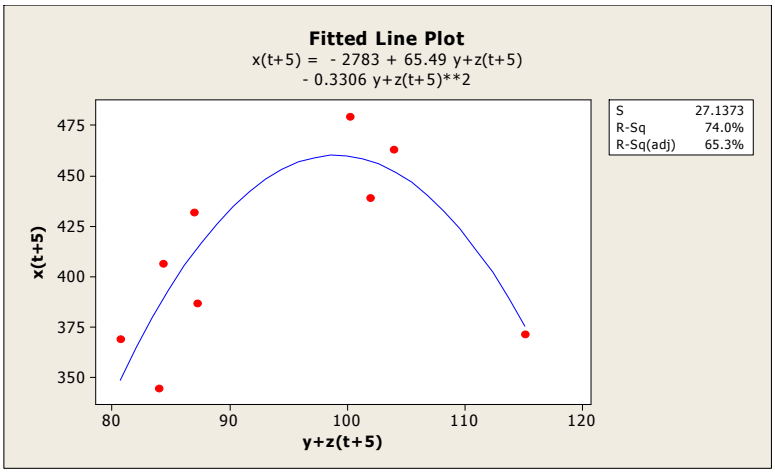


Figure 3 Quadratic regression analysis: x(t+5) versus y+z(t+5) of the backward five comparison

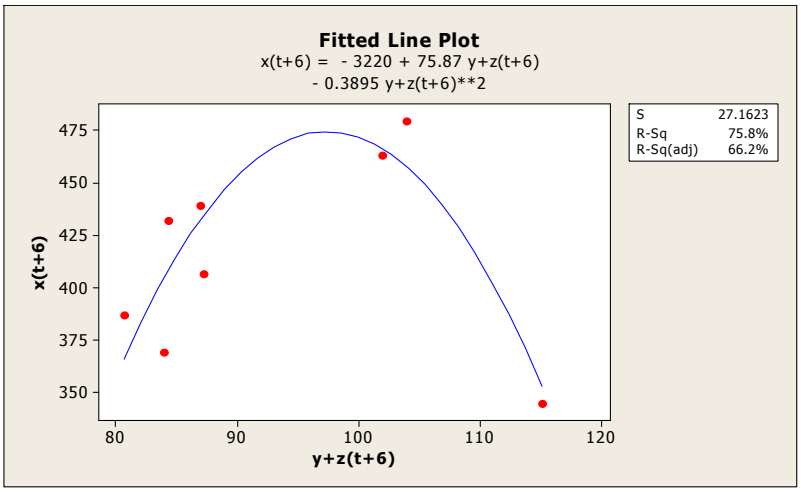


Figure 4 Quadratic regression analysis: x(t+6) versus y+z(t+6) of variance of the backward six comparison

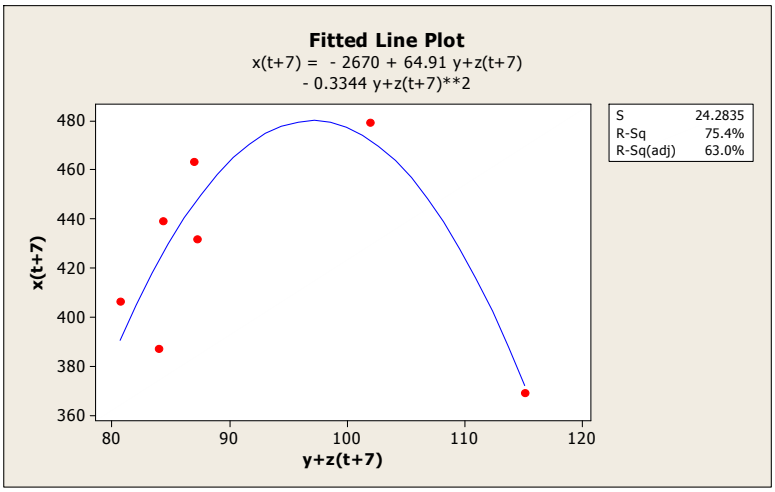


Figure 5 Quadratic regression analysis: x(t+7) versus y+z(t+7) of variance of the backward seven comparison

5. Conclusion

This study explored causality between financial investment in sports and health care expenditure. This study used the new method of Quadratic Regression can reflected the affection of the sports funding to health care expenditures after 5 years. Those health care expenditures will gradually decline because sports financial investment increase continuous funds.

In addition, sports funding level and health care expenditures explored cope with the demand side and the supply side. If planners begin that were only from a single point of view, the overall sports funding level and health care expenditures allocation will not know enough. So far the planning and the actual situation was that resulting in over or under of estimate the situation. It will affect the efficiency that use of funds throughout the health care. (1) Health care expenditures policy of oversupply that will make medical resources and funding wasted (2) as well as provide Sports-related hardware and software plan promote health care plan.

Further, this investigated the sports funding level and NHI expenditure that forecast. These dates, from Sports Administration, Ministry of Education And Health care Insurance Administration, Ministry of Health and Welfare, are Taiwan government. The result of this study showed whole sports funding increase to that reduce the expenditures for social health insurance. Recommendations for future research that collect more items, it is in order to facilitate future analysis central and location sports funding more the detail discuss that other issue. Hence, Suggestion apply causality method for other study area.

(1) Maintaining invests sports funding for reducing health care expenditures.

(2) Maintaining plan more appropriating sports and leisure projects, it increasing sports activity participating number.

(3) Offering Doctors sports medical plan and regional health care funding reduce plan. This reducing plan aims to improve sports prescription for reducing medical health care expenditures.

(4)Because this is the conception of preventive medicine, doctors the main income is not drugs prescription, on the contrary, based on regional using drugs reducing rate.

REFERENCES

[1] Barry, M.. *Heart Foundation's Blueprint for an active Australia.* Melbourne: National Heart Foundation of Australia, 2014.

[2] Diederich, A., & Salzmann, D.. Public preferences regarding therapeutic benefit, costs of a medical treatment and evidence-based medicine as prioritization criteria. *Journal of Public Health*, vol.*23, no.*3, pp.137-148, 2015.

[3] Hoye, R., Smith, A., Westerbeek, H., Stewart, B., & Nicholson, M.. *Sport Management: Principles and Applications*. Oxford, UK: Elsevier's Science & Technology, 2006.

[4] Hsiao, C-T., Liu, C-S., Liang, H-C., & Wu, C-F.. The influencing factor analysis of security reserve fund Taiwan's National Health Insurance Program. *Taiwan Business Performance Journal, Taipei, Taiwan*, vol.5, no.2, pp.241-255, 2012.

[5] Leeahtam, P., Sriboonjit, J., Sriboonchitta, S., Chaitip, P., Chaiboonsri, C., Peter, H., & Calkins, P. H.. Efficiency and Satisfaction Evaluation of Thailand's Universal Health Care in Meeting the Millennium Development Goals. *International Journal of Intelligent Technologies and Applied Statistics*, vol.4, no.3, pp.303-326, 2011.

[6] Li, H-N., Blake, A., & Thomas, R.. Modelling the economic impact of sports events: The case of the Beijing Olympics. Economic Modelling, 30, pp.235-244, 2013.

[7] Milton, K., Smith, B., &Bull, F.. Action area 3: Health care. In: M. Barry (Ed.), *Heart Foundation's Blueprint for an active Australia* (2_{nd}) (pp. 26-31). Melbourne: National Heart Foundation of Australia, 2014.

[8] Plotnikoff, R., Healy, G., Morgan, P., Gilson, N., & Kennedy, S.. Action area 2: Workplaces. In: M. Barry (Ed.), *Heart Foundation's Blueprint for an active Australia* (2_{nd}) (pp. 20-25). Melbourne: National Heart Foundation of Australia, 2014.

[9] Salmon, J., Foreman, R., Eime, R., Brown, H., Hodge, S., & Milton, K.. Action area 6: Sport and active recreation. In: M. Barry (Ed.), *Heart Foundation's Blueprint for an active Australia* (2_{nd}) (pp. 44-49). Melbourne: National Heart Foundation of Australia, 2014.

[10] Samadzadeh, M., Abbasi, M., & Shahbazzadegan, B.. Comparison of sensation seeking and self-esteem with mental health in professional and amateur athletes, and non-athletes. *Procedia-Social and Behavioral Sciences,* vol.15, pp.1942-1950, 2011.

[11] World Health Organization.. WHO Library cataloging-in-Publication Data. World Health Organization2012, Geneva, Switzerland: WHO Document Services, 2012.

[12] Zeng, J.. Conduction Mechanism of Medical Service with Environmental Factors: A Nonparametric Approach. *International Journal of Intelligent Technologies and Applied Statistics,* vol.5,no.1, pp.87-100, 2012.

Building a Type-2 Linguistic Regression Model and its Application on Technique of Company Valuation

Yicheng Wei, Fei Song and Junzo Watada

ABSTRACT. *Information is sometimes given in in linguistic terms in real life vague in meaning. Thus, type-1 fuzzy set is introduced to modulate this uncertainty. Same words may give various meaning to people, where the uncertainty also exists when associated with the membership function of a type-1 fuzzy set. Type-2 fuzzy set is invented to express the hybrid uncertainty of both primary and secondary fuzziness. We built a type-2 linguistic regression model based on credibility theory, that is more desirable with employing confidence intervals to deal with such hybrid uncertainty. It could accept type-2 input and output and give a rise to a nonlinear programming problem focus on a well-trained model, which would be helpful and useful in linguistic assessment cases. Finally, we apply the new model as a technique for company valuation in private equity business.*

Keywords: Type-2 fuzzy set, Linguistic rules, Regression model, Creditability theory, Confidence interval, Company valuation

1. **Introduction.** Fuzzy sets play a pivotal role in computing with words being casted in the setting of granular computing [1]. The essence of granular computing is to carry out computing that exploits information granules [2]. Information granules are regarded as collections of elements that can be perceived and treated together because of their similarity, functional properties, or spatial or temporal adjacency [3], [4], [5], [6]. In this sense, fuzzy logic becomes instrumental as an effective vehicle to manipulate information granules.

It becomes apparent that experts with much professional experiences are capable of making assessment using their intuition and experiences. In such cases, experts may express judgements with linguistic terms. The difficulty in the direct measurement of certain characteristics makes their estimation highly imprecise and this situation implies the use of fuzzy sets [7], [8]. Information in real life may contain linguistic vagueness. Traditional set theory uses characteristic function to define whether an element belongs to a certain set (event) and does not trying to dealing with such uncertainty. Fuzzy set (type-1 fuzzy set) was first introduced in 1965 by Lofti A Zadeh [8]. After that, Watada and Tanaka expanded a fuzzy quantification method in 1987 [9]. From then on, it is able to describe an artificial membership function with its output called primary membership grades, to which extend one ele- ment belongs to a certain set (event). On the background that the membership function of a type-1 fuzzy set may also have uncertainty associated with it, Lofti A. Zadeh invented type- 2 fuzzy sets(type-2 fuzzy set) in 1975 [10]. A type-2 fuzzy set enables us to implement fuzziness about the membership function into fuzzy set theory and is a way to address the above concern of type-1 fuzzy sets head-on. However, type-2

fuzzy set did not become popular immediately because of its complexity of calculation. type-2 fuzzy sets are difficult to understand and use because: (1) the three-dimensional nature of type-2 fuzzy sets makes them difficult to handel. (2) using type-2 fuzzy sets is computationally more complicated than using type-1 fuzzy sets. Thus, the conception was only investigated by a few researchers; for example, Mizumoto and Tanaka [11] discussed what kinds of algebraic structures the grades of type-2 fuzzy sets form under join, meet and negation; Dubois and Prade [12] investigated the operations in a fuzzy- valued logic. It is not until recent days that type-2 fuzzy sets have been applied successfully to type-2 fuzzy logic systems to handle linguistic and numerical uncertainties [13], [14], [15], [16], [17]. Most of the existing studies on modeling fuzzy regression analysis have focused on data consisting of numeric values, interval-like numbers, or fuzzy numbers without taking fuzziness of its membership grade into consideration.

In practical situations, there exists a genuine need to cope with data that involve the factors of type-1 fuzziness and type-2 fuzziness. For example, let us discuss experts' valuation of a company. Suppose five inspectors (experts) evaluate the company on the basis of ten attributes. Each expert grades each piece according to his experiences and expertise. These gradings are given linguistically, e.g., good, very good, bad, and very bad, etc. When we intend to build a multi-attribute model of the experts' evaluation, we have to consider both the fuzziness of the data and the linguistic fuzziness of whom gives the data.
Various fuzzy regression models were introduced to cope with qualitative data coming from fuzzy environments where human (expert) subjective estimates are used. The first fuzzy linear regression model was proposed by Tanaka [7]. Tana- ka [18], Tanaka and Watada [19], Watada and Tanaka [20] presented possibilistic regression based on the concept of possibility measure. Chang [21] discussed a fuzzy least-squares regression, by using weighted fuzzy-arithmetic and the least- squares fitting criterion. Watada [22] developed models of fuzzy time-series by exploiting the concept of intersection of fuzzy numbers.

Motivated by the above reasoning, the objective of this paper is to introduce a class of linguistic regression model from the perspective of type-2 fuzzy set based on creditability theory. We introduce some type-reduction technology called vertical slice centroid type-reduction to defuzzificate the T2 fuzzy set then use creditability theory introduced by Liu [23] to define the confidence interval of it. After that, we transfer the type-2 fuzzy variable into type-2 fuzzy value with confidence intervals and build an linguistic regression model. A well-trained model could get the evaluation itself for the data already entered and output the linguistic data after the intermediate steps defuzzification and refuzzification.

The remainder of this paper is organized as follows. In Section 2, we cover some historical background of creditability theory, linguistic model and type-2 fuzzy sets. Section 3 a linguistic type-2 fuzzy regression has been built and formulates a type-2 linguistic regression model. In section 4 we apply it to the field of company valuation. Finally, concluding remarks are presented in Section 5.

2. Historical background.

A. Type-2 Fuzzy Set

Type-2 fuzzy sets were first described by Zadeh as a development for his fuzzy set theory [24]. According to [25] type-2 fuzzy sets are "sets whose membership grades are themselves type-1 fuzzy sets". A type-2 fuzzy set, denoted by $\tilde{A}$, can be defined at the universe X as

$$\tilde{A} = \int_{x \in X} \int_{x \in J_x} \mu_{\tilde{A}}/(x,u) \tag{1}$$

where $Jx \subseteq [0, 1]$ is the set of primary membership grades of $x \in X$, with $u \in Jx$, $\forall x \in X$, and $\mu_{\tilde{A}}(x, u)$ is the type-2 membership function [26] [27]. Since type-2 membership functions are defined in R^3 [28] [29], obviously there is a lot of obstacles for drawing, handling and understanding them [26].

B. Creditability Theory

Credibility measure [30] is an average of the possibility and the necessity measure, i.e., $Cr\{\cdot\} = (Pos\{\cdot\} + Nec\{\cdot\})/2$, and it is a self-dual set function, i.e., $Cr\{A\} = 1 - Cr\{A^c\}$ for any A in $P(\Gamma)$. The motivation behind the introduction of the credibility measure is to develop a certain measure, which is a sound aggregate of the two extreme cases, such as the possibility (which expresses a level of overlap and is highly optimistic in this sense) and necessity (which articulates a degree of inclusion and is pessimistic in its nature). Based on credibility measure, the expected value of a fuzzy variable is presented as follows:

$$E[Y] = \int_0^\infty Cr\{Y \geq r\}dr - \int_{-\infty}^0 Cr\{Ylr\}dr \tag{2}$$

provided that at least one integral is finite.

Let ε be a fuzzy variable with expected value e. Then, the variance of ε is defined by $V[\varepsilon] = E[(\varepsilon - e)^2]$.

C. Linguistic Fuzzy Regression Model

In making assessments regarding some objects, we use multi-attribute evaluation. The difficulty in the direct measurement of certain characteristics makes their estimation highly imprecise and this situation results in the use of fuzzy values and linguistic values. Often, experts use a linguistic word to judge an object from various features and characteristics. And the whole process is pursued in linguistic way. For instance, although it is possible to measure numerical value, it is difficult to analytically interpret the obtained numerical value in terms of possible influence. This result might have impacted on further decision making.

To cope with linguistic variables, we define processes of vocabulary translation and vocabulary matching which convert linguistic expressions into membership functions defined in the unit interval. That is, human words can be translated (formalized) into fuzzy sets (fuzzy numbers, to be more specific) which are afterward employed in a fuzzy

reasoning scheme. Fuzzy regression analysis [7], [6], [31] is employed to deal with the mapping and assessment process [32], [33] of experts which are realized from linguistic variables of features and characteristics of an objective into the linguistic expression articulating the total assessment.

3. Linguitic fuzzy regression model with confidence intervals

A. De-Linguitic

We built a model based on the relationship between the assessments given for different attributes and the overall assessment of the object totally. The data given by experts are in the form of linguistic words with hybrid uncertainties of type-1 fuzziness and type-2 fuzziness.

Then, we translate attributes from linguistic values Li into type-2 fuzzy set. First we get primary grades X_L making use of triangular membership functions:

$$X_L \equiv (a, b, c) \tag{3}$$

where X_L denotes the representative value of the fuzzy event, a is the central value and b, c are the left-side bound and right-side bound, respectively.

Then we use the frequency of one evaluation for one subject from experts as its type-2 fuzziness to formulate $\tilde{X_L}$ The estimation of the total assessment is written by the following type-2 fuzzy assessment function:

$$Y_i = f(\tilde{X_{L_{i1}}}, \tilde{X_{L_{i1}}}, \cdots, \tilde{X_{L_{iK}}}) \tag{4}$$

where $i = 1, 2...N$, is the number of experts, K is the number of the attributes of the object. Then the $\tilde{X_L}$ is obtained from the vocabulary dictionary of experts. From this dictionary we can convert the linguistic words to type-2 fuzzy variable.

B. Vertical Slice Centroid Type-Reduction

We have transferred the linguistic word to type-2 fuzzy set. However, the hybrid uncertainties are hard to calculate. Thus we need a process called defuzzification or type-reduction. Vertical Slice Centroid Type-Reduction (VSCTR) is a highly intuitive method employed by John [34]; the paper of Lucas et al. [35] renewed interest in this strategy. In this approach the type-2 fuzzy set is cut into vertical slices, each of which is defuzzified as a type-1 fuzzy set. By pairing the domain value with the defuzzified value of the vertical slice, a type-1 fuzzy set is formed, which is easily defuzzified to give the defuzzified value of the type-2 fuzzy set. Though chronologically preceding it, this method is a generalisation of the Nie-Tan method for interval type-2 fuzzy sets [36].

In VSCTR we calculate only the centroids Cj of the j^{th} vertical slice of $\tilde{B}$. These calculated centroids become the new memberships of elements $y \in Y$. Thus the type-reduced set is obtained by

$$C_{\tilde{B}} = \int_{y \in Y} C_j / y = \int_{y \in Y} \frac{\int_{u \in J_y} u \times f_y(u)}{\int_{u \in J_y} f_y(u)} / y \tag{5}$$

A type-reduced type-2 fuzzy set is a type-1 fuzzy set without much information distortion then.

C. Type-2 Credibility Based-Interval Regression

All the linguistic data have been converted to type-reduced type-2 fuzzy variable data. We then to transfer them into type-2 fuzzy variable with confidence intervals and build a type-2 fuzzy regression model, which is based on the possibilities linear model.

Type-2 fuzzy regression model with confidence interval is the format of data that come from linguistic words, where input data X_{iK} and output data Y_i, for all $i = 1, 2, ..., n$ and $k = 1, 2, ..., K$. They are all type-reduced type-2 fuzzy variables, which defined as:

$$Y_i = \bigcup_{t=1}^{M_{Yi}} \{(Y_i^t, Y_i^t, Y_i^t), p_i^t\},$$
$$X_{iK} = \bigcup_{t=1}^{M_{XiK}} \{(X_{iK}^t, X_{iK}^{t,l}, X_{iK}^{t,r}), q_{iK}^t\} \tag{6}$$

respectively. This means that all values are given as fuzzy numbers with probabilities, where fuzzy variables (Y_i^t, Y_i^t, Y_i^t) and $(X_{iK}^t, X_{iK}^{t,l}, X_{iK}^{t,r})$ are associated with probability p_i^t and q_{iK}^t for $i = 1, 2, , N$, $k = 1, 2, , K$ and $t = 1, 2, , MY_i$ and M_{XiK} respectively.

Let us denote fuzzy linear regression model with fuzzy coefficients $\bar{A}_1, \cdots, \bar{A}_K$ as follows:

$$\bar{Y}_i = \bar{A}_1 X_{i1} + \cdots + \bar{A}_K X_{iK} \tag{7}$$

And then we need to determine the optimal fuzzy parameters $\bar{A}i$. Two optimization criteria are considered. One concerns the fitness of the fuzzy regression model, h. The other one deals with fuzziness captured by the fuzzy regression model 7. Let us elaborate on the detailed formulation of these criteria.

In this study, we employ the confidence-interval based inclusion, which combines the expectation and variance of type-reduced type-2 fuzzy variables and the fuzzy inclusion relation satisfied at level h, to deal with the model (7) as discussed in [3], [31]. There are also some other ways to define the fuzzy inclusion relation $\subset h$, which will yield more

complicated fuzzy regression models. For instance, in order to retain more complete information of the type-2 fuzzy data, we can use the fuzzy inclusion relation directly for the product between a fuzzy parameter and a fuzzy value at some level.

Before building the type-2 fuzzy regression model with confidence interval, we define the confidence interval that is induced by the expectation and variance of a type-reduced type-2 fuzzy variable based on the credibility theory. When we consider the one-sigma confidence interval of each fuzzy variable, we can express it as the following interval:

$$I(e_{X_{iK}}, \sigma_{X_{iK}}) = \left[E(X_{iK}) - \sqrt{Var(X_{iK})}, E(X_{iK}) + \sqrt{Var(X_{iK})}\right] \tag{8}$$

After then, in order to obtain linguistic expression, we need to match the obtained fuzzy numbers to the most appropriate linguistic words (Vocabulary Matching). First we consider the one-sigma confidence interval of each fuzzy variable, and it is expressed as follows:

$$\begin{aligned} I(e_{X_{iK}}, \sigma_{X_{iK}}) &= [e_{X_{iK}} - \sigma_{X_{iK}}, e_{X_{iK}} + \sigma_{X_{iK}}] \\ I(e_{Y_i}, \sigma_{Y_i}) &= [e_{Y_i} - \sigma_{Y_i}, e_{Y_i} + \sigma_{Y_i}] \end{aligned} \tag{9}$$

Then, the new confidence-interval-based type-2 fuzzy regression mode is built as follows:

$$\left.\begin{aligned} min_{\bar{A}} \quad & J(\bar{A}) = \sum_{k=1}^{K} (\bar{A}_k^r - \bar{A}_k^l) \\ subject\ to \quad & \bar{A}_k^r \geq \bar{A}_k^l \\ & \bar{A}_i = \sum_{k=1}^{K} \bar{A}_k I(e_{X_{iK}}, \sigma_{X_{iK}}) \supset_h I(e_{Y_i}, \sigma_{Y_i}) \end{aligned}\right\} \tag{10}$$

where $i = 1, 2, ..., N$, $k = 1, 2, ..., K$, and the $\subset h$ denotes the fuzzy inclusion relation realized at level h.

Since the product of a fuzzy number (fuzzy coefficient) and an interval (confidence interval) is influenced by the signs of each component, in order to solve the model (10), we need to take into account all the cases corresponding to different combinations of the signs of the fuzzy coefficients, as well as the σ-confidence intervals of the fuzzy random data.

D. Solution of the Regression Model

The solution of model (10) can be rewritten as a problem of N samples with one-output and K-input interval values. This problem is difficult to solve, since it consists of NK products between the fuzzy coefficients and confidence intervals. In order to solve the proposed model (10), we can employ a vertices method, as given shortly, i.e., these multidimensional vertices are taken as new sample points with fuzzy output numbers. In the

sequel, we can solve this problem using the conventional method. Nevertheless, this problem suffers from combinatorial explosion that becomes very much visible when the number of variables increases.

Type-2 fuzzy regression model can be developed to include the mean interval values of all samples in the model. Therefore, it is sufficient and necessary to consider only both two vertices of the end points of the interval of each dimension of a sample. For example, one sample with one input interval feature can be expressed with two vertices of the end points of the interval with a fuzzy output value. As a consequence, in T2FR-Model, if we denote $I^{L}ik$ and Iik^{U} as the left and right end points of the expected primary grades intervals of the input Xik, respectively, that is

$$I_{iK}^{L} = E(X_{iK}) - \sqrt{Var(X_{iK})}, \qquad I_{iK}^{U} = E(X_{iK}) + \sqrt{Var(X_{iK})} \tag{11}$$

for i = 1, 2, … , N ; k = 1, 2, … , K; the original T2FR- Model can be converted into the following conventional fuzzy regression model by making use of the vertices method:

$$\left.\begin{array}{ll}
min_{\bar{A}} & J(\bar{A}) = \sum_{k=1}^{K} (\bar{A}_k^r - \bar{A}_k^l) \\
subject\ to & \bar{A}_k^r \geq \bar{A}_k^l \\
(1) \rightarrow & \bar{Y}_i = \sum_{k=1}^{K} \bar{A}_1 \cdot I_{i1}^L + \bar{A}_2 \cdot I_{i2}^L + \cdots \\
 & + \bar{A}_K \cdot I_{iK}^L \supset_h I(e_{Y_i}, \sigma_{Y_i}) \\
(2) \rightarrow & \bar{Y}_i = \sum_{k=1}^{K} \bar{A}_1 \cdot I_{i1}^U + \bar{A}_2 \cdot I_{i2}^L + \cdots \\
 & + \bar{A}_K \cdot I_{iK}^L \supset_h I(e_{Y_i}, \sigma_{Y_i}) \\
(3) \rightarrow & \bar{Y}_i = \sum_{k=1}^{K} \bar{A}_1 \cdot I_{i1}^L + \bar{A}_2 \cdot I_{i2}^U + \cdots \\
 & + \bar{A}_K \cdot I_{iK}^L \supset_h I(e_{Y_i}, \sigma_{Y_i}) \\
\vdots & \vdots \qquad\qquad \vdots \\
(2^K) \rightarrow & \bar{Y}_i = \sum_{k=1}^{K} \bar{A}_1 \cdot I_{i1}^U + \bar{A}_2 \cdot I_{i2}^U + \cdots \\
 & + \bar{A}_K \cdot I_{iK}^U \supset_h I(e_{Y_i}, \sigma_{Y_i})
\end{array}\right\}. \tag{12}$$

The regression model (12) can be easily solved by exhaustive way provided that K is small. Unfortunately, this problem cannot be solved within a reasonable computing time when K becomes even moderately large. For example, when we have 1000 features and 10000 samples, the linear programming problem will come with $2 \times 10000 \times 2^{1000}$ constraints and 1000 nonnegative constraints. Given this, we have to resort to some heuristic strategies.

E. Heuristic Method

We use the new notations for $\bar{A}_k = [\bar{a}_k, a_k]$, for $k = 1, 2, \ldots, K$, in (10) and indicate step(n)of the algorithm by a suffix, say $\bar{A}_k^{(n)} = [\bar{a}_k^{(n)}, a_k^{(n)}]$ Depending on different sign of A_k, the product of fuzzy number $\bar{A}_k$ and $I(e_{Xik}, \sigma_{X_{i1}})$ involves three cases, for $i = 1, 2, \ldots, N$, an α-level set of fuzzy degree of a structural attribute at the level $h0$ is denoted as follows:

$$(\bar{A}_k)_{h^0} = [\underline{a}_k, \bar{a}_k] \tag{13}$$

– for each i and k, due to the signs of confidence interval and (13) the interval representing the product $(\bar{A}_k \cdot I(e_{Xik}, \sigma_{Xik}))h_0$ requires several cases to be considered separately, as shown in Table I, where $\bar{e}_{ik} = E[X_{ik}] + Var[X_{ik}]$ and $e_{ik} = E[X_{ik}] - Var[X_{ik}]$.

4. Apply the new model to the technique of company valuation

Here is a simple example from linguistic evaluation about present market value and future value for 4 different enterprises and they have some inner relations, i.e. supply chain, then we could build a regression model. The given numbers are from the authoritative rating agencies, for instance, the revenue by company A was 5 million in objective way and 6 million

TABLE V. AFTER TRANSFER THE LINGUISTIC TERMS TO TYPE-2 FUZZY SET

X_{11}	(0.4/0.6+0.6/0.7)/5	+	(0.7/0.7+0.3/0.1)/6
X_{21}	(0.7/0.4+0.3/0.6)/4	+	(0.6/0.8+0.4/0.5)/5
X_{31}	(0.3/0.7+0.7/0.5)/15	+	(0.4/0.9+0.6/0.4)/18
X_{41}	(0.3/0.3+0.7/0.4)/20	+	(0.5/0.3+0.5/0.4)/24
X_{12}	(0.4/0.7+0.6/0.9)/7	+	(0.7/0.3+0.3/0.5)/9
X_{22}	(0.9/0.3+0.1/0.1)/3	+	(0.7/0.5+0.3/0.2)/14
X_{32}	(0.8/0.5+0.2/0.6)/18	+	(0.6/0.7+0.4/0.3)/22
X_{42}	(0.9/0.6+0.1/0.7)/25	+	(0.6/0.9+0.4/0.4)/28
Y_1	(0.8/0.7+0.2/0.6)/15	+	(0.6/0.7+0.4/0.4)/17
Y_2	(0.7/0.4+0.3/0.3)/9	+	(0.4/0.2+0.6/0.3)/7
Y_3	(0.5/0.5+0.5/0.4)/28	+	(0.6/0.4+0.4/0.7)/30
Y_4	(0.7/0.7+0.3/0.9)/35	+	(0.7/0.5+0.3/0.8)/40

in optical way, in the future the company would have a objective value about 7 million and if the situation continues, optimistically with the excellent campaign 9 million would be reachable. And the Table IV focuses on the comprehensive market value from now to the future, it has a affinity bond with the market performance. Suppose that we have ten excellent analysts and they hold the different evaluations about the data, which were given by the rating agencies, evaluate both present and future concluded in optimistic condition and objective condition, the details shown in Table II, III and IV.

Count the frequencies of different evaluation and apply them the numerical weighs, in extend that is (extreme good,0.9), (very good,0.7), (good,0.6), (normal,0.5), (bad,0.4), (very bad,0.3), (extreme bad,0.1), and in possibility, (huge,0.9), (very large,0.8), (large,0.7), (considerable,0.6), (fair,0.5), (modest,0.4), (small,0.3), (very small,0.2) and (tiny,0.1) in the charge. Say *rule* 1. Eventually, we get the type-2 fuzzy set for this case, see Table V. And

we need to short the uncertainty on the secondary grade at the same time adding the confidence interval for the values instead. For more desirable calculating and more precise model we introduced.

Using the VSCTR for the data and we get the type-1 prior considering them into confidence intervals. The fuzzy regression structure with confidence interval for the given data reads as follows:

$$\bar{Y}_i = \bar{A}_1 I[e_{X_{i1}}, \sigma_{X_{i1}}] + \bar{A}_2 I[e_{X_{i2}}, \sigma_{X_{i2}}]$$

where $I(e_{Xik}, \sigma_{X_{i1}})$, for k = 1, 2, and the one-sigma confidence intervals shown in (8). Since $N = 4$, $K = 2$, from the model (10), and assuming $(\bar{A}_k)_{ho}$=[$\bar{A}_k^l$, $\bar{A}_k^r$], k = 1*and* 2, the model can be built. First of all, we need to calculate all the $I(e_{Xik}, \sigma_{X_{i1}})$, and $I(e_{Yk}, \sigma_{Y1})$, for i = 1, 2, 3, 4, k = 1 *and* 2. We need to calculate the pairs (e_{Xik},σ_{Xik}) and e_{Yk},σ_{Yk}.

Hence, the confidence intervals for the input data and output data are obtained in the follow equations:

$$\begin{aligned} I[e_{X_{ik}}, \sigma_{X_{ik}}] &= I[e_{X_{ik}} - \sigma_{X_{ik}}, e_{X_{ik}} + \sigma_{X_{ik}}] \\ I[e_{Y_i}, \sigma_{Y_i}] &= I[e_{Y_i} - \sigma_{Y_i}, e_{Y_i} + \sigma_{Y_i}] \end{aligned} \tag{14}$$

for i = 1,2,3,4 and k = 1,2. They are listed in Tables ?? and ??, respectively. We make use of Algorithm 1 to construct a regression model. Noting that K = 2, all the confidence intervals are positive, and we need to set and from the Algorithm, we get the following linear programming:

$$(\bar{A}_k^{(1)} \cdot I[e_{X_{ik}}, \sigma_{X_{ik}}])_{h^0} = [\underline{a}_k^{(1)} \cdot e_{ik}, \bar{a}_k^{(1)} \cdot e_{ik}]$$

TABLE I. DIFFERENT CASES OF THE PRODUCT

Case	Condition	Result
Case I	$\bar{e}_{ik} \geq \underline{e}_{ik} \geq 0$	
I-a	$\bar{a}_k \geq \underline{a}_k \geq 0$	$(\bar{A}_k \cdot I(e_{X_{ik}}, \sigma_{X_{ik}}))_{h^0} = [\underline{a}_k \cdot \underline{e}_{ik}, \bar{a}_k \cdot \bar{e}_{ik}]$
I-b	$\bar{a}_k \geq 0 \geq \underline{a}_k$	$(\bar{A}_k \cdot I(e_{X_{ik}}, \sigma_{X_{ik}}))_{h^0} = [\underline{a}_k \cdot \bar{e}_{ik}, \bar{a}_k \cdot \bar{e}_{ik}]$
I-c	$0 \geq \bar{a}_k \geq \underline{a}_k$	$(\bar{A}_k \cdot I(e_{X_{ik}}, \sigma_{X_{ik}}))_{h^0} = [\underline{a}_k \cdot \bar{e}_{ik}, \bar{a}_k \cdot \underline{e}_{ik}]$
Case II	$0 \geq \bar{e}_{ik} \geq \underline{e}_{ik}$	
II-a	$\bar{a}_k \geq \underline{a}_k \geq 0$	$(\bar{A}_k \cdot I(e_{X_{ik}}, \sigma_{X_{ik}}))_{h^0} = [\bar{a}_k \cdot \underline{e}_{ik}, \underline{a}_k \cdot \bar{e}_{ik}]$
II-b	$\bar{a}_k \geq 0 \geq \underline{a}_k$	$(\bar{A}_k \cdot I(e_{X_{ik}}, \sigma_{X_{ik}}))_{h^0} = [\bar{a}_k \cdot \underline{e}_{ik}, \underline{a}_k \cdot \underline{e}_{ik}]$
II-c	$0 \geq \bar{a}_k \geq \underline{a}_k$	$(\bar{A}_k \cdot I(e_{X_{ik}}, \sigma_{X_{ik}}))_{h^0} = [\bar{a}_k \cdot \bar{e}_{ik}, \underline{a}_k \cdot \underline{e}_{ik}]$
Case III	$\bar{e}_{ik} \geq 0 \geq \underline{e}_{ik}$	
III-a	$\bar{a}_k \geq \underline{a}_k \geq 0$	$(\bar{A}_k \cdot I(e_{X_{ik}}, \sigma_{X_{ik}}))_{h^0} = [\bar{a}_k \cdot \underline{e}_{ik}, \bar{a}_k \cdot \bar{e}_{ik}]$
III-b	$\bar{a}_k \geq 0 \geq \underline{a}_k$	$(\bar{A}_k \cdot I(e_{X_{ik}}, \sigma_{X_{ik}}))_{h^0} = [\underline{a}_k \cdot \bar{e}_{ik}, \underline{a}_k \cdot \underline{e}_{ik}]$
III-c	$0 \geq \bar{a}_k \geq \underline{a}_k$	$(\bar{A}_k \cdot I(e_{X_{ik}}, \sigma_{X_{ik}}))_{h^0} = [a_k^\star \cdot e_{ik}^\star, a_k^{\star\star} \cdot e_{ik}^{\star\star}]$

note that $a_k^\star \cdot e_{ik}^\star = min\{\underline{a}_k \cdot \bar{e}_{ik}, \bar{a}_k \cdot \underline{e}_{ik}\}$, $a_k^{\star\star} \cdot e_{ik}^{\star\star} = max\{\underline{a}_k \cdot \bar{e}_{ik}, \bar{a}_k \cdot \underline{e}_{ik}\}$

TABLE II. OBJECTIVE VALUE AND OPTICAL VALUE ASSESSMENT BY 10 ANALYSTS FOR PRESENT

Present		View about the Objective Value and Opportunity for the Ideal Value Held by Different Analysts									
Value of company		1	2	3	4	5	6	7	8	9	10
A	5	good	very good	good	good	very good	very good	very good	good	very good	very good
	6	large	tiny	large	tiny	large	large	large	large	large	large
B	4	bad	bad	bad	good	bad	good	bad	bad	bad	good
	5	fair	very large	very large	fair	fair	very large	very large	fair	very large	very large
C	15	very good	normal	normal	normal	very good	normal	normal	normal	very good	normal
	18	huge	huge	huge	modest	modest	modest	modest	huge	modest	modest
D	20	very bad	very bad	very bad	bad	bad	bad	bad	bad	bad	bad
	24	small	modest	modest	small	modest	small	small	modest	small	modest

TABLE III. OBJECTIVE VALUE AND OPTICAL VALUE ASSESSMENT BY 10 ANALYSTS FOR FUTURE

Future		View about the Objective Value and Opportunity for the Ideal Value by Different Analysts									
Company		1	2	3	4	5	6	7	8	9	10
A	7	very good	very good	extreme good	extreme good	extreme good	extreme good	very good	very good	extreme good	extreme good
	9	small	small	fair	fair	fair	small	small	small	small	small
B	3	bad	bad	bad	bad	bad	bad	bad	bad	bad	very bad
	4	fair	fair	very small	fair	fair	very small	fair	very small	fair	fair
C	18	normal	normal	good	normal	good	normal	normal	normal	normal	normal
	22	large	small	small	large	small	large	small	large	large	large
D	25	good	good	good	good	good	very good	good	good	good	good
	28	modest	huge	huge	huge	modest	modest	huge	huge	modest	huge

TABLE IV. COMPREHENSIVE MARKET PERFORMANCE ABOUT THE FOUR COMPANIES FOR PRESENT AND FUTURE

Comprehensive		Comprehensive Market Performance about the Four Companies for Present and Future									
Evaluation		1	2	3	4	5	6	7	8	9	10
A	15	very good	very good	good	very good	good	very good	very good	very good	very good	very good
	17	large	large	large	modest	modest	large	modest	large	modest	large
B	9	bad	bad	very bad	bad	very bad	bad	bad	very bad	bad	bad
	7	small	very small	very small	small	small	very small	very small	small	small	small
C	28	normal	28,bad	bad	bad	normal	normal	bad	bad	normal	normal
	30	modest	modest	modest	large	large	modest	modest	large	modest	large
D	35	good	good	good	extreme good	good	extreme good	extreme good	good	good	good
	40	fair	fair	fair	very large	fair	very large	fair	very large	fair	fair

$$
\left.
\begin{aligned}
&\textit{min} && J(\bar{A}) = \bar{a}_1^{(1)} - \underline{a}_1^{(1)} + \bar{a}_2^{(1)} - \underline{a}_2^{(1)} \\
&\textit{subject to} && \bar{a}_1^{(1)} \geq \underline{a}_1^{(1)}, \bar{a}_2^{(1)} \geq \bar{a}_2^{(1)} \\
& && [\underline{a}_1^{(1)}, \bar{a}_1^{(1)}] \cdot 5.44 + [\underline{a}_2^{(1)}, \bar{a}_2^{(1)}] \cdot 7.61 \\
& && \qquad \supseteq [13.10, 18.74] \\
& && [\underline{a}_1^{(1)}, \bar{a}_1^{(1)}] \cdot 4.60 + [\underline{a}_2^{(1)}, \bar{a}_2^{(1)}] \cdot 8.17
\end{aligned}
\right\}
$$

Solving the linear programming, we obtain:

$$\begin{aligned} min\ J(\bar{A}) &= \bar{a}_1^{(1)} - \underline{a}_1^{(1)} + \bar{a}_2^{(1)} - \underline{a}_2^{(1)} \\ &= 0.21 - 0.21 + 2.32 - 0.77 = 1.55. \end{aligned}$$

Next, we move to Step 2. Since the a(1) k and a ¯(1) k are nonnegative, then according to case I-a, we can determine

$$(\bar{A}_k^{(2)} \cdot I[e_{X_{ik}}, \sigma_{X_{ik}}])_{h^0} = [\underline{a}_k^{(2)} \cdot e_{ik}, \bar{a}_k^{(2)} \cdot e_{ik}]$$

Then we determine a(2)k and a ¯(2) k , by solving the following linear programming:

$$\left.\begin{aligned} min \quad & J(\bar{A}) = \bar{a}_1^{(1)} - \underline{a}_1^{(1)} + \bar{a}_2^{(1)} - \underline{a}_2^{(1)} \\ subject\ to \quad & \bar{a}_1^{(1)} \geq \underline{a}_1^{(1)} \geq 0, \bar{a}_2^{(1)} \geq \bar{a}_2^{(1)} \geq 0 \\ & [\underline{a}_1^{(2)} \cdot 4.84, \bar{a}_1^{(2)} \cdot 6.04] + [\underline{a}_2^{(2)} \cdot 6.48, \\ & \qquad \bar{a}_2^{(2)} \cdot 8.74] \supseteq [13.10, 18.74] \\ & [\underline{a}_1^{(2)} \cdot 4.05, \bar{a}_1^{(2)} \cdot 5.15] + [\underline{a}_2^{(2)} \cdot 3.14, \\ & \qquad \bar{a}_2^{(2)} \cdot 4.24] \supseteq [6.85, 9.49] \\ & [\underline{a}_1^{(2)} \cdot 12.75, \bar{a}_1^{(2)} \cdot 20.35] + [\underline{a}_2^{(2)} \cdot 14.71, \\ & \qquad \bar{a}_2^{(2)} \cdot 25.37] \supseteq [26.17, 32.43] \\ & [\underline{a}_1^{(2)} \cdot 16.61, \bar{a}_1^{(2)} \cdot 27.27] + [\underline{a}_2^{(2)} \cdot 21.55, \\ & \qquad \bar{a}_2^{(2)} \cdot 31.65] \supseteq [24.86, 49.52] \end{aligned}\right\} \quad (16)$$

Solving this linear programming, we obtain:

$$\begin{aligned} min\ J(\bar{A}) &= \bar{a}_1^{(2)} - \underline{a}_1^{(2)} + \bar{a}_2^{(2)} - \underline{a}_2^{(2)} \\ &= 0.39 - 0.39 + 1.83 - 0.89 = 0.94. \end{aligned}$$

Since $a(2)k \cdot a(1)k \geq 0$, $a\bar{}(2)\ k \cdot a\bar{}(1)\ k \geq 0$, we move directly to Step 5. We check all the vertices, in this case, 16 vertices in the regression that are obtained by (16) and we could found some vertices do not satisfy the range $I[eYi, \sigma Yi]$, given the limited pages, we would not listed them all, and after the check, we need to add at most 32 qualifications if the lower range or the upper range do not met. In our example we add 13 qualifications in (17). And from (17), the optimal value of $J(A\bar{})$ is obtained:

$$\begin{aligned} min\ J(\bar{A}) &= \bar{A}_1^r - \bar{A}_1^l + \bar{A}_2^r - \bar{A}_2^l \\ &= 0.66 - 0.66 + 2.48 - 0.39 = 2.09. \end{aligned}$$

Then, we terminate the Algorithm and return the optimal solution:

$$\bar{A}_1^l = \bar{A}_1^r = 0.66, \bar{A}_2^l = 0.39, \bar{A}_2^r = 2.48.$$

Thus, the type-2 fuzzy regression model with confidence interval is given in the form:

$$\begin{aligned} \bar{Y}_i &= \bar{A}_1 I[e_{X_{i1}}, \sigma_{X_{i1}}] + \bar{A}_2 I[e_{X_{i2}}, \sigma_{X_{i2}}] \\ &= \bar{A}_1 I[e_{X_{i1}}, \sigma_{X_{i1}}] + ((\bar{A}_2^l + \bar{A}_2^r)/2, \bar{A}_2^l, \bar{A}_2^r) I[e_{X_{i2}}, \sigma_{X_{i2}}] \\ &= 0.66 I[e_{X_{i1}}, \sigma_{X_{i1}}] + [1.44, 0.39, 2.48] I[e_{X_{i2}}, \sigma_{X_{i2}}]. \end{aligned}$$

$$\left.\begin{array}{ll} min & J(\bar{A}) = \bar{a}_1^{(1)} - \underline{a}_1^{(1)} + \bar{a}_2^{(1)} - \underline{a}_2^{(1)} \\ subject\ to & \bar{a}_1^{(1)} \geq \underline{a}_1^1 \geq 0, \bar{A}_2^{(1)} \geq \bar{A}_2^{(1)} \geq 0 \\ & \\ & \underline{a}_1^{(2)} \cdot 4.78 + \underline{a}_2^{(2)} \cdot 6.28 \leq 13.10 \\ & \underline{a}_1^{(2)} \cdot 3.97 + \underline{a}_2^{(2)} \cdot 3.31 \leq 6.85 \\ & \underline{a}_1^{(2)} \cdot 12.14 + \underline{a}_2^{(2)} \cdot 14.39 \leq 26.17 \\ & \underline{a}_1^{(2)} \cdot 18.10 + \underline{a}_2^{(2)} \cdot 19.99 \leq 24.86 \\ & 18.74 \leq \bar{a}_1^{(2)} \cdot 6.10 + \bar{a}_2^{(2)} \cdot 8.94 \\ & 9.49 \leq \bar{a}_1^{(2)} \cdot 5.23 + \bar{a}_2^{(2)} \cdot 4.07 \\ & 32.23 \leq \bar{a}_1^{(2)} \cdot 20.96 + \bar{a}_2^{(2)} \cdot 25.69 \\ & 49.52 \leq \bar{a}_1^{(2)} \cdot 25.78 + \bar{a}_2^{(2)} \cdot 33.21 \\ & \star The\ added\ portion\ is\ followed. \\ & \underline{a}_1^{(2)} \cdot 20.96 + \underline{a}_2^{(2)} \cdot 14.39 \leq 26.17 \\ & \underline{a}_1^{(2)} \cdot 25.78 + \underline{a}_2^{(2)} \cdot 19.99 \leq 24.86 \\ & \underline{a}_1^{(2)} \cdot 18.10 + \underline{a}_2^{(2)} \cdot 33.21 \leq 24.86 \\ & 18.74 \leq \bar{a}_1^{(2)} \cdot 4.78 + \bar{a}_2^{(2)} \cdot 6.28 \\ & 18.74 \leq \bar{a}_1^{(2)} \cdot 4.78 + \bar{a}_2^{(2)} \cdot 8.94 \\ & 18.74 \leq \bar{a}_1^{(2)} \cdot 6.10 + \bar{a}_2^{(2)} \cdot 6.28 \\ & 9.49 \leq \bar{a}_1^{(2)} \cdot 3.97 + \bar{a}_2^{(2)} \cdot 3.31 \\ & 9.49 \leq \bar{a}_1^{(2)} \cdot 3.97 + \bar{a}_2^{(2)} \cdot 4.07 \\ & 9.49 \leq \bar{a}_1^{(2)} \cdot 5.23 + \bar{a}_2^{(2)} \cdot 3.31 \\ & 32.23 \leq \bar{a}_1^{(2)} \cdot 12.14 + \bar{a}_2^{(2)} \cdot 14.39 \\ & 49.52 \leq \bar{a}_1^{(2)} \cdot 25.78 + \bar{a}_2^{(2)} \cdot 19.99 \\ & 49.52 \leq \bar{a}_1^{(2)} \cdot 18.10 + \bar{a}_2^{(2)} \cdot 19.99 \end{array}\right\}. \quad (17)$$

We could recover the regression model in linguistic rule, we use E for evaluation, and R for range that R = 0.66 ·(e_{Xi1} + σ_{Xi1} − (e_{Xi1} − σ_{Xi1}) +1.44 · (e_{Xi2} + σ_{Xi2} − (e_{Xi2} − σ_{Xi2})), which means the standard level of the company, and calculate the difference between $\bar{Y}_i$ and e_{Yi},

the ratio of the difference and R, the numerical evaluation obtained.

$$E = \frac{1.44 \cdot e_{X_{i2}} + 0.66 \cdot e_{X_{i1}} - e_{Y_i}}{R}$$

transfer E to word guiding by rule 2, that is if E greater than 1, it was splendid good or below 0, junk level perhaps.(0,0.33], it was overvalued, (0.33,0.67), it deserved, [0.67,1), the company was undervalued. then we got our result. that the four companies evaluation in sequence of A, B ,C, and D should be: overvalued, deserved, undervalued, superb.

5. Conclusion

In this paper we built a model for transferring linguistic data to type-2 fuzzy data and importing confidence-interval regression model, in the end recover the result to linguistic data. After talking about type-2 fuzzy set and reduce function as well as linguistic transform, we use expectations and variances of type-reduced type-2 fuzzy variables to construct the confidence interval based type-2 fuzzy data. The proposed vertices method can convert the original type-2 fuzzy regression to a conventional fuzzy regression, with the heuristic algorithm, integrates linear programming and vertices checking, which enables us to handle the proposed regression by solving a series of linear programming problems. An illustrative example was provided to demonstrate the solution process.

The method can be implemented to several applications, it works on the non-meta linguistic data handling, lots of evaluations could be qualifiable, and helps the decision maker do the more appropriate choice. And also the fuzzy multi-attribute evaluation for finance and management, further applications will be discussed in our forthcoming studies.

REFERENCES

[1] L. A. Zadeh, What is Computing with Words, *Computing with Words in Information/Intelligent Systems*, pp. VIII-IX, 2006.

[2] L. A. Zadeh, Fuzzy Sets and Information Granularity, *Advances in Fuzzy Set Theory and Applications*, pp. 3-18, 1979.

[3] S. Li, S. Imai, J. Watada, Building Linguistic Random Regression Model and its Application, *Proceedings of the International Con- ference on Knowledge-Based Intelligent Information and Engineering Systems KES-IDT*, 2012.

[4] W. Pedrycz, *Granular Computing: An Emerging Paradigm*, 2001.

[5] W. Pedrycz, Computational Intelligence as an Emerging Paradigm of Software Engineering, *Proceedings of SEKE 2002, Ischia, Italy, July 15-19*, pp. 7-14, 2002.

[6] J. Watada, W. Pedrycz, A Fuzzy Regression Approach to Acquisition of Linguistic Rules, *Handbook of Granular Computing*, pp. 719-732, 2008.

[7] H. Tanaka, S. Uejima, K. Asai, Linear regression analysis with fuzzy model, *IEEE Transactions on Systems, Man and Cybernetics SMC-12*, pp. 903-907, 1982.

[8] L. A. Zadeh, Fuzzy sets, *Information and Control*, vol. 8, no. 3, pp.338-353, 1965

[9] J. Watada, H.Tanaka, Fuzzy quantification methods, *Proceedings,the 2nd IFSA Congress*, pp. 66-69, 1987.

[10] L. A. Zadeh, the Concept of a Linguistic Variable and Its Application to Approximate Rea-soning-1,

Information Sciences, vol. 8, no. 3, pp. 199-249, 1975.

[11] M. Mizumoto and K. Tanaka, Some properties of fuzzy sets of type-2, *Information and Control*, vol. 31, no. 4, pp. 312-340, 1976.

[12] D. Dubois and H. Prade, Operations in a fuzzy-valued logic, *Information and Control* vol. 43 no. 2, pp. 224-240, 1979.

[13] R. I. John, P. R. Innocent, and M. R. Barnes, Type-2 fuzzy sets and neuro-fuzzy clustering or radiographic tibia images, *Proc.6th Int. Conf. on Fuzzy Systems*, pp. 1375-1380, 1997.

[14] R. I. John and C. Czarnecki, A Type 2 adaptive fuzzy inference system, *Proc. IEEE Conf. Systems, Man, Cybernetics*, vol. 2, pp. 2068- 2073, 1998.

[15] Q. Liang and J. M. Mendel, Interval type-2 fuzzy logic systems: theory and design, *IEEE Trans. Fuzzy Syst.*, vol. 8, no. 5, pp. 535-549, 2000.

[16] Q. Liang and Jerry M. Mendel, MPEG VBR video traffic modeling and classification using fuzzy techniques," *IEEE Trans. Fuzzy Syst.*, vol. 9, pp. 183-193, 2001.

[17] K. C. Wu, "Fuzzy interval control of mobile robots," *Comput. Elect.Eng.*, vol. 22, pp. 211-229, 1996.

[18] H. Tanaka, I. Hayashi, and J. Watada, "Possibilistic linear regression for fuzzy data," *European Journal of Operational Research*, vol. 40, no. 3, pp. 389-396, 1989.

[19] H. Tanaka and J. Watada, "Possibilistic linear systems and their appli- cation to the linear regression model," *Fuzzy Sets and Systems*, vol. 27, no. 3, pp. 275-289, 1988.

[20] J. Watada and H. Tanaka, "The perspective of possibility theory in decision making," *Multiple Criteria Decision Making Toward Interac- tive Intelligent Decision Support Systems, VIIth Int. Conf.*, pp. 328-337, 1986.

[21] Y. H. O. Chang, "Hybrid fuzzy least-squares regression analysis and its reliability measures," *Fuzzy Sets and Systems*, vol. 119, no. 2, pp. 225-246, 2001.

[22] J. Watada, "Possibilistic time-series analysis and its analysis of con- sumption," *Fuzzy Information Engineering*, pp. 187-200, 1996.

[23] B. Liu, *Theory and Practice of Uncertain Programming*, 2002.

[24] L. A. Zadeh, The concept of a linguistic variable and its application to approximate reasoning-I, *Information Sciences*, vol. 8, pp. 199-249, 1975.

[25] N. K. Karnik and J. M. Mendel, Operations on type-2 fuzzy sets, *Fuzzy Sets and Systems*, vol. 122, pp. 327-348, 2001.

[26] J. M. Mendel and R. I. B. John, Type-2 fuzzy sets made simple, *IEEE Transactions on Fuzzy Systems*, vol. 10, no. 2, pp. 117-127, 2002.

[27] X. Chen, R. Harrison, Y. Q. Zhang, and Y. Qiu, A multi-SVM fusion model using type-2 FLS, *IEEE International Conference on Fuzzy Systems*, pp. 6611-6615, 2006.

[28] U. Pareek and I. N. Kar, Estimating compressor discharge pressure of gas turbine power plant using type-2 fuzzy logic systems, *IEEE International Conference on Fuzzy Systems*, pp. 3113-3118, 2006.

[29] R. John, J. M. Mendel, and J. Carter, The extended sup-star composi- tion for type-2 fuzzy sets made simple, *IEEE International Conference on Fuzzy Systems*, pp. 7212-7216, 2006.

[30] B. Liu, Y. K. Liu, "Expected Value of Fuzzy Variable and Fuzzy Expected Value Models," *IEEE Transactions on Fuzzy Systems* vol. 10 no. 4, pp. 445-450, 2002.

[31] J. Watada, S. Wang, W. Pedrycz, Building Confidence-interval-based Fuzzy Random Regression Model, *IEEE Transactions on Fuzzy Systems* vol. 11, no. 6, pp. 1273-1283, 2009.

[32] J. Watada, Multiattribute Decision-making, *Applied Fuzzy System*, pp.244-252, 1994.
[33] J. Watada, The Thought and Model of Linguistic Regression, *Proceedings of the 9th World Congress of International Fuzzy Systems*, pp. 340-346, 2001.
[34] R. I. B. John, Perception Modelling Using Type-2 Fuzzy Sets, *PhD Thesis, De Montfort University*, 2000.
[35] L. A. Lucas, T. M. Centeno and M. R. Delgado, General type-2 fuzzy inference systems: analysis, design and computational aspects, *Proceedings of FUZZ-IEEE 2007*, pp. 1743-1747, 2007.
[36] M. Nie, W. W. Tan, Towards an efficient type-reduction method for interval type-2 fuzzy logic systems, *Proceedings of FUZZ-IEEE 2008*, pp. 1425-1432, 2008.

A Multiple Regression Analysis Approach for Mathematical Model Development in Dynamic Manufacturing System: A Case Study

Kok Hoe Ho[1], Joshua Prakash [1], and Kok Seng Ong[1]
[1]Faculty of Engineering and Green Technology Universiti Tunku Abdul Rahman
9, Jalan Bersatu 13/4, 46200 Petaling Jaya, Selangor, Malaysia
hokokhoe1980@yahoo.com

ABSTRACT.*We proposed an approach using multiple regression analysis to develop a mathematical model that represents a dynamic manufacturing system. Simulation data are specifically analyzed using this multiple regression analysis approach to obtain a data pattern. The aim of the approach is to reduce the gap between theory and real-time data of the system. To evaluate the effectiveness of the proposed mathematical model, simulation model was first validated using real-time data. The applicability of the proposed mathematical model was evaluated by testing with real-time data. The outcome positively demonstrated that the proposed mathematical model based on multiple regression analysis approach can be used to make predictions in the dynamic manufacturing environment with an acceptable error percentage range. The mathematical development in this field will enhance the future establishment of a decision making model using a spreadsheet in the management field.*

Keywords: multiple regression analysis, dynamic manufacturing system, statistical comparison, mathematical model, decision making model

1. Introduction

Mathematical modeling in dynamic manufacturing system requires an effective approach to narrow the gap between theory and practice of the model's application [14]. A survey of related literature has indicated the possibility of using a data pattern, such as fault pattern variable, to formulate a mathematical equation to represent a dynamic manufacturing environment system [11]. In general, the main objective of this approach is to identify a feasible method to link data pattern to a mathematical equation for practical application. A number of methodologies for developing mathematical model in the system are available, and one of these methodologies is the application of multiple regression analysis in the model. An example of such work is available in [11], and this previous work showed that it is possible to develop mathematical model using functional regression approach. The challenge of creating a mathematical model with a small error comparison using simulation and real-time data has been addressed [5,13]. Mathematical model development and simulation are used simultaneously in research papers. In contrast to simulation, mathematical model still plays an important role in a dynamic manufacturing system. Mathematical model applications in numerical analysis and spreadsheet models are a common practice in the field [2,9,16].

In the work of Al-Zuheri et al. [1], the area of dynamic manufacturing environment study is on walking worker assembly line. The authors worked on improving the decision-making process by using a mathematical model and simulation. The authors [1] compared the predicted results from simulation model and mathematical model including the error

value between the models using root-mean square (RMS).

Other researchers ([3,4,17]) have stated that semiconductor process is the most complicated manufacturing system involved in a dynamic system. In a previous study [3], a bottleneck prediction mathematical model that is based on an improved Adaptive network-based fuzzy inference system (ANFIS) has been proposed. The prediction accuracies from simulation and mathematical models were analyzed [3]. Catay et. al [4] presented a mathematical model for multi-period tool capacity planning in semiconductor manufacturing. The proposed model is validated using computational experiments using Lagrangean-based heuristic solution procedure, which is coded in C-programming language [4]. Jacomino et. al [8] presented two production planning approaches using mixed-integer programming and heuristics methods to realize a step toward the development of capacity planning at a finite capacity in semiconductor manufacturing. T No validation activity has been presented for the proposed models in the study [8]. Jacomino et. al [8] used CAPACE and ILOG CPLEX solver software to provide and analyze the result from the developed models.

Mathematical model formulation using data pattern analysis has been conducted previously [11]. Li [11] presented that a model-based signal detection and estimation approach can be applied, and the process can be represented by a suitable dynamics model (either in the form of state-space or transfer function). The author [11] studied the data pattern and developed the mathematical model as a regression model that can be used to make predictions by using a functional regression method. J. Faraway [10] noted that the functional regression approach is suitable when the response variable for prediction is functional. The author [11] did not perform validation on the regression model and demonstrated the proposed model using an example from the resistance spot welding process mentioned in previous studies. A previously published review [17] indicates that the multivariate regression approach tends to be more convenient when input data are noise or when the complex relationship among the input variables is not fully understood. Zhang et. al [17] cited the work of (J.Wang and B. Malakooti, 1992) and (M.K. Malhotra et. al, 1999) because this approach is widely used in research strategy and is proven to be effective and adaptive.

In this paper, we further extended the work of another researcher [11] on different dynamic manufacturing environments. The approach we adopted was to use a data pattern from a simulation model to formulate a mathematical model via regression method. Our definition of dynamic manufacturing system is product movement from the first process to the last process in an assembly semiconductor. A search in a literature database indicated the lack of information related to the development of mathematical model in this defined dynamic system. Hence, we are the first to work in this area to provide additional information by extending the results of a similar study [11]. The organization of this paper is described as follows. Section 2 discusses an approach that uses multiple regression analysis to formulate the mathematical equation of the system. Section 3 develops the paper's problem formulation. The details of the proposed model and its validation are presented in Section 4. In Section 5, real-time case study from the data collection time frame is tested in the proposed model, and results are discussed and analyzed. Conclusion and suggestions for further work are presented in Section 6.

2.**An Approach Using Multiple Regression Analysis**

Figure 1 illustrates the process flow chart of the approach using multiple regression analysis to develop a mathematical model.

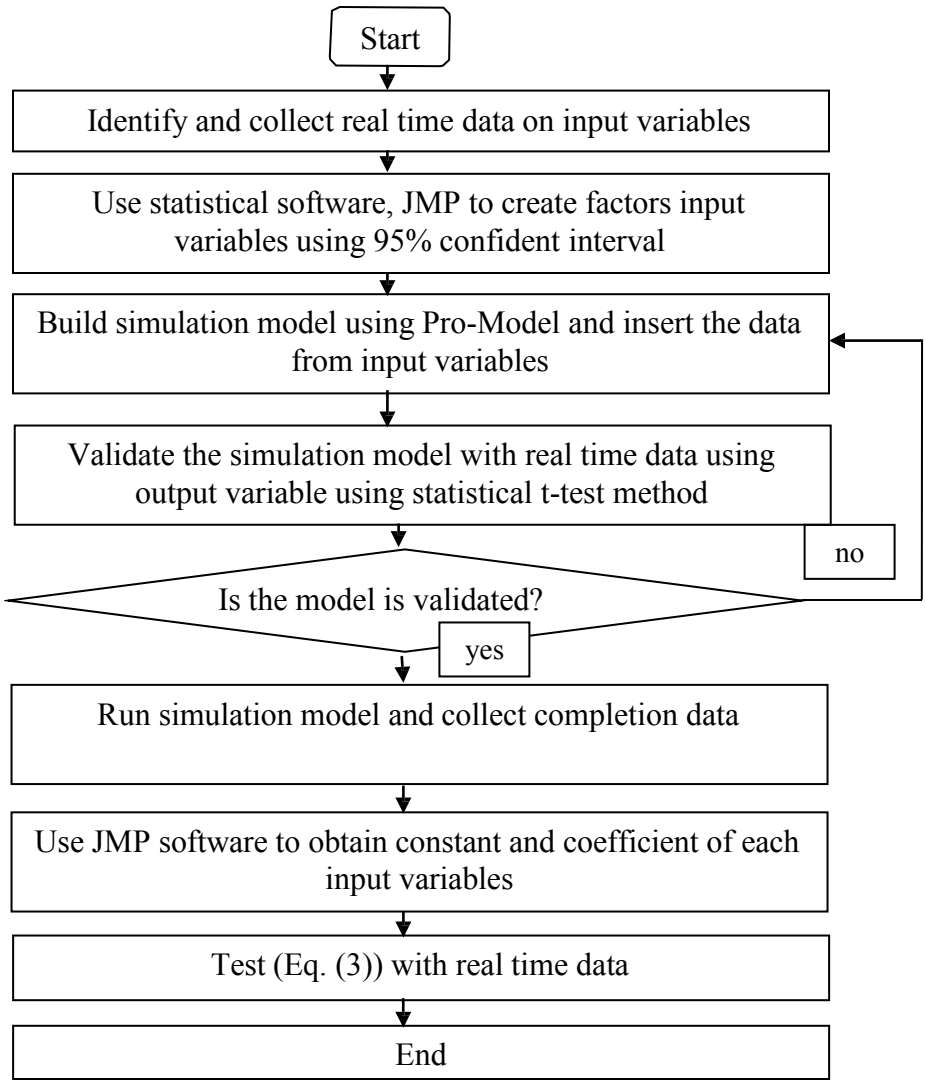


FIGURE 1. Approach using multiple regression analysis to develop a mathematical model.

The paper began with real-time data collection for input variables. The data were analyzed using JMP software to fit into most suitable data distribution on 2 level factors for 9 input variables based on 95% confidence interval and one 3 level factor for batch quantity. A simulation model was built using Pro-Model, and input variable data are inserted into the model. Model validation activity had to be addressed to ensure its accuracy as a representation of a real system [12]. This paper's simulation model validation was performed by using historical data technique. Sargent [15] described this technique to test whether simulation model behaves as the system does. A statistical t-test was used to validate the model with real-time data on respective processes. When the simulation model was validated, a sample of completion time of 30 batches for each run was collected. There is total of 1536 runs in the design of experiment table using full factorial with 1 replication run. 1 replication run for 1 full factorial study is justified as each factor of each level are covered in the design of experiment table for the data collection of completion time. The full factorial design is applied in the table as this is the first study to develop mathematical model using multiple regression approach on a manufacturing system and test it with real-time data using this approach. For each run, an average of total 30 batches is calculated and

inserted into JMP software. Then, the constant and coefficient of each input variables were obtained using JMP analysis. When the equation was established, the equation was tested by performing a comparison between prediction analysis and real-time data (case study).

3.**Problem Formulation**

We examined an example from semiconductor manufacturing as a case study (Figure 2). The configuration of the process is as follows: 3 die attach machines, 1 continuous available oven cure machine, 9 wire bond machines, and 3 pre-cap inspection machines.

FIGURE 2. Semiconductor manufacturing process flow

The response variable is completion time with 11 input variables as follows: cycle time per unit (Die Attach), cycle time per unit (Wire Bond), cycle time per unit (Pre Cap Inspection), machine downtime duration (Die Attach), machine downtime duration (Wire Bond), machine downtime frequency (Die Attach), machine downtime frequency (Wire Bond), setup time duration (Die Attach), setup time duration (Wire Bond), batch quantity, and cycle time per batch (oven cure). The task was to perform regression analysis on the data pattern of completion by using a combination of 2 and 3 level factors of input variables. A total of 1536 runs from a full factorial design of an experiment table using (2^9 x 3^1) were performed using Pro Model software to collect completion time data. Three level factors for batch quantity consisted of 2200, 3080, and 11264 units per batch, which were obtained from the assembly. In regression analysis, the completion time could be represented as a function of input variables as per Eq. (1), and d_b could be represented as the difference between T_b and T_{b-1} in Eq. (2).

The annotation used to explain the regression model is described below:
T_b = average completion time per batch, b
d_b = different between completion time per batch current minus completion time per batch previous (flow time of batch b)
CT_{DA} = cycle time per unit (Die Attach) / unit = seconds
CT_{WB} = cycle time per unit (Wire Bond) / unit = seconds
CT_{PC} = cycle time per unit (Pre Cap Inspection) / unit = seconds
DD_{DA} = machine downtime duration (Die Attach) / unit = seconds
DD_{WB} = machine downtime duration (Wire Bond) / unit = seconds
DF_{DA} = machine downtime frequency (Die Attach) / unit = minutes
DF_{WB} = machine downtime frequency (Wire Bond) / unit = minutes
ST_{DA} = setup time duration (Die Attach) / unit = seconds
ST_{WB} = setup time duration (Wire Bond) / unit = seconds
BQ = batch quantity / unit = quantity
CT_{OC} = cycle time per batch (Oven Cure) / unit = seconds
a_1 = coefficient of CT_{DA}
a_2 = coefficient of CT_{WB}
a_3 = coefficient of CT_{PC}
a_4 = coefficient of DD_{DA}
a_5 = coefficient of DD_{WB}

a_6 = coefficient of DF_{DA}
a_7 = coefficient of DF_{WB}
a_8 = coefficient of ST_{DA}
a_9 = coefficient of ST_{WB}
a_{10} = coefficient of BQ
a_{11} = coefficient of CT_{OC}
k = constant in the (Eq. (1)).

$$T_b = k + a_1CT_{DA} + a_2CT_{WB} + a_3CT_{PC} + a_4DD_{DA} + a_5DD_{WB} + a_6DF_{DA} + a_7DF_{WB} + a_8ST_{DA} + a_9ST_{WB} + a_{10}BQ + a_{11}CT_{oc} \quad (1)$$

$$d_b = T_b - T_{b-1} \quad (2)$$

4. **Establishment of Proposed Model and Its Validation**

Table 1 summarizes the method to analyze raw data into 2 level factors for 9 input variables and into 3 level factors for 1 input variable.

TABLE 1. Method analysis for 9 input variables using real time data

Input variables	Data	Distribution
CT_{DA}, CT_{WB}, CT_{PC}	95% confident internal (lower, upper)	Normal distribution
DD_{DA}, DD_{WB}, DF_{DA}, DF_{WB}	95% confident internal (lower, upper)	Exponential distribution, MTBF = mean time between failure
ST_{DA}, ST_{WB}	95% confident internal (lower, upper)	Exponential distribution

Table 2 represents the raw data from a real-time system for input variables to a simulation model. The simulation model from Pro-Model is validated with real-time data of output variable. Table 3 shows the model validation for Die Attach process.

TABLE 2. Input variable data for simulation model

Input variable	Data		
	Low	Middle	High
CT_{DA} (s)	2.8072	-	2.9460
CT_{WB} (s)	6.0902	-	6.0902
CT_{PC} (s)	0.9882	-	1.0498
DD_{DA} (s)	2141	-	4391
DD_{WB} (s)	1364	-	2797
DF_{DA} (min)	1066	-	2187
DF_{WB} (min)	1421	-	2193
ST_{DA} (s)	2957	-	6063
ST_{WB} (s)	1324	-	2714
BQ (unit)	2200	3080	11264
CT_{OC} (s)	7200 (fixed)		

Note: s = seconds; min = minutes

Table 3 illustrates the validation high and low setting data of Die Attach process from Table 2 using statistical t-test analysis in JMP software environment between simulation model and real time data on output variable. In this paper validation, $\alpha = 0.05$. The p-value

in high setting is 0.0961. Since p value was larger than α, it accepts null hypothesis indicating no significant between the model and real-time data. The p-value in low setting is 0.3490. Since p-value is larger than α, the null hypothesis is accepted and the model has no significant different with real-time system.

TABLE 3. Validation low and high setting data of Die Attach process from Table 2 using statistical t-test analysis in JMP software environment between simulation model and real time data on output variable

	Low	High		Low	High
Difference	-1441.5	2404.0	t ratio	-0.94408	1.69163
Std Err Dif	1526.9	1421.1	DF	57.99863	57.98362
Upper CL Dif	1614.9	5248.7	Prob > |t|	0.3490	0.0961
Lower CL Dif	-4498.0	-440.7	Prob > t	0.8255	0.0480
Confidence	0.95	0.95	Prob < t	0.1745	0.9520

Note: Assuming unequal variances

After validation process was completed, a total of 1536 runs with 1 replication were set using full factorial design (2^9x3^1=1536 when x_{11} is fixed input variable and x_{10} is 3 level factors). For each run, a 30 sample of completion time are collected to determine the flow time (d_b) and average completion time (T_b). Table 4 indicates the design of experiment table for data collection during simulation run using model from Pro-Model software.

TABLE 4. Data collection using simulation model in design of experiment table format

Run	CT_{DA}	CT_{WB}	CT_{PC}	DD_{DA}	DD_{WB}	DF_{DA}	DF_{WB}	ST_{DA}	ST_{WB}	BQ	CT_{OC}	T_b
1	2.9460	6.0902	1.0498	4391	2797	1066	1421	6063	1324	3080	7200	38267
1536	2.8072	6.4609	0.9882	2141	2797	1066	2193	2957	2714	3080	7200	38792

The collected data for Table 4 were analyzed in JMP environment to determine the value of constant and coefficient of each input variables in the regression analysis model. Two interaction input variables were omitted because the result of two interactions had no significant different with one interaction result. The result from JMP is shown below:

The equation T_b in (Eq. (2)) is stated as per below:

$$T_b = k + a_1CT_{DA} + a_2CT_{WB} + a_3CT_{PC} + a_4DD_{DA} + a_5DD_{WB} + a_6DF_{DA} + a_7DF_{WB} + a_8ST_{DA} + a_9ST_{WB} + a_{10}BQ + a_{11}CT_{oc}$$

$$= 7187.5725 + 387.1239\frac{[CTDA-2.8766]}{0.0694} + 1008.0011\frac{[CTWB-6.2756]}{0.1854} + 157.9690\frac{[CTPC-1.019]}{0.0308} + 9.5167\frac{[DDDA-3266]}{1125} + 3.9325\frac{[DDWB-2080.5]}{716.5} + 2.4477\frac{[DFDA-1626.5]}{560.5} - 0.1807\frac{[DFWB-1807]}{386} - 2.6148\frac{[STDA-4510]}{1553} + 24.3713\frac{[STWB-2019]}{695} + 10.1729BQ \quad (3)$$

Note: When a_{11} is zero as CT_{OC} is fixed value (1 level factor)

$$d_b = t_b - t_{b-1} = 0 \quad (4)$$

Based on the regression mode in Figure 3, the r^2 value was 0.9995. Since 0.9995 value was near to 100%, it was noted that the model explained all the variability of the response data around its mean and fitted the study's data.

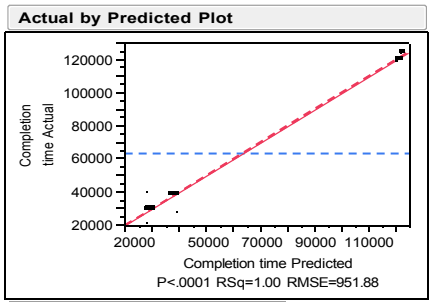


FIGURE 3. r^2 value on the graph between completion time predicted and simulation data result

5.Proposed Model Testing and Its Discussion

Table 5 indicates the comparison of 9 sample results between prediction mathematical and the real-time data on completion time response variable. The 9 samples data are consists of 3 batches which each batch contains 3 samples data. T_{b3} shows result data from prediction mathematical model using Eq. (3). T_{b4} shows the result data from the real time system on completion time. These real-time data of 9 samples were collected within the period along with the real-time data collection of the input variables for the simulation model. The relative error was in the range 11.62%–22.01%, with an average value of 18.85%.

TABLE 5. Relative error analysis between T_{b3} and T_{b4}

T_{b3}	T_{b4}	Relative error	% error
31371	25380	5991	19.10
33396	28380	5016	15.02
29299	33960	4661	15.91
30086	25260	4826	16.04
27295	22440	4855	17.79
30416	26880	3536	11.62
84660	68040	16620	19.63
83090	64800	18290	22.01
88197	69480	18717	21.22
Average % error			18.85

The error between the mathematical model and sampling real-time data in the study was in the range 10%–25%, which was satisfactorily acceptable in a previous study [6] this previous study cited the work of (S.C. Eickemeyer et.al, 2013).

According to [7], such validation is important to show the capability of the model to predict the behavior of the study. In contrast to the work of [6], Gottlich et. al [7] In contrast to the work of. Thus, the present paper's proposed mathematical model is tested with real-time data for the validation, citing [6] as reference. Based on the results, we concluded that the model had satisfactory quality estimate and was acceptable for performing prediction in the study with an error percentage in the range 10%–25%.

The Eq. (3) indicates the flow time of a manufacturing system. Simulation activity results showed that the d_b value is zero in the long run because t_b and t_{b-1} were nearly constant. This pattern of the simulation result was probably due to the configuration setting of the process in this study. The regression analysis approach was found in the literature, and this paper used additional variables, such as setup and machine downtime with

validation process using different manufacturing environments. The extension work using this approach includes the development of a methodology that uses simulation, design of experiment concept, and statistical tool analysis to derive a mathematical model. This approach is an alternative feasible way of finding a mathematical model in the setting of a configuration process. Although the approach is not new, the methodology is not commonly applied to manufacturing practice. The novelty of this paper is to signify the approach that uses multiple regression analysis to develop a mathematical model to represent a dynamic manufacturing environment. Our work contributes towards introduction of a feasible methodology to formulate a mathematical equation in dynamic manufacturing environment. Our results will benefit the future model work by other researchers, and we list advantages in the following statements. The first advantage is to enable the model to perform prediction in a real-time system with an acceptable error margin. The second advantage is the development of a feasible approach to build a model using multiple regression analysis technique without affecting configuration.

6.**Conclusions and Future Work**

In this paper, an approach that involved the use of multiple regression analysis was proposed for the mathematical development in a dynamic manufacturing system. The main goal of this mathematical model was to introduce a method for model development to narrow the gap between theory and practice in a dynamic manufacturing environment.

The effectiveness of the proposed mathematical model was evaluated using real-time data. The result between proposed mathematical model and real-time data showed positive effects when considering data from previous literature. Results showed that the model is satisfactory and acceptable and can be used to make predictions.

Future studies need to focus on improving the error percentage between the mathematical model and real-time data and on enhancing the methodology for mathematical development in this field. Our results can be used to continuously enhance the proposed model and to apply the model to real-time dynamic manufacturing systems in the future.

Acknowledgement. The authors wish to thank MyBrain15 program from Ministry of Education in Malaysia and Universiti Tunku Abdul Rahman (UTAR) under UTARRF 6200/J09 who provided financial support for this research. The authors also gratefully acknowledge the helpful comments and suggestions of the reviewers, who helped improve our presentation.

REFERENCES

[1] Al-Zuheri, a., Luong, L., & Xing, K. (2012). The role of randomness of a manual assembly line withwalking workers on model validation. *Procedia CIRP*, *3*, 233–238. doi:10.1016/j.procir.2012.07.041

[2] Baudin, Michel Mehrotra, V., Tullis, B. Yeaman, D. Hughes, R.A. (1992). From spreadsheet to simulations: a comparison of analysis methods for IC manufacturing performance. Semiconductor Manufacturing Science Symposium, IEEE / SEMI International

[3] Cao, Z., Deng, J., Liu, M., & Wang, Y. (2012). Bottleneck prediction method based on improved adaptive network-based fuzzy inference system (ANFIS) in semiconductor manufacturing system. *Chinese Journal of Chemical Engineering*, *20*(6), 1081–1088. doi:10.1016/S1004-9541(12)60590-4

[4] Catay, ., reng , . S., & Vakharia, A. J. (2003). Tool capacity planning in semiconductor manufacturing. *Computers and Operations Research*, *30*, 1349–1366. doi:10.1016/S0305-0548(02)00075-8

[5] Chincholkar, M.M, Barroughs, T., Herrmann, J.W. (2004). Estimating manufacturing cycle time and throughput in flow shops with process drift and inspection. Institutes of System Research and Department of Mechanical Engineering, University of Maryland

[6] Eickemeyer, S. C., Steinkamp, S., Schuster, B., Bodenhage, F., & Nyhuis, P. (2014). Reliable Capacity Planning Despite Uncertain Disassembly, Regeneration and Reassembly Workloads by Using Statistical and Mathematical Approaches – Validation in Subsidiaries of a Global MRO Company with Operations in Asia, Europe and North America. *Procedia CIRP*, Volume *23*,pages 252–257. doi:10.1016/j.procir.2014.10.097

[7] Göttlich, S., Hoher, S., Schindler, P., Schleper, V., & Verl, A. (2014). Modeling, simulation and validation of material flow on conveyor belts. *Applied Mathematical Modelling*, *38*, 3295–3313. doi:10.1016/j.apm.2013.11.039

[8] Jacomino, M. E. M. F. M. P. V. G. L. (2014). A Step Toward Capacity Planning at Finite Capacity in Semiconductor Manufacturing, 2239–2250.

[9] Jennifer Robinson, John Fowler, Eileen Neacy. (2003). Capacity loss factors in semiconductor manufactuiring. Available from: www.fabtime.com/files/CapPlan.pdf [Accessed 28 December 2013]

[10] J. Faraway. (1997). Regression analysis for functional response. Technometrics, 254-261. Available: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.27.5397&rep=rep1&type=pdf [Accessed 29 December 2014]

[11] Li, W. (2007). Manufacturing process diagnosis using functional regression. *Journal of Materials Processing Technology*, *186*(April 2004), 323–330. doi:10.1016/j.jmatprotec.2006.12.052

[12] Martens, J., Put, F., & Kerre, E. (2006). A fuzzy set theoretic approach to validate simulation models. *ACM Transactions on Modeling and Computer Simulation*, *16*(4), 375–398. doi:10.1145/1176249.1176253

[13] Muhammad Marsudi, Dzuraidah Abdula Wahab, Che Hassan Che Haron. (2009). Application of spreadsheet and queueing network model to capacity optimization in product development. World Academy of Science, Engineering and Technology. Available from: http://waset.org/publications/8394/application-of-spreadsheet-and-queuing-network-model-to-capacity-optimization-in-product-development [Accessed 18 December 2013]

[14] Mula, J., Poler, R., García-Sabater, G. S., & Lario, F. C. (2006). Models for production planning under uncertainty: A review. *International Journal of Production Economics*, *103*(1), 271–285. doi:10.1016/j.ijpe.2005.09.001

[15] Sargent, R. G. (2011). Verification and validation of simulation models. *Proceedings of the 2011 Winter Simulation Conference S. Jain, R.R. Creasey, J. Himmelspach, K.P. White, and M.*, 183–198.

[16] Susan Coles, Jennifer Rowley. (1996). Spreadsheet modeling for management decision making. IndustrialManagement and Data System, Emerald

[17] Zhang, J., Qin, W., Wu, L. H., & Zhai, W. B. (2014). Fuzzy neural network-based rescheduling decision mechanism for semiconductor manufacturing. *Computers in Industry*, *65*, 1115–1125. doi:10.1016/j.compind.2014.06.002