International Journal of Business, Human and Social Sciences
ISSN: 2517-9411
Vol:12, No:11, 2018

Influence Analysis of Macroeconomic Parameters on Real Estate Price Variation in Taipei, Taiwan

Li Li, Kai-Hsuan Chu

***Abstract*—**It is well known that the real estate price depends on a lot of factors. Each house current value is dependent on the location, room number, transportation, living convenience, year and surrounding environments. Although, there are different experienced models for housing agent to estimate the price, it is a case by case study without overall dynamic variation investigation. However, many economic parameters may more or less influence the real estate price variation. Here, the influences of most macroeconomic parameters on real estate price are investigated individually based on least-square scheme and grey correlation strategy. Then those parameters are classified into leading indices, simultaneous indices and laggard indices. In addition, the leading time period is evaluated based on least square method. The important leading and simultaneous indices can be used to establish an artificial intelligent neural network model for real estate price variation prediction. The real estate price variation of Taipei, Taiwan during 2005 ~ 2017 are chosen for this research data analysis and validation. The results show that the proposed method has reasonable prediction function for real estate business reference.

***Keywords*—**Real estate price, least-square, grey correlation, macroeconomics.

I. Introduction

THE real estates are not only the place to live in, but they maybe also the most important part of assets of individual owner. The real estates are also the most interesting investment target of Chinese people. In capital cities of industrialized countries, real estates are the greatest component of citizen private fortune. Hence, the real estates is not only the living requirement, it also represents the personal wealth and glory. In addition, the real estate price fluctuation may also impact the households' investment and consumption situation [1]. It is also an important impact factor for investing company, real estate developer, banker and policy makers. Hence, it was concerned as an important economic index. Since the house supply is limited to urban planning and land cannot be moved or created, the real estate price in highly populated area has long-term increasing tendency. However, their prices still have certain fluctuations due to macroeconomic index variations. The real estate bubble growing and bursting may cause national social and banking system serious problem. The 2008 United States sub-prime mortgage crisis and 1990s Taiwan's real estate bubble bursting are two typical examples. In addition, the real estate price change may influence the socioeconomic conditions and further impact the national economic index. Hence, the rich investor and government official have to pay attention to this phenomenon. However, the investor and market adventurer have high interesting and expectation to earn the capital gains from real estate investment. Then, the housing market and housing price will have volatility problem due to this obviously unreal housing demand variation.

The real estate market and price may be influenced by macro-economic indices, spatial, community and environmental differences [2]. Some of those variables depend on the location and construction of each house except macro-economic conditions [3]. Generally, they are used to assess the real estate current price by using hedonic regression model [4] or neural network model [5]. However, those studies focused on the current real estate valuation. Hedonic method is usually used to analyze the location value of a property by using multiple regression techniques on large data sets and require a microeconomic theory as formality basis. As long as the provided data are enough, neural network method has the advantages of learning ability and less pre-assumption. However, the prediction problem of housing price short term variation was not clearly investigated till now.

Since the real estate investment is a large funding for individual or company, the price change tendency prediction is an important factor for investor or household to make decision for buying/selling the real estates at right time for making better profit or saving investment budget. Therefore, how to catch the real estate changing tendency and predict the trend precisely is an important research topic for related foundation or government. It is also an important economic factor for world financial circumstances. For example, the United States real estate price crush in 2008 caused large global economic problems and crisis. It is called a financial tsunami and caused a lot of company and household bankruptcy. Hence the real estate price variation trend is an important factor for financial manager. However, the influence factors are too many to analyze and their effects are too complicated to understand or predict. Hence, the real estate price variation prediction is still an interesting research topic.

Muller [6] explained that the demand and supply are two important factors of real estate market. In addition, the real estate boom cycle is dependent on related macro-economic indices. Garch scheme was proposed to estimate the investment risk or product price [7]. Cointegration and error correction models were proposed to investigate the long/short term relationship between real estate prosperity and macro-economic indices [8]. They found that the money supply, residential use rate and building permit area have long term

Li Li is with the Nankai University, Department of Financial Management, Business School, Nakai District, Tianjin, P.R. China 300071 (phone: +86 022-23503929 e-mail: lilee58@126.com).

Kai-Hsuan Chu is with the Nankai University, Department of Financial Management, Business School, Nakai District, Tianjin, P.R. China 300071 (phone: +886 918-218296 ; e-mail: artist.chu@ best-rich.com).

influence on the pre-sale house price.

Since the macroeconomic variables may be the leading indices, simultaneous indices and laggard indices of real estate price variation, each variable role and leading time period should be evaluated first. Here, a variation analysis algorithm was proposed to find the time delay and correlation intensity of each macro-economic variable with respect to the real estate price fluctuation based on least square and grey prediction correlation schemes. Then, the important leading and simultaneous indices are chosen to predict the real estate price variation situation. Since, the correlation function between macro-economic parameters and the real estate price variation are too complicated to model based on classical mathematical theorem, the artificial intelligent neural network are employed to estimate the price variation individually in this study.

II. Influence Analysis of Macroeconomic Indices on Real Estate Price Variation

The real estate price variation may be influenced by more than 15 macroeconomic variables. In previous research [9], GDP, GNP, M2, CPI, exchange rate, currency interest rate, stock market index, economic grow rate and signal, permit of building construct area, real estate composition index, house price/income ratio, mortgage rate, residential use rate and governmental policy changing factors are usually cited indices for price variation investigation. However, the importance analysis of each variables were not well investigated till now. Before establishing the real estate price prediction model, each index influence level and timing phase correlation should be evaluated first. Based on time history analysis of those variables' variation curves, some of them are leading the house price fluctuation, some of them are occurred in the meanwhile, and others are laggard. Only leading and simultaneous indices are meaningful to the price variation prediction. Here, least square scheme and grey correlation analysis are employed to investigate each index importance and timing phase relationship.

A. Least Square Correlation Analysis

Since, each index has different scale; it is difficult to compare the correlation level based on their original economic values. Hence, the normalize variation rate of each index is adopted for the importance and timing phase analysis. The Cathay House Price Index or the Sinyi Home Price Index season variation rates are selected as the denominator and each macro-economic variable index season changing rate is chosen as the numerator to obtain each index relative changing ratio. Then, the root mean square error scheme is employed to calculate each variable correlation index and depict each index correlation level. The root mean square error correlation analysis formula can be described as:

$$L_i = \sqrt{\frac{\sum_{j=1} (P_j - T_{ij})^2}{n}} \tag{1}$$

where L_i is the ith parameter index correlation coefficient, P_j is the jth season index value and T_{ij} is the jth season index of ith house price index. The magnitude of this correlation coefficient value represents the matching level of that parameter variation with respect to the house price index fluctuation. If the correlation coefficient is smaller, the parameter variation tendency is closer to the house price index fluctuation. That means their correlation level is higher.

The timing sequence analysis of each index can be employed to find the seasons lead or lag for each index based on iterative season data shifting calculation. The smallest correlation coefficient and the shifting seasons are obtained from this data set analysis. Then, the macro economic variables can be classified into leading indices, simultaneous indices and laggard indices accompanying with their timing lead/lag period.

B. Grey Correlation Level Analysis

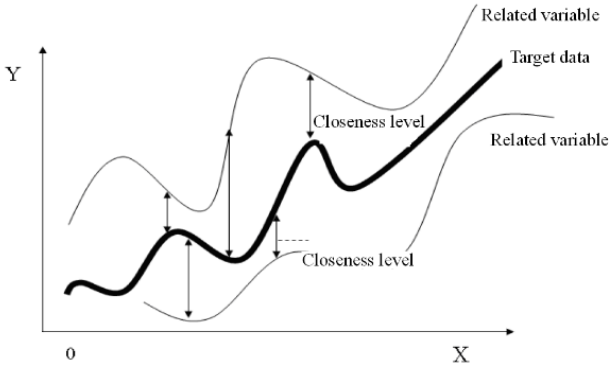


Fig. 1 The grey correlation level description

Grey correlation level analysis can be used to quantitatively analyze the relative variation situation of each parameter with respect to the system dynamic changing process. It also can be explained with the geometric plot of time sequential data as Fig. 1. If the inspection index curve is more close to the target curve, their variation tendency is more matched. That means their correlation level is stronger. The grey correlation level is an index for representing the dependence of two time sequential data. Its operation process and calculation formula are briefly described as:

$$\gamma(x_0(k), x_i(k)) = \frac{\Delta_{\min} + \zeta\Delta_{\max}}{\Delta_{oi}(k) + \zeta\Delta_{\max}} \tag{2}$$

where $x_0(k)$ is the target data sequence and $x_i(k)$ is the testing data sequence. $\zeta \in (0,1]$ is a recognizing coefficient, and

$$\Delta_{\min} = \min_{\forall i} \min_{\forall k} \Delta_{0i}(k) = \min_{\forall i} \min_{\forall k} \left| \chi_0(k) - \chi_i(k) \right|,$$

$$\Delta_{\max} = \max_{\forall i} \max_{\forall k} \Delta_{0i}(k) = \max_{\forall i} \max_{\forall k} \left| \chi_0(k) - \chi_i(k) \right|$$

Then the grey correlation level of these two sequence data can be calculated based on:

$$\gamma(x_0, x_i) = \sum_{k=1}^{n} \beta_k \gamma(x_0(k), x_i(k)) \quad (3)$$

where β_k is a weighting coefficient and $\sum_{k=1}^{n} \beta_k = 1$. User can assign the weighting value for each parameter depending on its importance. If the specific difference is not known, we can assign equal weighting coefficient to each parameter. Based on the grey correlation level of each macroeconomic parameter index, the importance ranking of those macroeconomic indices can be listed for finding the main influence indices for future analysis or house price prediction model investigation.

III. RBF Neural Network Model for House Price Variation Prediction

Since, the relationship between real estate price variation and macroeconomics parameters is very complicated, it is impossible to develop an explicit mathematical model for describing it. Neural network has the advantages of using a black box to represent the mapping between an objective function and multi-variables. Hence, it is useful to establish an artificial intelligence model for this house price variation system research. Here, a radial basis function neural network (RBFNN) is employed to model the relationship between macro-economic parameters and variation of the Cathay House Price Index or the Sinyi Home Price Index. RBFNN has the feature of using one hidden layer only and the semi-affine nonlinear functions are employed as the activation function in hidden layer instead of sigmoid functions. Gaussian functions are used as the activation functions of each neuron in the Hidden layer of this economic system model. The excitation value of these Gaussian functions is the distance between the input value of sliding variable $s(t)$ and the central position of a Gaussian function.

$$\theta_j = (s - c_j)^2 = \|s - c_j\| \quad (4)$$

where c_j is the central position of neuron j. The weightings, w_j, between input layer neurons and hidden layer neurons are specified as constant 1.0. The weightings, w_k, between hidden layer neurons and output layer neurons are adjusted based on an adaptive rule. The output of a RBFNN is

$$g(s) = \sum_{j=1}^{n} w_j \phi_j(\|s - c_j\|) \quad (5)$$

where $\phi_j(s) = \exp(-\frac{\|s - c_j\|^2}{\sigma_j^2})$ is a Gaussian function, and j^{th} is the j neuron of the output layer. σ_j and c_j are the spread factor and central position of the Guassian function, respectively. N is the number of neurons and s is the input value of the RBFNN. Then, a RBFNN based real estate price variation model is proposed by combining a learning rule for adjusting the weighting factors and the linear combination of Gaussian function. The structure of a RBFNN is shown in Fig. 2. In addition, the Gaussian functions parameters σ_j and c_j can be specified as constants for general-purpose applications.

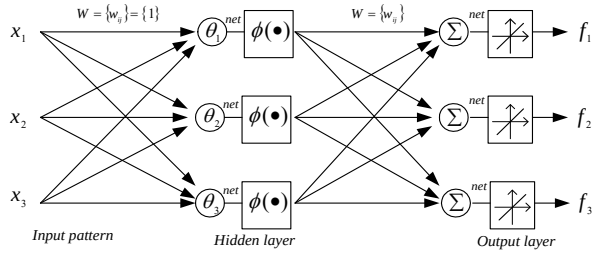


Fig. 2 Radial Basis function neural network diagram

IV. Data Analysis and Influence Comparison of Each Macro-Economic Parameter

Based on previous real estate price evaluation researches [8], [9], many macro-economic indices may influence the property price variation. Those parameters can be classified into three categories: leading indices, simultaneous indices and laggard indices as shown in Table I. Similar research results also can be found from Taiwan Ministry of Interior official publication: Real Estates Cycle Indicators [10]. However, they had not provided the theoretical basis support. Here, the least square and grey correlation analysis schemes are proposed to investigate these macro-economic indices relevance level and the leading or laggard timing length by season. The analysis results will be compared with that of previous information.

TABLE I
Influence of Macro-Economic Parameters

Real estate Climate indices	Investing	Manufacturing	Trading	Using
Leading indices	Gross Domestic Product Money supply Construction stock indices	Movement of Loans for Construction	Consumer Price Index	
Simultaneous indices	Volume index of prime land Benchmarking lending rate	Building permit of residence	New case standard unit price New house purchasing loans	Residential use rate
Lagging indices		Permit for resident occupancy Construction industry average salary	Registration of translation of building Land value increment tax	House rent price index Household annual growth rate

A. The Influence of Macro-Economic Parameters

In this study, the Cathay House Price Index and the Sinyi Home Price Index season variation rate are selected as the matched target. They are most representative house price indices information in Taiwan for pre-sale house and available

house, respectively. Gross domestic product, money supply M2, gross net income (GNI), economic grow rate, prosperity signal, house price tendency index, house price/GNI ratio, building permit of residence, consumer price index, benchmarking lending rate, new house-purchasing loans are selected as the effective influence parameters. In the beginning, all season data of these macro-economic variables are searched from all official public publication source or real estate companies between 2005 2nd quarter and 2017 4th quarter. The variation tendencies of each macro-economic index with respect to the Cathay House Price Index or the Sinyi Home Price Index are plotted in Figs. 3-5. Since, each variable has different scale value, the season change rates are calculated for further analysis. In addition, the normalize variation rate of each index is adopted for the correlation level and relative timing phase analysis. The Cathay House Price Index or the Sinyi Home Price Index season variation rate is selected as the denominator and each macro-economic variable index season changing rate is concerned as the numerator to obtain each index relative changing ratio. Then, the root mean square error scheme is employed to calculate each variable correlation index. The computation results of those macro-economic variables are listed in Table II. Then, the correlation level of each macro-economic index with the real estate target index can be obtained.

If the macro-economic index season variation was forced to make time shifting by season and calculate the summation of their season square error between real estate price index and the macro-economic parameters changing rate, the number of seasons timing lead/lag of each parameter can be found based on the statistics of summation of square error corresponding to each season shifting. The iterative searching results are listed in Table III. It can be observed that customer price index is the only laggard variable for Cathay House Price Index. Prosperity signal, house price tendency index, house price/GNI ratio, money supply M2, and benchmarking lending rate are laggard indices for Sinyi Home Price Index.

TABLE II
CORRELATION LEVEL OF EACH MACRO-ECONOMIC PARAMETER

	Macro-economic parameters	Cathay House price index		Sinyi house price index	
No		square error	ranking	square error	ranking
1	Prosperity signal	0.205	11	0.205	11
2	GDP	0.042	2	0.040	3
3	GNI	0.040	1	0.040	1
4	M2	0.029	3	0.025	2
5	Building permit	0.144	10	0.146	9
6	Economic grow rate	0.050	8	0.044	7
7	CPI	0.030	6	0.030	6
8	House price trend index	0.217	9	0.214	10
9	Average lending rate	0.060	7	0.057	8
10	House price/GNI ratio	0.041	4	0.037	4
11	Mortgage loading ratio	0.044	5	0.041	5

Fig. 3 The variation tendency of macro-economic parameters with respect to the Cathay and Sinyi house price indices

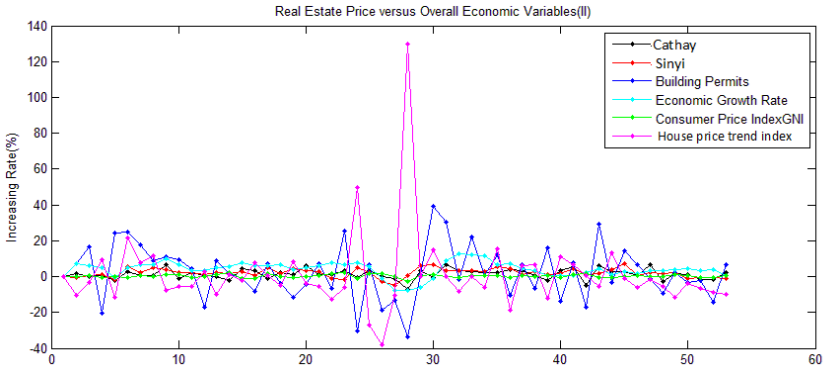


Fig. 4 The variation tendency of macro-economic parameters with respect to the Cathay and Sinyi house price indices

Fig. 5 The variation tendency of macro-economic parameters with respect to the Cathay and Sinyi house price indices

TABLE III
THE MACRO-ECONOMIC PARAMETERS TIMING SERIAL RELATION

Macro-economic parameters	Season shifting (Cathay / Sinyi)
Prosperity signal	No / no
GDP	No / 1 season lag
GNI	1 season lead / 1 season lag
M2	5 seasons lead / 1 season lead
Building permit of residence	No / 1 season lag
Economic grow rate	No / 2 seasons lag
CPI	5 seasons lag / 1 season lag
House price trend index	3 seasons lead / 1 season lead
Average lending rate	No / 5 seasons lag
House price/GNI ratio	9 seasons lead / 8 seasons lead
Mortgage loading ratio	9 seasons lead / 8 seasons lead

TABLE IV
THE GREY CORRELATION LEVEL AND RANKING OF MACRO-ECONOMIC PARAMETERS

No.	Macro-economic parameters	Cathay House price index		Sinyi house price index	
		Square error	ranking	Square error	ranking
1	Prosperity signal	0.688	10	0.680	10
2	GDP	0.943	5	0.921	4
3	GNI	0.945	3	0.923	3
4	M2	0.942	1	0.921	1
5	Building permit	0.772	9	0.776	9
6	Economic grow rate	0.837	7	0.841	7
7	CPI	0.920	2	0.880	2
8	House price trend index	0.792	11	0.775	11
9	Average lending rate	0.845	8	0.801	8
10	House price/GNI ratio	0.931	4	0.915	5
11	Mortgage loading ratio	0.927	6	0.890	6

B. Grey Correlation Level Analysis

Grey correlation level analysis can be used to quantitatively analyze the relative variation situation of each parameter with respect to the system dynamic changing process. If the inspection index curve is more close to the target curve, their variation tendency is more matched. That means their correlation level is stronger. The grey correlation level is an index for representing the dependence of two time sequential data. The grey correlation curve of each macro-economic index with respect to the Cathay House Price Index and the Sinyi Home Price Index can be plotted based on the AGO operation of their original data. Then, each macro-economic index grey correlation level can be calculated based on (2) and (3). Their correlation levels and ranking are listed in Table IV. It can be observed that the correlation level analysis results based on least square error and grey relevance schemes have certain consistence from Tables II and IV. The high relation level macro-economic indices are GDP, GNI, M2, CPI, house price/ GNI ratio, and house mortgage burden. They are high relevance indices and chosen as the parameters for establishing RBF neural network house price variation prediction model.

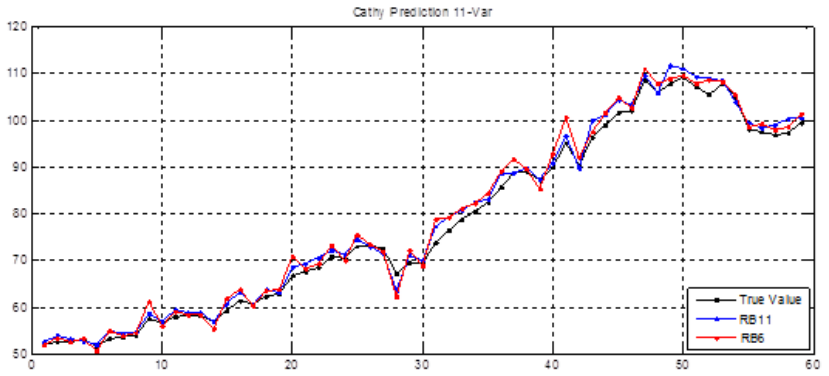
C. RBF Neural Network Model Prediction Analysis

The first 40 seasons' macroeconomic indices are used to train the RBF neural network and obtained a RBFNN model with appropriate weighting gains for the house price variation estimation. Then, this trained RBFNN was employed to predict the house price variation based on season changing. In order to evaluate the accuracy, the prediction results based on RBFNN were compared with two most familiar house indices, Cathay House Price Index and the Sinyi Home Price Index, for pre-sale house and available house sale mart, respectively. The numerical simulation results of RBFNN model with 11 and high relation 6 macroeconomic input parameters for predicting Cathay house index and Sinyi house index are plotted in Figs. 6 (a) and (b), respectively. It can be observed that the estimation results are matched with that of Cathy house price very well. The prediction errors of RBF11 and RBF6 are less than 4% and 5.5%, respectively. The computed normalized real estate prices' overall variation based on RBFNN11 and RBFNN6 are plotted in Fig. 6 (b) for comparing with that of Sinyi house price. It can be observed that the estimation results are matched with that of Sinyi house price very well. The prediction errors of RBF11 and RBF6 are less than 3.6% and 4.6%, respectively.

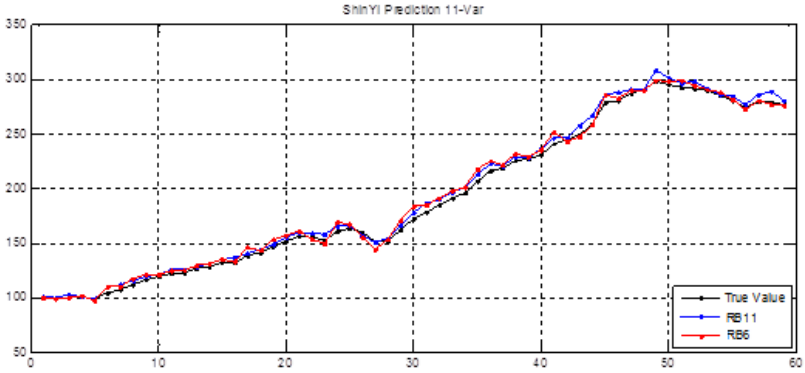
V. DISCUSSION

Based on two correlation level analysis results, we can find that GDP, GNI, M2, CPI, house price/GNI ratio, and house mortgage burden are six important macro-economic variables in predicting the real estate price of Taipei, Taiwan. This result is very close to other literature reports [8], [9] with a little difference. However, two numerical schemes are proposed in this research to evaluate the influence ranking and find the leading time (by season) of each macro-economic parameter

with respect to house price fluctuation.



(a)



(b)

Fig. 6 The numerical simulation results of RBFNN model with 11 and high relation 6 macroeconomic input parameters for (a) predicting Cathay house index (b) predicting Sinyi house index

Gross domestic product and GNI are two important indices used to represent official economic development by many countries. They are the indices of people affording to pay the housing price and their announcing have certain time delay. Hence, they are the coincident indices. Money supply M2 index is an important currency control policy of Central Bank. It is also a critical index of capital sufficiency in housing market that will introduce plentiful investing capital for real estates. The housing price will be pushed up by this leading variable That will introduce plentiful investing capital for real estates. Customer price index is used to estimate the weighted prices of a basket of consumer goods and services. The index response is lag of M2 and market finance. It is a lag index for housing price variation. House price/GNI ratio and house mortgage burden can represent the capability of people affording the current housing price. They are leading variables. Actually, there have other variables cannot be systematized in this analysis. For example, government changes the house tax or owner policy suddenly, or the globally economic situation has severe variation. They may cause a quick conversion and the impact level is difficult to evaluate. It is still a problem need to study and model. However, the proposed RBF neural network model can be used to approximately forecast the real estate price fluctuation based on the variation data of selected macro-economic indices.

VI. Conclusion

The correlation level between real estate price variation and the macro-economic parameters indices can be evaluated based on least square and grey correlation analysis schemes. The relevance level and the timing lead or lag behaviors had been explored based on objective real market data analysis. The highly relevance parameters are selected to establish an artificial intelligent neural network model for real estate price fluctuation prediction. The Cathay House Price Index and the Sinyi Home Price Index of Taipei Taiwan were selected for this investigation and data analysis. The empirical results show that the RBFNN prediction model has good estimation results and the prediction error was less than 5%. The housing price valuation is an important process during real estate trading for agents, appraisers, assessors, mortgage lenders, property developer and investors. It is useful in real estate business for house sailing price setting and management.

ACKNOWLEDGMENT

Authors would like to thank the grant support for this research by NSFC # 71672087 and # 71802111.

REFERENCES

[1] Case B., Clapp J., Dubin R. and Rodriguez M., "Modeling spatial and temporal house price patterns: A comparison of four models," Journal of Real Estates Finance and Economic, Vol. 29 no. 2, pp. 167-191, 2004.
[2] Kim K. and Park J., "Segmentation of the housing market and its determinants: Seoul and its neighboring new towns in Korea, Australian Geographer, Vol. 36 no. 2, pp. 221-232, 2005.
[3] Robin Dubin, "Predicting House Prices Using Multiple Listing Data," The Journal of Real Estate Finance and Economic, Vol. 17, no. 1, pp. 39-59, 1998.
[4] Hasan Selim, "Determinants of house prices in Turkey: Hedonic regression versus artificial neural network," Expert Systems with Applications, Vol. 36, pp. 2843-2852, 2009.
[5] Jian-Guo Liu, Xiao-Li Zhang and Wei-Ping Wu, "Application of Fuzzy neural network for Real Estate Prediction,' Advances in Neural Networks, Volume 3973 of the series Lecture Notes in Computer Science, pp. 1187-1191, 2006.
[6] Glenn R. Mueller,"Real Estate Rental Growth Rates at Different Points in the Physical Market Cycle", Journal of Real Estate Research, Vol. 18, no. 1, pp. 131-150, 1999.
[7] Reinaldo C. Garcia, Javier Contreras, Marco van Akkeren, and João Batista C. Garcia, "A GARCH Forecasting Model to Predict Day-Ahead Electricity Prices," IEEE Transactions on Power Systems, Vol. 20, no. 2, pp. 867-874, 2005.
[8] Chen-Wei Pen and Kim-W o Chang, "The influence study of Macro-economic on Real Estate Climate," NSC Research Journal, Literature and Social Science, Vol. 10, no. 3, pp. 330-343, (in Chinese), 2000.

Li Li got her financial management Ph. D. degree from Nankai University business school in 2006. Currently, she is a professor of financial management department, Nankai University. Here research interesting are company financial management, logistics financial management and stock investment and mark analysis.

Kai-Hsuan Chu is a Ph.D. graduate student of Department of financial management, business school, Nankai University. His research interesting is company financial management and real estate marketing analysis.