The Pricing Dynamics in the Housing Market of China

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Abstract. This work constitutes, in part, our efforts in exploring more realistic and appropriate approaches for valuing mortgage backed securities as well as facilitating the financial management of market participants in China's housing market. Unlike structural analysis where usually only interest rate effect is considered in valuing properties and relevant securities, this paper focuses on the housing price dynamics in relation to the house price changes in time and several key contributing factors in China's real estate market. The data used for the study are the monthly housing price indexes from July 2005 to December 2010, collected and maintained by the National Bureau of Statistic of China. Several autoregressive models are proposed, analyzed, and compared to best identify these relations. The study shows that house price changes in current month are influenced by the house prices in previous months, with the optimal number of price lags inferable using regression procedures. Land price and consumer price index are also contributing factors for housing price changes. An autoregressive model in the form of fractional degree polynomial of contributing factors is shown to have best forecasting power. Numerical experiments and simulation are carried out to test the effectiveness and robustness of our model.

Keywords: Housing Price, Mortgage Security, Autoregressive Model, Parameter Estimation, Numerical Simulation

1. Introduction

Price dynamics of China's housing market has been studied by considerable literatures. However, there does not seem to have a unified and generalized model for explaining the market movement in sound accuracy as calibrated by both in sample and out of sample analysis, as desired by many scholars and industry practitioners. Given the validity of such a quest from various parties and the importance of a model to adjacent fields such as commercialization and valuation of mortgage securities, it is desirable to study the housing price mechanism from progressive dynamic perspective. This would contrast the usual literatures with structural analysis in nature such as Xie et al. (2009a, b) where only interest effect is considered in addressing house buyer's market strategies. A successful attempt in this respect may solve the financial queries from many property investors, and the applications of the method may stretch beyond pricing of commercial housing to a large spectrum of asset pricing and modeling problems. In the next section two, three main variables which may impact house prices are identified and discussed. Section three explains the data and methodology used for the study. Section four provides numerical examples and results of our models. Concluding remarks and comments are given in section five.

2. Factor Analysis

Under the hypothesis of efficient market, all the market information is reflected in the currently priced value. According to Zhang (2006), houses are often viewed as an investment product whose price changes are influenced by the expectation of future return, especially when this expectation has a property of 'self-actualization'. Investors whose financial decisions are influenced by such a mechanism tend to regard price increase as a positive signal of the real estate market that leads to a further price increase. Similar mechanism may also persuade new buyers to join the market. This shows that the housing prices in the recent past periods may positively impact the housing price trend until the influence of other factors may become prominent enough to divert such a trend. Empirical studies on basis of such premises can be found in Tu and Zhang (2005), for instance.

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For real estate industry, land cost is an important component of price. The supply side of the market is low in elasticity and the land price is mainly determined by the demand. In recent years, the large demand of land boosts the land prices, especially after an important notice, *Provision for the transferring state-owned land by bids, auction or listing*, was issued in 2003, where a more market oriented land allocation method was adopted. The provision enables land prices to be quoted and negotiated in a more competitive market.

Inflation constitutes another factor in house price dynamics. For example, Reilly et al. (1977) discusses the hedging ability of real estate on inflation using data from different countries. In Follain (1982), two opposing effects of inflation on housing demand were discussed. On one hand, inflation reduces the size of the mortgage loan a household can obtain, thus drags down the house demand. On the other hand, an increasing inflation rate diminishes the after-tax cost of house purchasing, which results in an upward move of housing demand.

3. Data and Methodology

The data used in this paper are collected and maintained by the National Bureau of Statistic of China. They are available at the Bureau's official website and the National Statistic Yearbook of China. However, only monthly indexes from July 2005 to December 2010 of each variable instead of the actual amount in RMB are available. This is mainly because the existing accounting regulations of real estate market in China do not require the disclosure of housing prices in further details. The first data set is the month to month average house price index of China during the period from July 2005 to December 2010. The second data set used is the month to month residential land price index of China. The third data set is the month to month consumer price index of houses in China. In our paper, we use housing consumer price index as a good proxy for inflation.

One of the simplest ways to model dependencies between consecutive observations is to apply the following autoregressive model, which can be found in, for instance, Stock and Watson (2006):

$$Y_t = \delta + \theta Y_{t-1} + \varepsilon_t \quad (1)$$

where Y_{t-1} is the dependent random variable in time period $t-1$, also referred as the first lagged value of Y_t or first lag of Y_t; and u_t is the random error which is independently and identically distributed with mean 0 and variance σ^2.

On basis of the above simplest autoregressive model, we would like to construct models more applicable to the current problem. In particular, we apply the following p^{th} order autoregressive equation, containing information of more distant past periods.

$$\Delta Ln(hp_t) = \beta_0 + \beta_1 \Delta Ln(hp_{t-1}) + \beta_2 \Delta Ln(hp_{t-2}) + \cdots + \beta_p \Delta Ln(hp_{t-p}) + \varepsilon_t$$

where

i) $\Delta Ln(hp_t) = Ln(hp_t) - Ln(hp_{t-1})$ is the difference of logarithm house price in period t and $t-1$.

ii) $\Delta Ln(hp_{t-j})$ is the j^{th}lagged value of logarithm house price, which means the value of j months ago

iii) ε_t is the random error, the definition of which is the same as that for the *Model (1).*

We use $\Delta Ln(hp_t)$ to define the proportional change of logarithm house price index, the appropriateness of which can be proved by simple calculus analysis. Similarly, we use $\Delta Ln(A_t)$ as the appropriate form of time series data set A_t, representing the proportional change of each variable, where A_t may represent land price index, residential land price index, or consumer price index, depending on the context.

4. Numerical Results and Data Analysis

On the basis of the methodology of autoregressive modeling, we characterize the relationship between proportional house price changes in period *t*, $\Delta Ln(hp_t)$, and the corresponding values for distant periods, $\Delta Ln(hp_{t-j})$, by the following model:

$$\Delta Ln(hp_t) = \beta_0 + \beta_1 \Delta Ln(hp_{t-1}) + \beta_2 \Delta Ln(hp_{t-2}) + \cdots + \beta_p \Delta Ln(hp_{t-p}) + \varepsilon_t \quad (2)$$

The table below gives the stationary test for the the time series data $\Delta Ln(hp_t)$.

Table 4.1 Stationary Test of $\Delta \mathrm{Ln}(\mathrm{hp_t})$

Null Hypothesis: DLNHP has a unit root Lag Length: 1 (Automatic based on SIC, MAXLAG=10)			
		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.844086	0.0579
Test critical values:	1% level	-3.538362	
	5% level	-2.908420	
	10% level	-2.591799	

*MacKinnon (1996) one-sided p-values.

We observe that the stationary test statistics $ADF = -2.844086$, which is smaller than the theoretically tabulated value -2.591799 at 10% significant level. Therefore, time series data $\Delta Ln(hp_t)$ is stationary at 10% level. It is improbable to find a perfect model to accommodate all the information, thus to select an optimal number of regressors becomes pivotally important.

Table 4.2 Regression Results on $\Delta \mathrm{Ln}(\mathrm{hp_t})$ and $\Delta \mathrm{Ln}(\mathrm{hp_{t-j}})$

Dependent Variable: $\Delta Ln(hp_t)$
Method: Least Squares

Variable	AR(1)	AR(2)	AR(3)	AR(4)
Constant	0.000883*	0.0011**	0.001*	0.001034*
	(0.000486)	(0.000489)	(0.000513)	(0.000533)
$\Delta Ln(hp_{t-1})$	0.842154***	1.068758***	1.103694***	1.127117***
	(0.068328)	(0.124467)	(0.129831)	(0.132017)
$\Delta Ln(hp_{t-2})$		−0.269206**	−0.415251**	−0.469356**
		(0.124288)	(0.186714)	(0.195547)
$\Delta Ln(hp_{t-3})$			0.135517	0.266392
			(0.129725)	(0.195829)
$\Delta Ln(hp_{t-4})$				-0.114717
				(0.131794)
R-squared	0.710155	0.730343	0.734859	0.74136
Adjusted R-squared	0.705480	0.721354	0.721145	0.722891
S.E. of regression	0.002651	0.002595	0.002608	0.002620
Sum squared resid	0.000436	0.000404	0.000394	0.000385
Durbin-Watson stat	1.544760	1.922672	1.940089	1.871604
Akaike info criterion	-8.996633	-9.023826	-8.998346	-8.972526
Schwarz criterion	-8.929167	-8.929977	-8.861112	-8.799503

Note: ***, ** and * indicate rejection of null hypothesis at 1%, 5%, and 10% significant level respectively.

Next we need to decide which forms of residential land price and consumer price index should be included in the model. The common procedure of estimating the relationship between two variables is to check if linear relationship exists. However, simulations using linear equations show that simply extending the data set or adding more lags does not yield satisfactory models. So nonlinear equations must be attempted. Table 4.3 presents the regression results derived from our trial and error process using power and fractional power functions. Overall, we obtain the following model:

$$\Delta Ln(hp_t) = 0.00042 + 0.992545 * \Delta Ln(hp_{t-1}) - 0.319813 * \Delta Ln(hp_{t-2}) + 0.007325 * \sqrt[3]{\Delta Ln(lp_t)} \quad (4)$$

Table 4.3 Regression results when adjusting the functions of variables

Variable			
Constant	0.001083**	0.000420	0.000636
	(0.000493)	(0.000586)	(0.000599)
DLNHP_1	1.074039***	0.992545	1.038881***
	(0.126073)	(0.127309)	(0.125731)
DLNHP_2	−0.286383**	−0.319813	−0.322640*
	(0.132597)	(0.123907)	(0.129934)
DLNLP^2	0.326393		
	(0.831260)		
DLNLP^(1/3)		0.007325*	
		(0.003663)	
DLNLP^(1/3)_1			0.004878
			(0.003683)
R-squared	0.731046	0.747457	0.738130
Adjusted R-squared	0.717370	0.734615	0.724815
S.E. of regression	0.002614	0.002533	0.002579
Sum squared resid	0.002614	0.000378	0.000392
Durbin-Watson stat	1.933386	1.946400	1.908081
Akaike info criterion	-8.994689	-9.057648	-9.021385
Schwarz criterion	-8.858617	-8.921576	-8.921576

Note: ***, ** and * indicate rejection of null hypothesis at 1%, 5%, and 10% respectively.

5. Conclusion and Discussion

This paper attempts to find the relationship between house price changes and three contributing variables, namely house prices of previous months, residential land price, and inflation represented by consumer price index in China's real estate market. Autoregressive models and modified regressive models are applied to explore quantitative relationship between those variables. A series of statistical analysis and tests are carried out to obtain the coefficients for our models and to calibrate the accuracy and effectiveness of our model. Our analysis shows that the distribution of house price changes is stationary and we can derive the future value of housing price changes by investigating its previous value. It is observed that the house price changes of current month are influenced by its value of last month and the month before last. Both land price and consumer price index contain predictive contents to house price changes and can help improve the performance of the regressive model.

One recommendation for future contrast analysis is to rectify the limitation of data type used in the current paper. In the current modeling, all the three variables are all explained in the form of index using a basis value 100. Therefore, the difference between prices for each month is relatively small. For future research, it is desirable to use actual amount in the unit of Yuan. Another angle for further study is to adopt stochastic models instead of autoregressive models to describe the possible mean reverting properties intrinsic to any interested set of financial data. Facilitated with functional analysis techniques, the application of mean reverting stochastic models may lead to very accurate and implementable closed form solutions to many financial optimization problems as shown in Xie et al. (2009), for instance. The usefulness of such analytical solutions mostly depends on the accurateness of the corresponding parameter estimation procedure. For Bayesian approach for parameter estimations related to stochastic modeling, one may refer to Feng et al. (2012). In addition to these, how the housing price changes may affect the buyers' propensity for selling the property or settling the mortgage loans remains an interesting and open question, which deserves further study.

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