

# Heterogeneous Demand, Government Intervention and Housing Price: Chaos Analysis Perspective

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## ABSTRACT

Started from the microbodies of real estate market, this paper supposed real estate price is mainly determined by the bodies' market behaviors and related interactions, while the demanders in real estate market are heterogeneous. and local government and central government are with different purposes in regulating the market. For these considerations above, this paper constructed a real estate price deterministic model, and conducted a numeric simulation. The main findings include: the price fluctuation of real estate market has chaotic characteristics, and the systematic parameters have a comparatively big effect on market equilibrium. The sensitivity that both consumption demanders and real estate developers have on real estate price is positively correlated to real estate market equilibrium. In the long term, the price of real estate market will be approaching to its actual value.

**Keywords:** heterogeneous, government intervention, house prices, chaos

## INTRODUCTION

As a major component of social wealth, the development of the real estate has become an important force to promote industrialization and urbanization. For the reason that the real estate as the dual attributes of being a kind of consumer goods and being a kind of investment goods, its price fluctuations will have a profound impact on the social stability, the real economy and the financial system development.

The early research on real estate mainly started from macroeconomic perspective, adopted the assumption of real estate heterogeneity and used the theories of stock-flow, service-flow and asset pricing or the theory of hedonic price method that assumed the prices of real estate are various, to conclude the affecting factors to real estate price through constructing reduced form model or hedonic price method. The affecting factors on house prices are basically from demand and supply angles (Green, 1999; Krainer, 2005).

From demand angle, it includes the consumer demand and the house investment demand. The variation of demands among different classes can be summarized as: the demand of low-income households is mainly consumer-oriented, while the demand of high-income class is more likely to be investment-oriented (Ioannides and Rosenthal, 1994; Lin and Lin, 1999; Harter-Dreiman, 2004). Furthermore, house demand is directly related to population, expected permanent income, wealth, return on investment, age, and consumption preferences, etc. (Bramley, 1993).

As for supply angle, it is mainly affected by the actual construction costs, wages, the amount of land supply and the number of existing house, etc. (Abraham and Hendershott, 1994; Hwang and Quigley, 2006). Some factors such as employment rate, interest rate, local economic situation, monetary policy, and locations will impact the house prices through affecting both the housing demand and supply side. Among these factors, monetary policy is a very important one, especially on short run prices (Baffoe-Bonnie, 1998; Del Negro and Otrok, 2007; Kiel and Zabel, 2008; Zhou, 2005; Pi et al., 2017).

### Contribution of this paper to the literature

- Besides the interaction between demand and supply in real estate market, local government and central government are authorities in regulating real estate market, but their purposes are heterogeneous.
- The more sensitive the consumption demand is, the more stable the real estate market will be tending to. In addition, the sensitivity that real estate developers have to price is positively correlated real estate market equilibrium. In the long term, the price of real estate market will be approaching to its actual value.
- In China's real estate market, the government has strong macroeconomic control ability, and some bodies such as real estate consumers and developers will pay great attention to the government's strategy in real estate market.

The affecting extends from different factors are various. Generally, the driving forces are mainly from the demand side, but local government as a force cannot be ignored. Comparatively, the effect from the supply side could be slimmer (Dong, 2010). In addition, there could be location variances when considering different factors' effects on house prices. For instance, the effect of the credit size on the house price is larger in eastern and western regions, while smaller in central region (Liang and Gao, 2017).

According to early research, the factors on house prices can be categorized as fundamental and non-fundamental ones (Li and Rui, 2007). Among them, the variation of fundamental factors will lead to the housing prices' fluctuation (Mankiw and Weil, 1989). Therefore, the empirical research of affecting factors can indirectly explain and predict the tendency of housing price fluctuation. For instance, Mankiw & Weil (1989) constructed the tendency prediction model among the United States, proving that the decreasing growth rate of the aging population would lead to the sharp fall of house price in the next 20 years.

In addition to population factor, some factors such as resident income, interest rates are usually adopted to explain and predict the house price and its tendency. For example, Fortura & Kushner (1986) established a house price equation with the data from 30 metropolitan areas in Canada in 1981 and concluded that there is a strong positive correlation between the average residents' income and the housing price; McQuinn & O'Reilly (2008) proved that disposable income and interest rates are the main factors to affect the house price of Ireland.

Early studies had described the external forms from macro perspectives; however, the commodity price is mainly determined by market agents' willingness and purchasing capability, thus it is an interactive product contributed by both demanders and suppliers. For this reason, more emphasis should be paid from market micro-mechanism to discuss the market agents' behaviors and their interactions. Besides, the government body is an important participant among market, and it could make macro regulations to real estate market, thus the real estate price model should include government as an important economic body.

Existing empirical studies using linear analysis concluded that economic fundamentals are uncertain to affect real estate prices (McQuinn and O'Reilly, 2008). Baffoe-Bonnie (1998) found that there is a negative linear Granger correlation between mortgage interest rates and the house prices. But McGibany & Nourzad (2004) cannot confirm the Granger causality by a long run cointegration and error correction model between the mortgage interest rates and the house prices. Meanwhile, there are expansion and systolic period in the housing market, thus the house price may fluctuate differently during the various period. In conclusion, the results from both qualitative inference and quantitative analysis alike show that non-linear analysis should be the point in deepening the house price research.

## THEORY MODEL

Fundamentally, the behavior of market traders will directly determine the market price changes most. Under the established trading institution, information impacts market price through the market traders. Many traders make their investment decision at a different time according to their understanding of the information and their own beliefs. This investment decision produces the market demand and forms the market price within a given trading mechanism (McGibany and Nourzad, 2004). So the theoretical model reflecting the determination of house price should be established based on the interaction between the demanders and suppliers in a housing market. Meanwhile, demanders make different trade decisions according to their demands and their comprehension of trade information from the market.

### Market Participants

Suppose there are four kinds of economic bodies in the housing market: house demander, house supplier, local government and central government. Then we can prove each body will impact market prices.

### Local government

The real estate industry generally has a long industrial chain and significant driving capabilities. Meanwhile, for the purpose of stimulating economic growth, local government will advocate the development of real estate to ignite the overall economic growth and increase the fiscal revenue by selling lands at higher prices on competitive land markets.

Therefore, for the local government, it will take real estate industry as a focus among numerous industries and set a minimum price threshold for this industry. Prices lower than the threshold will harm the development of the local real estate market and will deteriorate local economic development and fiscal revenue. Correspondingly, there should be a minimum control price for every given real estate market:

$$P_t \geq P_{min} = m \tag{1}$$

where,  $P_t$  is the house price, and  $m$  is the lowest price regulated by the local government.

### Central government

With the rapid development of the capital market and the change of the total amount and the structure of the financial assets, the influence of the virtual economy on the real economy is becoming more and more prominent. The effect of asset price fluctuation is largely beyond on capital market itself. Fluctuations in asset prices are often accompanied by financial instability, thus the rising and shrinking of the asset prices could lead to systemic financial risks.

Therefore, the stability of asset prices has gradually become one of the objectives that the central government chases through macroeconomic regulation and control. For the central government, the real estate industry is an important factor in stimulating economic growth; however its over-development may lead to systemic financial risks, and excessively high prices are harmful to the social stability. As a result, the central government will control the rising house price by controlling house supply and investment demand, and there hereby will be the highest control line of the house prices:

$$P_t \leq P_{max} = M \tag{2}$$

where,  $M$  is the highest house price set by the central government.

### House demander

According to the purchasing purposes, the demands from housing market can be categorized as consumption demand and investment demand, among which, consumption demand mainly aims to satisfy the life, and investment demand is to obtain premium. Apparently, housing demands are the sum of these two kinds of demands.

We label housing consumption as  $G$ . For the reason that housing demand is inversely proportional to the price and it must be positive, the demand function can be expressed as:

$$D_t^G = \max(d_0 - dP_t, 0) \tag{3}$$

where,  $D_t^G$  is the consumption demand,  $d_0$  is the maximum consumption demand, and  $d$  is the marginal propensity to consume in the housing market.

There are two kinds of heterogeneous investors: the fundamentalist who understands fundamentals, and the chartist who knows the technical analysis and takes follow-up actions (McGibany and Nourzad, 2004).

Referring to Day and Huang (1990), the net demand function of the fundamentalist is denoted as:

$$D_t^F = \frac{C(F - P_t)}{(P_t - m + \varepsilon)^{d_1} (M - P_t + \varepsilon)^{d_2}} \tag{4}$$

where,  $D_t^F$  is the fundamental analysis investment demand,  $\varepsilon$  is the gap that the fundamentalist thinks the price will deviate from the maximum (minimum) value.  $d_1$  and  $d_2$  are the probabilities with which the fundamentalist thinks the real estate price will deviate from the actual price.  $C$  is the feedback value that fundamentalist assigns to the real estate price fluctuation.

Similar to De Long et al. (1990), it is assumed that the Chartist demand function is:

$$D_t^C = \beta(P_t - P_{t-1}) \tag{5}$$

where,  $D_t^C$  is the Chartist investment demand,  $\beta$  is the feedback value that the Chartist assigns to house price fluctuation trends.

### House supplier

Supposing that the market supply comes from the non-negative real estate suppliers (the real estate developers), and it satisfies the law of supply, i.e., the supply is proportional to the price. The supply function is denoted as:

$$S_t = b_0 + bP_t \tag{6}$$

where,  $S_t$  is the supply quantity in the housing market  $b_0$  is the minimum supply quantity,  $b$  is the slope of supply.

For simplicity, we set intercept  $b_0 = 0$ , then the supply function is  $S_t = bP_t$ , and  $b > 0$ .

### Basic Assumptions

The theoretical model is based on the following basic assumptions:

**Assumption 1:** The market is the basic way to real estate resource allocation.

Under China’s socialist market economic system background, China adopted the reform of basic housing system reform in 1998 and canceled the welfare housing distribution afterward. We can assume that China’s real estate market has become a basic way to allocate real estate resources, and the price mechanism has been the main means to regulate the housing market.

**Assumption 2:** The economy bodies in the housing market are rational.

We assume that the participants of demander and the real estate developers are rational, and they’re pursuing maximized benefits in the interaction. Similarly, the governments are rational, and their purpose is to maximize the social benefits and fiscal revenue.

### Model Construction

According to non-equilibrium cobweb model, the commodity price in the next term will be adjusted based on that of the current term and the demand-supply situation. Therefore, the recursion formula of real estate pricing is denoted as:

$$P_{t+1} = P_t + a(D_t - S_t)$$

where,  $D_t - S_t$  is the excessive demand function, denoting the gap between actual demand and supply. The bigger gap will lead to higher demand for real estate, vice versa.  $a$  represents price adjustment parameter, indicating the velocity and strength with which the actual price is adjusted based on last term’s demand-supply situation, and  $a > 0$  reflects the same directions from price adjustment and excessive demand function.

Incorporating the functions from (3), (4) and (5) and supply function (6) into recursion function, and adding the bottom price from local government and ceiling price from central government to it, we can obtain a real estate price determination model as (7):

$$P_{t+1} = \begin{cases} M & , P_t \geq M \\ P_t + a \left[ d_0 - dP_t + \frac{C(F - P_t)}{(P_t - m + \varepsilon)^{d_1}(M - P_t + \varepsilon)^{d_2}} + \beta(P_t - P_{t-1}) - bP_t \right] & , m \leq P_t \leq M \\ m & , P_t \leq m \end{cases} \tag{7}$$

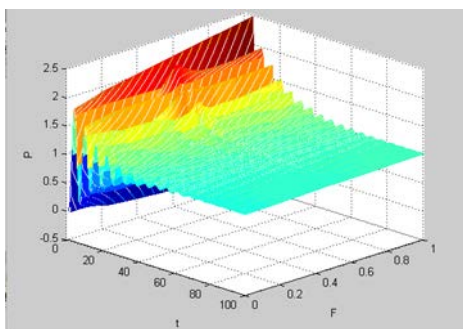
### NUMERIC SIMULATION

Apparently, some parameters in the model of section 2 will not change within a given period. In order to better simulate the equation, we firstly select the unchanging parameters:

- (1) Taking real estate actual value as the center, the price will fluctuate along with the actual value. We denote  $M$  as the upper limit of price fluctuation,  $m$  as the lower limit, and  $\varepsilon$  as the gap between fluctuation extremum and the limit in short period; and we set  $m = 0$ ,  $M = 1$ , and  $\varepsilon = 0.1$ ;
- (2) According to fundamentalist, the real estate prices are with the same probability to deviate from the actual prices and reach to the upper limit and lower limit. Thus, we set  $d_1 = d_2 = 0.5$ ;
- (3) For a stronger response to price fluctuation in short period, Chartist has higher feedback value than fundamentalist has, thus we set  $\beta = 0.88$  and  $C = 0.2$ .

### Systematic Analysis

In order to explore the systematic characteristics of real estate price model based on non-equilibrium cobweb model, we further select the changeable parameters after we finish unchangeable parameter selection.



**Figure 1.** The effect of  $F$  on real estate price

- (1) Assuming the actual price of real estate is 0.5, i.e.,  $F = 0.5$ , and both fundamentalist and Chartist know the value;
- (2)  $d_0$  and  $d$  are the demand function coefficients. According to the feature of demand function, we set  $d_0 = 1$  and  $d = 0.9$ ;
- (3)  $b$  is the coefficient of supply function. In response to supply function, we set  $b = 0.9$ ;
- (4) For simplicity, we set  $a = 1$ .

When the selected parameters are substituted into the equation that is subjected to  $P_{t+1} = P_t = P^*$ , the solutions to (7) are 3 fixed points:  $P_1^* = 0.158$ ,  $P_2^* = 0.5$ ,  $P_3^* = 0.927$ . We can find that  $P_2^*$  equals to the equilibrium value, and at this point, the absolute value of graph slope is bigger than 1. This result indicates that the system is not stable around this point, and the track of real estate price around this point is very complicated. Therefore, the selected parameters lead to a chaotic system.

## The Change of Parameters on Real Estate Price

### *The change of actual price $F$ on real estate price*

When others are fixed, the changes of  $F$  from 0.5 to 1 will impose effects to real estate price fluctuations. As shown in **Figure 1**, the stable value from real estate fluctuation will change along with the actual value, but it will stay around the actual value. In addition, **Figure 1** also demonstrates that the fluctuation scope will be enlarged with the increase of actual value  $F$ .

Evidently, though there will be speculators who will expand price fluctuation according to the increase of the actual value of  $F$ , the real estate price will back to its actual price from long term.

### *The effect of demand function coefficient $d$ on real estate price*

The demand function coefficient  $d$  signifies the extends of sensitivity that purchasers are with when facing the price fluctuation; bigger  $d$  shows that the purchaser is more sensitive to price.

From the numeric simulation, we know that the effect of demand function coefficient  $d$  on the real estate price is very complicated. When  $d$  stays at the interval of 0.4 to 1, the price will finally tend to be stable after a period of fluctuations, and the equilibrium price will be approaching to the actual price along with the increase of  $d$ .

However, when  $d$  is at the interval of 0 to 0.4, real estate price will not be stable from long-term, but it will fluctuate around an interval. In detail, the interval will be far higher than the actual price when  $d$  becomes smaller and tends to be 0; when  $d$  approaches to 0.4 more, the fluctuating interval will be only slightly higher than real estate actual price.

Thus we can conclude that when purchasers are more sensitive to real estate price, the price will tend to be more stable, and the stable point will be approaching to actual price; when purchaser are less sensitive to real estate price, the price will tend to be more fluctuating, and far more deviating to actual price will intensify the real estate bubble.

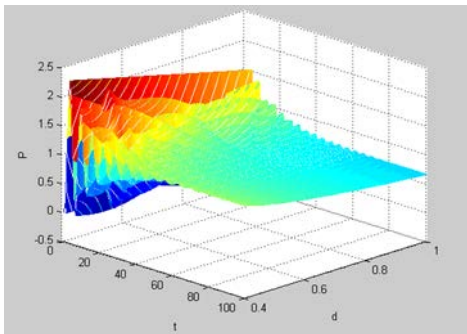


Figure 2. The effect of  $d(0.4-1)$  on real estate price

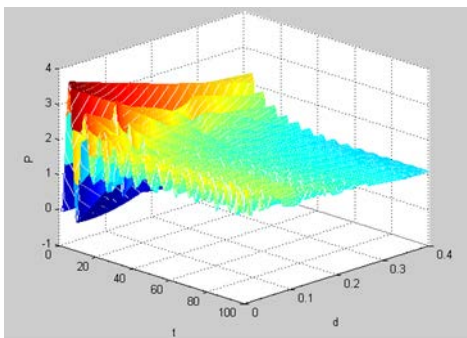


Figure 3. The effect of  $d(0-0.4)$  on real estate price

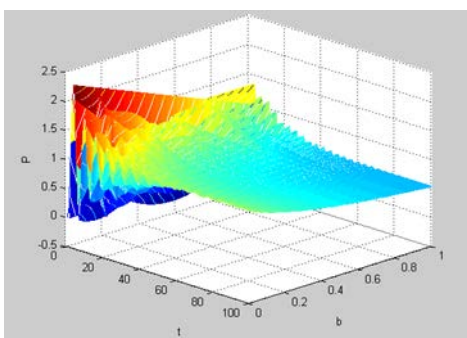


Figure 4. The effect of  $b$  on real estate price

### *The effect of supply function coefficient $b$ on real estate price*

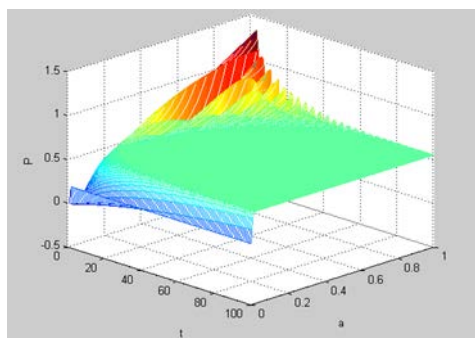
Supply function coefficient  $b$  indicates the sensitivity that real estate developer is with to price fluctuation; bigger  $b$  means developer is more sensitive to price, vice versa.

From Figure 4 we know that  $b$  will affect the real estate long-term stable price. When  $b$  is big enough to approach to 1, real estate price will be approaching to its actual value from long term; when  $b$  becomes smaller, the real estate will have a higher stable price, and it will fluctuate with a bigger range.

Therefore, when housing supply is more sensitive to real estate market price, the equilibrium price will more tend to the actual price, and the market is more rational.

### *The effect of price adjustment parameter $a$ on the real estate price*

The price adjustment parameter  $a$  reflects the extent by which the real estate price is affected by excessive demand. From Figure 5,  $a$  has no effect on the long-term stable value of real estate price, but it will affect the fluctuation.



**Figure 5.** The effect of  $a$  on real estate price

When  $a$  is between the interval of 0 and 0.2, real estate price will not fluctuate but only increase to a stable point; when  $a$  stays at the interval of 0.2 and 1, real estate price will fluctuate at first, and then tend to be stable. Besides, bigger  $a$  determines wider range and higher frequency that real estate price will fluctuate with.

From the analysis above, we know that the value of  $a$  cannot directly affect the long-term stable price of real estate market, but will affect the process to obtain the stability. When  $a$  tends to be bigger, the real estate market will be more fluctuated when approaching to stability; when  $a$  is given a smaller value, the fluctuation of real estate will be staying at a slimmer range.

## CONCLUSION AND LIMITATION OF THIS RESEARCH

Started from the microbodies of real estate market, this paper supposed real estate price is determined by the bodies' market behaviors and related interactions. In addition, the demands in real estate market are heterogeneous, and the heterogeneities have two-fold meanings: firstly, demanders, including consumption ones and investment ones, are heterogeneous in real estate demand; secondly, there are two heterogeneous traders in real estate investment demand: one observes that real estate price will fluctuate along with actual value, thus it will purchase when price is lower than the actual value, and will sell out when price is higher than actual value; and the other will adopt technical analysis to consider the price trend.

Besides the interaction between demand and supply in real estate market, local government and central government are authorities in regulating real estate market, but their purposes are heterogeneous. For these considerations, this paper constructed a real estate price deterministic model and conducted a numeric simulation to the theoretical model. The results confirmed that the price fluctuation of real estate market is with chaotic characteristic, and the systematic parameters have a comparatively big effect on market equilibrium. The sensitivity that consumption demanders are with on real estate price is positively correlated to real estate market equilibrium; in another word, more sensitive the consumption demand is, more stable the real estate market will be tending to. In addition, the sensitivity that real estate developers have to price is positively correlated real estate market equilibrium. In the long term, the price of real estate market will be approaching to its actual value.

In China's real estate market, the government has strong macroeconomic control ability, and some bodies such as real estate consumers and developers will pay great attention to the government's strategy in real estate market. For this reason, further study could make efforts in segmenting the government's strategies and discussing various effects that dissected strategies on real estate market equilibrium. Furthermore, the feedback that real estate market obtains from government's macroeconomic control and its tendency on real estate price could also be taken as future study directions.

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