Explanation for Real Estate Speculative Bubbles Using Game Theory

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ABSTRACT

It is well-established that the real estate markets in different countries were under different conditions depending on the nation's policies. This research aims to determine the dominant strategy and the strategic belief for both developers and homebuyers in the Chinese real estate market. The market was classified into two conditions (rational exuberance and irrational exuberance) and was analyzed using a "dynamic game of incomplete information" model. The probability of beliefs was calculated using the posterior belief. The result showed the developer's dominant strategy is to raise the price in a rational exuberance market whereas the homebuyer's dominant strategy is to stabilize the demand in an irrational exuberance market. According to the perfect Bayesian equilibrium found in the game model, the results also proved that both developer's and the homebuyer's strategic beliefs have relied on the other's income and belief.

Keywords: *Real estate, Speculative bubbles, Game theory, Equilibrium*

1. INTRODUCTION

This article mainly focuses on houses in the Chinese market (first-hand houses). The reason is that the rising prices of first-hand houses in China have seriously affected the safety of state-owned funds. If they continue to increase, they will soon lead to real estate bubbles in China. Under such circumstances, China has adopted many restrictive policies against the real estate industry. The first measure is to set the price ceiling. The "Regulations on the Price Administration of the People's Republic of China" put forward a guiding price, including the benchmark price, floating range, and margin. In other words, it is the price limit set by the state. The production and business unit sets the price independently within the range specified by the state. Thus, all prices will have a prescribed range of change, and there will be no extreme situations. The second approach is the purchase restriction policy, which varies from city to city. Taking Beijing as an example, only local households with no properties in Beijing and valid temporary residence permits in Beijing can purchase two houses. This approach limits the number of units sold, restricting effective demand and reducing the possibility of a bubble economy.

Speculation behavior, which is trading at a profit by taking advantage of price differences in the market, imposes great impacts on economic fluctuations and drives price bubbles to form. There are a few main types of economic bubbles: stock market bubbles, real estate bubbles, and bubbles on other markets, including but not limited to energy resources, precious metals, and other goods. The history of economic bubbles can be traced back to the Dutch tulip mania during the 17th century. When it comes to the Eastern world, recently, two of the most typical cases might be the post-bubble mess in Japan in the 1990s and the financial crisis in Southeastern Asia in 1998, which are mainly because of the speculative behavior in the stock and real estate market. Essentially, all these bubbles are interrelated and can mitigate from one market to another, from one country to another, especially during this era of globalization.

In terms of the formation of real estate bubbles, they usually happen when the housing price increases at a rapid pace. Regularly, the market price would rise with the inflation rate or the growth in average incomes. When

the prices are already too high, the bubbles would burst and therefore land prices would come to collapse, followed by a recession in the area. Note that this is different from a real estate boom in that the cycle must always run its course and a correction happens more gradually with the prices eventually returning to more realistic values. The purpose of this paper is to examine the changes in China's primary real estate market, thereby helping consumers and developers to make better choices in the market.

The exact cause of economic bubbles is such a controversy that people can hardly reach an absolute consensus. Some economists firmly claim that bubbles are related to inflation and therefore believe that the factors generating inflation could also be the same reasons to trigger bubbles to occur. Others hold the opinion that there is a basic value to every asset and the bubbles indicate an excess of the fundamental value. This rising movement must eventually return to the basic value, which is its natural state.

Real estate speculation involves belief, feedback effects, and other related factors. It is the interaction among these factors that motivates the speculation behaviors and generation of the real estate bubbles. When the real estate market is experiencing an exuberance, the developer sets the price at a high level. Under the feedback effect, the homebuyer will expect the price to rise further and will benefit from resailing the asset if they purchase at this time. In turn, the belief of the homebuyer will also affect the developer's belief, motivating him to raise the price and develop new projects to gain more profits. As a consequence, the supply and demand in the real estate market will rise sharply.

Moreover, it is worth noticing that the condition of the real estate market is also affected by the financial support of the banks. When the price grows continuously, the bank will anticipate a boom in the real estate market and offer greater support to investments of both developers and homebuyers. Otherwise, the bank will offer less support to investments.

In a nutshell, the interaction among developers, homebuyers, and banks could result in a rising price and the formation of bubbles in the real estate market. Since the information remains incomplete in all three parties, the dynamic games of incomplete information will be used in this report to demonstrate the mechanism behind it.

Hirshleifer used the refined model of speculation, deeming price and price anticipations as endogenous variables. First, the interaction between price risk and quantity risk was discussed in the paper. Then, it concluded that only those individuals deviating from representative beliefs in the market will hedge or speculate. Additionally, it claimed that it is natural to associate speculation with optimistic opinion and hedging with pessimistic opinion[1]. Harrison and Kreps dived into how speculative investors behave in a stock market with miscellaneous expectations. A general model of the market for a single stock as well as several numerical examples was shown in the paper. It summarized that investors attach a higher value to the ownership of the stock than they do to ownership of the dividend stream that it generates [2]. Roehner discusses the spatial mechanisms of speculative bubbles in Paris. It starts with a study of the price trends in the different regions of Paris and then compares them with the overall trend. Twenty areas of the interior architecture of Paris were chosen as the basic data for the study. It demonstrates that the spread of speculative attitudes plays an important role in the economy, as it triggers price increases, even in areas where these are not expected due to lower income levels and relatively poor housing standards [3].

Mu and Ma's research result about games in the real estate market in 2007 indicated that cooperation is the optimal strategy. It investigates the pricing strategy for land and real estate and regulating the tax rate is an efficient way for governments to increase profit. The relationship between a non-cooperative game and a cooperative game is discussed by comparing the statistics [4]. Research by Kit in 2013 investigated the use of the game theory at the strategic level in real estate development, trying to explain economic observations among metropolitan cities. Using data spanning from 1995 to 2013 among 5 property types (single-family house, apartment, industrial, office, and retail) and 44 MSAs, analyzing the relationships between the volatility of underlying assets, the land cost ratio, the option premium value, and the timing of development [5]. Mohammad Hatim and Zuyi researched how game theory could be applied to market transitions, the research used dynamic programming, modeling to find the Nash equilibrium of the game between all the participants in the market. It formed a game tree of a dynamic game of incomplete information between all participants and analyzed different results based on different circumstances. The research concluded that all participants try to maximize their payoffs [6]. His research aims to determine the optimal strategy for the government and the developer in a country's real estate market. The research also sets up a Bidding and auction game model to calculate the expected payoff of both participants in the game. The research offers some references to the final decisions for the government department and developer, it also proposes some policy recommendations for the construction of the market system in real estate [7].

Zou concentrates on the cause of the foam in the housing economy that composes of the main body of the real estate economy and then raises a series of measurements. According to the present situation of the

real estate economy in China, the research compared the economic system in China in past and present It also puts forward reasonable mechanisms and strategies for the further development of the estate economy [8]. In this paper, Almeida examined how to prevent and detect the creation of speculative bubbles in the Brazilian market. The research used a recursive unit root test. It focuses on two major Brazilian cities. It applies recursive SADF and GSADF tests to the PR datasets. The study found a rapid growth of a speculative bubble in Brazil over the last two years [9]. The study is an article written by Diego Escobar on the evaluation of the existence of a bubble of trusts of real estate. It detects the presence of single or multi-period bubbles in four REIT indices by using the SADF. Data from 1980 to 2013 were investigated as a database in the paper. However, this method is only suitable for determining the existence of a bubble and cannot predict whether it will burst [10].

2. MODEL SETTING

Suppose there are two types of real estate markets before the emergence of the bubbles, exuberance, and depression. The exuberant market is divided into two types: rational exuberance and irrational exuberance, denoted by h and f respectively. Since real estate always plays a value-added role, loans secured by land property are widely deemed as prime ones, regardless of market conditions. While the housing price remains stable, banks will offer different levels of financial support in various periods. Investors regard strong financial support of the bank as common knowledge in exuberant markets, and vice versa. Consequently, developers and homebuyers can use the information as a measure to judge the type of the markets. As banks reduce financial support during the recession, the market type could be easily identified by the developers and homebuyers and therefore the interaction between the three parties is relatively fixed. Therefore, it will not focus on the banks in the study of real estate speculative bubbles, but rather explore the game equilibrium of the participants in exuberant markets.

Since banks are usually powerful supporters in exuberant times, the game is played only between developers and homebuyers. They face incomplete information. Specifically, each one knows only his type but not the other. Assuming that both developers and homebuyers will be able to repay their loans on time during exuberant markets as well as irrational exuberant markets. However, it cannot deny that developers may only focus on housing development, lacking market analysis and estimates of repayment capacity, which is referred to as moral hazard behavior given the information asymmetry. Similarly, the moral hazard of homebuyers, which indicates using mortgages to purchase risky land properties, cannot be rejected as well.

Normally, the developers can identify the market type based on their own experience, while the homebuyers are only informed of two types of markets, h, and f. They hold only a prior belief that the developer expects the market to be exuberant with probability and the market to be irrationally exuberant with probability. The developer moves first and determines whether to change the price. If the developer expects the market to experience a rational exuberant period and therefore there is a great potential demand, then he raises the price of the property, denoted by. Conversely, if the developer believes the market is irrational exuberance, then they may have two choices. The first one is to raise property prices. Noticing that the growth of the property price, the homebuyer may invest speculatively and ends up with higher land prices. The second option for the developer is to stabilize the property price at a certain lev, which seems more reputable. In this case, the developer's behavior will not trigger an evident increase in land prices, since his main goal is to earn an average industry profit. Then, it can be further assumed that the probability of the developer raising prices will be after receiving information on the irrational exuberance of the market.

The homebuyer is the last to move in the game. He realizes the market types, and f, and predicts the action of the developer through changes in the land price. However, he does not have full access to private information about the developers. When the developer keeps the price unchanged, the optimal decision for the homebuyer is to choose low demand, denoted by the. However, when the homebuyer is fully aware of the constant price rise, he then faces an information asymmetry. In other words, he does not know whether the increase in prices ascribes to a real exuberant market or the developer's incentive to obtain huge profits in an irrationally exuberant market under feedback effects. It supposes the homebuyer decides to choose high demand Q_h with probability after finding the price increase by the developer. Since homebuyers share similar preferences and actions, further price growth will emerge if a majority of them adopt a high-demand strategy during a period of increasing land prices. Essentially, this positive feedback effect is exactly what the developer is trying to achieve.

3. DEVELOPER & SELLER ANALYSIS

Figure 1 below shows the game tree of dynamic games of incomplete information. w_{Ai} and w_{Bi} refer to the payoff of the developer and the homebuyer, respectively. As it can find from the game tree, if the developer expects the market in a rational exuberance period, then the development of real estate meets the needs of society and buyers can afford commercial housing at their current income level from a micro point of view. At a macro level, investments in the real estate market and other major indicators are compatible with

economic development, which are not divorced from the foundation of the national economy. Thus, the real estate market runs smoothly. In this case, even if the housing price rises, it will not trigger speculation behaviors, let alone any real estate bubbles. Developer who invests during the exuberant period faces less market risk and earn higher profits w_{A1} as price increases. Therefore, the developer's revenue is maximized under this circumstance.

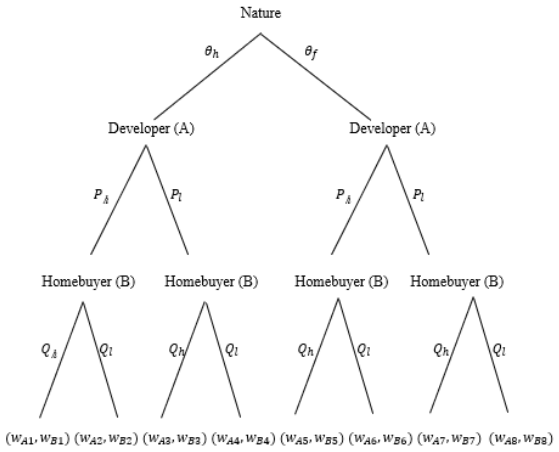

Figure1 The game tree of dynamic games of incomplete information

However, if the developer can identify that the market is under irrational exuberance, then he may create an illusion of an exuberant market and earn payoff w_{A5} by raising prices, which is higher than w_{A8} when he remains prices unchanged. Once this scenario turns out to be true, the strong demand will cause prices to boost further. As a response, other investors will increase the inputs, and eventually, bubbles are generated. Then the developer takes huge profits. But if the developer's behavior does not give rise to positive feedback effects of the market, then the new commercial housing may have overstocked and the developer is unable to get his money back, which results in w_{A6}, and it is the minimum payoff of the developer. In addition, w_{A2} is the payoff when the market is exuberant and the developer raises the price and the homebuyer chooses low demand. Since can be derived when the homebuyer chooses low demand.

In another situation, if the developer maintains a stable price while homebuyers choose high demand in a real exuberant market, the payoff of the developer will be w_{A3}. Since $P_h > P_l$ and, the following size relationships of the payoffs can be preliminary $> w_{A3}$, $w_{A5} > w_{A3}, w_{A3} > w_{A8}, w_{A3} > w_{A4}, w_{A7} > w_{A4}$ and $w_{A2} > w_{A4}$. As higher prices prompt the developer to increase supply and land reserves, the developer obtains more profit if he enlarges the housing supply at this time. Therefore, $w_{A2} > w_{A3}$ can be derived, In terms of w_{A7}, it is the developer's profit when the market is under an irrational exuberance and the homebuyer chooses high demand. Since the market risk is greater, in this case,$w_{A3} > w_{A7}$ can be obtained, and likewise, $w_{A4} > w_{A8}$.

Based on the aforementioned analysis, assume that $w_{Ai} > 0, i = 1,2,3,4,5,6,7,8$. In other words, the developer will always earn a positive payoff. Furthermore, the size relationships of the payoffs can be defined as follows: $w_{A1} > w_{A5} > w_{A2} > w_{A3} > w_{A7} > w_{A4} > w_{A8} > w_{A6}$ Since $w_{A1} > w_{A3}$ and $w_{A2} > w_{A4}$, raising prices for the developer is always a dominant strategy in an exuberant market.

Meanwhile, if the developer identifies that the market is under rational exuberance, then the homebuyer's payoff when he chooses high demands is w_{B1}. It is an optimal choice at this moment no matter the homebuyer aims to get real estate use-value or to make a capital gain. This is because the rise of housing price has an economic base as a supporter while the homebuyer will face a lower risk to make a capital gain by reselling. Therefore, rising demand will make high profits for the homebuyer at this time. Additionally, if the homebuyer decides to remain the demands unchanged, his payoff w_{B2} is a suboptimal choice. Similar to rising demands, making a capital gain is the main goal, but differ from increasing demands, stabilizing demands will result in a loss in payoff for the homebuyer.

Besides, if the developer identifies that the market is under irrational exuberance, then the homebuyer's payoff when he chooses low demands is w_{B8}, which is a regular payoff with lower risk when the market stays fixed. Therefore, it could identify this payoff as a non-minimum payoff since $P_h > P_l$ and $w_{B2} > w_{B8}$. When the market is under irrational exuberance, the payoff for the homebuyer is W_{B6} when the developer and the homebuyer choose to raise the price and stabilize the demand, respectively, since the payoffs in this circumstance partly rely on the speculative urge, his payoff w_{B6} is lower than w_{B8}. Similarly, it can find if the homebuyer decides to increase the demand at this time, he will simultaneously face the largest risk and receive the least payoff w_{B5}.

Furthermore, it is undeniable that the homebuyer's rising demand will result in a higher payoff in a rational exuberant market, the homebuyer will face lower risk in a rational exuberant market than an irrational one. Therefore, it can determine that $w_{B3} > w_{B2}, w_{B4} > w_{B8}$. Based on the aforementioned analysis, the size relationships of the payoffs of the homebuyer can be defined as follows:

$$w_{B1} > w_{B3} > w_{B2} > w_{B4} > w_{B8} > w_{B7} > w_{B6} > w_{B5} \quad (1)$$

Since $w_{B8} > w_{B7}$stabilizing demands the homebuyer is always a dominant strategy in an irrational exuberance market.

Now define the homebuyer's posterior believe:

$$X = Prob\{f|P_h\} = \frac{P(P_h|f)\cdot P(f)}{P(P_h)} = \frac{aPr_f}{aPr_f + Pr_h} \quad (2)$$

$$Y = Prob\{h|P_h\} = \frac{P(P_h|h)\cdot P(h)}{P(P_h)} = 1 - \frac{aPr_f}{aPr_f + Pr_h} \quad (3)$$

Assuming that the developer moves first and the homebuyer moves second, while the homebuyer cannot change his strategy after the developer's moves. Also suppose that the strategy of b, respectively. The strategy space is D_A and D_B, respectively ($D_A = D_B$ = [0,1], $a \in D_A, b \in D_B$), (the more "a" approaches to 1, the more likely the developer to raise the price, the more "a" approaches to 0, the less likely the developer to raise the price; the more "b" approaches to 1, the more likely the homebuyer is to expand the demand, the more "b" approaches to 0, the less likely the homebuyer is to expand the demand). In the formulae, $a^*$and b^* denote the developer's and the homebuyer's strategy beliefs when they receive their maximum expected payoffs.

If the developer knows the market is in irrational exuberance, then the expected payoff of the developer will be:

$$V_A(a, b^*) = a[bw_{A5} + (1-b)w_{A6}] + (1-a)w_{A8} \quad (4)$$

It should set the first-order condition of the expected payoff equals to 0:

$$bw_{A5} + (1-b)w_{A6} - w_{A8} = 0 \quad (5)$$

which leads to:

$$b = \frac{w_{A8} - w_{A6}}{w_{A5} - w} \quad (6)$$

Then assuming that a' and b' denote the strategy used by the developer and the homebuyer, respectively when their first-order condition equals 0.

Having noticed the developer's raise of price, if homebuyer believes that the market is in a rational exuberance, then the expected payoff of the homebuyer will be:

$$V_B(a^*, b, P_h) = b(X \cdot w_{B5} + Y \cdot w_{B1}) + (1-b)\cdot(X \cdot w_{B6} + Y \cdot w_{B2}) \quad (7)$$

Substituting X and Y setting the first-order condition equal to 0:

$$\frac{dV_B}{db} = (w_{B5} - w_{B6}) + \frac{Pr_h}{aPr_f + Pr_h}(w_{B1} - w_{B2} + w_{B6} - w_{B5}) \quad (8)$$

which leads to:

$$a = \frac{w_{B1} - w_{B2}}{w_{B6} - w_{B5}} \times \frac{Pr_h}{Pr_f} \quad (9)$$

That is to say if $a = a'$, the homebuyer's expected payoff is constant. If $a < a'$, the homebuyer's expected payoff is maximized when b = 1. If $a < a'$ the homebuyer's expected payoff maximized when b = 0. Under the assumptions made previously, the equilibrium fits in perfect Bayesian equilibrium: $a^* \in argmax_a V_a(a, b^*); b^* \in argmax_a V_B(a^*, b, P_h)$.

From the process of the game, it can be concluded that one player's belief is depended on the other player's belief. When the developer expects the homebuyer's belief to be $b > b'$, his optimal decision is to keep raising the price and induce the homebuyer to generate a positive feedback effect. (a ≡1). When the developer expects the homebuyer's strategy belief to be $b > b'$, his optimal decision is to stabilize the price because raising the price will not cause a feedback effect in any way (a ≡0)

As for the homebuyer, when the homebuyer expects the developer's strategy belief to be $a < a'$, it means that the developer predicts the market is in irrational exuberance and is not likely to raise the price. If the developer still raises the price at the moment, the market will vary into a rational exuberance market so that the homebuyer will shift demand (b ≡1). Conversely, if they believe that the developer's strategy belief is $a < a'$, then the homebuyer probably will identify the market is under irrational exuberance and will reduce demands (b ≡0).

4. CONCLUSION

From the game process, it can be seen that the strategic beliefs of developers and homebuyers are determined by the other's beliefs and income, and they influence each other. When the developer believes that the homebuyer's strategic belief is $b > b_1$, he tends to adopt the strategy of raising prices to induce the homebuyer to generate a positive feedback effect. In this condition, the belief can be reformed a ≡ 0. If the developer expects $b < b_1$, then the developer will think that raising prices will not form a positive feedback effect. To obtain a higher payoff, they will keep prices unchanged. In this condition the belief can be reformed an≡ 1 If the developer anticipates $b = b_1$, then it does not matter which action the homebuyer takes for the developer. In this condition, the belief can be reformed a∈ [0,1].

Equation (6) displays that the homebuyer's belief is determined by the payoffs of the developer under different conditions. The size of this formula depends on the value of the numerator and denominator, where the denominator is the difference between the payoff of the feedback effect after the developer's push in price and the payoff failing to trigger the feedback effect. The greater the difference between the two, the stronger the incentive for the developer to trigger the feedback effect, the less probable it is for the homebuyer to choose high demand. Therefore, the developer is more unlikely to gain huge profits through this action.

When the homebuyer believes that the developer's strategic belief is $a < a_1$, it means that the developer has less incentive to raise prices once identifies that the market is under an irrational exuberance. In this condition, the belief can be reformed $b \equiv 1$. If the developer still raises prices, then the homebuyer will expect the market to be in an exuberance. Therefore, they would choose high demand. When $a > a_1$ homebuyer will anticipate the developers to increase the price. So he will choose low demand since the market in this case could be under an irrational exuberant period. In this condition, the belief can be reformed $b \equiv 0$. When $a = a_1$ the homebuyer is indifferent to the two potential actions. In this condition, the belief can be reformed $b \in [0,1]$.

Under the game equilibrium, the developer's strategic belief is not only affected by the posterior belief of the homebuyers but also affected by the payoff of the buyers under the potential choices. If the homebuyer holds a priori belief that the market is exuberant from the very start of the game, he is more likely to increase demand after having observed the developer's price rise.

If the difference in payoffs between following a trend and not following a trend increase during an exuberant period, then the homebuyer is more likely to follow suit. If the difference in payoffs between following and not following strategies increases during irrational exuberance, then the homebuyer is more likely not to follow.

The greater use of game theory in the real estate market in the future may promote market efficiency and thus contribute to the country's economic development. It is hoped that subsequent studies will be conducted to investigate the economic bubble in the secondary real estate market. As well as give countermeasures.

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