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TIMING DECISIONS OF HOUSING SALES AND DEVELOPMENT BASED ON REAL OPTION THEORY

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Abstract. Based on the real option theory, this paper studies the impact of uncertainty on the timing decisions required in housing development and sales. Data of newly-built houses and corresponding plots in Hangzhou, China, are used for empirical analysis. In order to better reflect the changes in market demand under frequent policy intervention, in addition to the usual price volatility, this paper introduces the volatility of trading volume to measure the uncertainty of China's real estate market. The results show that the volatility of trading volume has a significant impact on timing decisions. Also, trading volume volatility can better reflect the characteristic of deferred option than can price volatility, especially during the sales phase. This study provides evidence to support Bar-Ilan and Strange's (1998) research of sequential investment. Because of the existence of the second option, i.e., sales timing, the starts in the first stage are not too sensitive to uncertainty. In the case of the second option, the longer the construction period is, and the lower the cost of the first stage is, the higher will be the probability of triggering the start. In addition, the characteristics of market risk aversion are obvious in the study area, especially in the suburban area.

Keywords: real option, survival analysis, timing of land development, timing of house sales, uncertainty, trading volume.

Introduction

China's real estate industry is experiencing rapid development. Holding vacant land and using a multi-phased sales strategy are two prominent phenomena in China's real estate market. The timing decisions related to both land development and sales are two problems that are not only bound up with the interests of the developers themselves; they are also of vital importance to the regulation of the real estate market.

In view of the problem of vacant land, "the Law on Urban Real Estate Administration", which was promulgated in 1994, stipulates that a certain land idling fee can be levied on those lands which are not developed within a year after the start date arranged in the contract. For those which are not developed two years after the start date, the development rights can be withdrawn without compensation. In 1999, the "disposal method of idling land" was promulgated and then revised in 2012. The definition of vacant land and the method of levying such lands are clearly defined. However, these provisions have not been well implemented in actual practice. Of the 813 plots examined in this article, 456 plots (56.1% of the total) were not developed within a year of the acquisition of those plots. In addition, building on 225 plots (27.7% of the total) was delayed for more than two years. In 2010, the Ministry of Housing and Urban and Rural Development stipulated that, for housing projects which obtain pre-sale permits, the developers should release all sales listings and prices within a maximum of 10 days. However, "property hoarding" behavior (a conservative way to sell real estate in order to get more profit) has been difficult to prohibit. Basically, property hoarding is an investment option problem. However, such timing behavior on the part of developers will affect both the supply and the expectations of the market. This in turn will have a great influence on the real estate market in China's cities, where the supply of new houses accounts for half of the total. Research on the development and sales process of housing projects is conducive to the formulation of targeted marketing management policies.

In the theoretical study of real estate investment decisions, most scholars assume that, among the variables of rent, house price, cost and income, one or two variables will follow the geometric Brown movement (Capozza & Li, 2002; Clarke & Reed, 1988; Rocha et al., 2007). Depending

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on the research perspective, some studies focus on the uncertainty of supply, demand or urban population (Jou & Lee, 2015; Lee & Jou, 2010). However, due to the availability of data, most empirical studies have measured the uncertainty of the real estate market from the perspective of price or rent volatility (Bulan et al., 2009; Cunningham, 2006). In addition, scholars study the influence of the uncertainty of the market environment and the impact such uncertainty has on the timing of developments and asset prices. In theoretical research and in some empirical studies in other countries, most results confirm that uncertainty will delay the timing of an investment. Whether or not this conclusion applies to China's real estate market still needs further verification.

The pre-sales system of residential buildings is a popular mode in Asian real estate markets. In other words, the housing can be sold when it meets certain construction progress criteria prior to completion. Moreover, in China's real estate system, housing projects are usually developed and sold by the same company. Many opportunities exist in the selection of the timing of construction and of sales. How to choose the timing of each stage in order to maximize the value of the project, as well as what factors affect the decision-making behavior, are worthy of further study. Although several papers have studied either the development or the sales perspective of China's real estate market in isolation, few studies have explored the relevance of both together. This paper uses the project data of newly-built residential buildings in urban areas in Hangzhou, as well as the matched plots, in order to examine the timing of the development and subsequent sales. The relationship between the two issues is then discussed, in an effort to reveal the characteristics of sequential decision-making by developers. The trait of phased development, sales and pre-sales in a housing market are considered when constructing models. In addition, some factors, which can be adjusted during the development process, are considered. These factors include development density, the standard of housing decoration, etc. Other variables, such as the number of sales periods, are also taken into consideration, in order to observe the influence of uncertainty on the timing decision of sales during different phases.

The paper is organized as follows: Section 1 discusses previous studies. Section 2 presents hypotheses and empirical models. Section 3 introduces the data and variables. Section 4 presents the empirical study of development timing decisions under conditions of uncertainty. Section 5 examines the option effect of the sales of housing projects. Last section presents the conclusions of the study.

1. Literature review

The three core hypotheses of the real option theory are 1) investment irreversibility, 2) investment uncertainty and 3) flexibility of investment timing (Dixit & Pindyck, 1994). Titman (1985) first applied the real option model to the real estate market. His study considers the two discrete states of the price. Clarke and Reed (1988) were the first to study the optimal time and optimal density of investment in real estate development in a continuous time frame. Considering the uncertainty of land development costs and house rental prices in the future, when the ratio of house rental prices and development costs exceeds a certain critical value, the developer will choose to develop; otherwise the vacant land will be retained and left vacant. Williams (1991) also employs a continuous time method, considering the double random case of net cash inflow and development costs. The study maintains that reaching the upper limit of regional density will delay development. Development options are more valuable when they exist under conditions of flexible densities. The optimal-stopping framework used by Capozza and Li (1994) is an extension of McDonald and Siegel's (1986) continuous time investment model. The authors studied the impact of the expected growth rate of rental prices on the timing of developments. The study also introduces capital intensity variables to analyze the impact on investment timing. Guthrie (2010) focuses on the frequency and quantity of land development. The results show that a higher average level of demand growth will create more frequent development. The greater the demand volatility is, the less frequent developments will occur. However, once started, the development will be quicker.

Compared to the existing body of theoretical research, the empirical study of the real option in the field of real estate investment has been slowly developed. This research is now divided into two major categories. The first is the study of the impact of real options on project and land value. Quigg (1993) first used large sample data of market prices to estimate the real option value of land. The option model she proposes combines the analytical framework of Williams (1991) with the empirical method, thereby assuming that the costs of development and building prices follow the geometric Brown movement. Grovenstein et al. (2011) improves Quigg's approach, especially by estimating development cost elasticities. Grovensein's study found that the average land option premium level was 6.7%, which is very similar to that of Quigg's study (6%). The second category is to validate the effect of the waiting option with empirical data. Cunningham (2006) uses the data of land block characteristics, architectural features, the transaction of physical assets and the shape of a site in Seattle as the study object. The empirical results show that a one-standard deviation increase in price uncertainty reduces the likelihood of development by 11%. The impact of the evidence of real options is more obvious in suburbs. To separate the option effect, Bulan et al. (2009) decompose the risk into systemic and non-systemic risks. They demonstrate that competition weakens the relationship between investment and non-system risk, and greatly reduces the sensitivity of the option to uncertainty. Somerville (2001) believes that real estate development – from taking the land to the completion of the building project – is a series of irreversible investment processes. Through the adoption of panel data from the Canadian metropolitan area, no evidence was found to indicate that completion is an option based on starts, while permits, on the other hand, can be regarded as an option to starts. A real estate project – from acquiring the land to development and from development to sales – is a two-stage sequential investment process. In this case, the company may be willing to use an "exploratory investment strategy" to carry out the first stage option at a relatively lower trigger price (Bar-Ilan & Strange, 1998). Miles (2009) uses the quarterly data of permits, starts and completions from the Census Bureau, and adopts the GARCH method to measure uncertainty. It is also found out that uncertainty has a negative impact on housing starts, but completion is not sensitive to uncertainty.

Empirical research on the option effect of China's real estate market is relatively rare. Wang et al. (2016) uses the survival analysis model and studies the influence of uncertainty, competition, and the macroeconomic situation on development timing in Hangzhou. Unlike the research results from other countries, Wang's study finds that house price volatility will lead to earlier land development, while any increase in policy uncertainty will reduce the possibility of development. However, the degree of policy risk is measured by the money supply and interest rate at the national level. Also, the changing regulations and policies introduced at city level are neglected. Yang et al. (2015) uses residential transaction records to study the sales behavior of real estate developers in Beijing. Their research shows that house price uncertainty will delay sales, and the impact is quite significant in the core urban area. The study adopts the actual date of the housing transaction as the measurement of sales time. This not only reflects the developer's holding time, but also the consumers' waiting time when the market is depressed.

Previous studies use either the starts or transactions to examine the timing of real estate investment decisions. These studies ignore the differences and mutual influence between those two phrases. Few studies simultaneously discuss the development and sales of real estate. Furthermore, according to the research of Bar-Ilan and Strange (1998), Martins and da Silva (2005) and Friedl (2002), when considering the sequential investment and time to build options, the impact of uncertainty on investment timing may be different to what is found in traditional "real option" literature. Most existing studies follow the assumptions of Capozza and Helsley (1990), and Dixit and Pindyck (1994), whereby investment is immediate. Without considering the factors of development lag and suspension in the real option model, the above study concludes that uncertainty delays development. However, when sequential investment, combined with time to build and the possibility of build or sale suspension are included, development may occur even sooner under conditions of uncertainty, primarily due to the opportunity cost of waiting. The situation with these assumptions is undoubtedly more in line with the housing market in China. The construction period is quite long, and a multi-phase development and sale strategy are sequential investments, which allow for suspension to some degree. This paper will carry out research under this specific situation.

2. Research hypothesis and empirical model

Real estate products are developed and sold in multi-phased formats. This means the decision process includes a series of options. Along with the advent of each stage, some previously uncertain problems are becoming clearer. This is a process of sequential decision making.

2.1. Real options for phased sequence investment

The main forms of China's housing market commodities are multi-story and high-rise apartments. As the construction area of the developing community is usually quite large and the amount of development capital required is huge, phased development and phased sales strategies are commonly used. Each period can be considered to be highly interrelated segments of the building project. Under such circumstances, a phased sequential investment strategy is superior to a parallel investment strategy (Childs et al., 1998; Kort et al., 2010). Ott et al. (2012) constructs the phased development and sales decision-making model of large-scale residential development projects. As pointed out in Ott's study, full development, lumpy or smooth-phased developments can all be optimal in different market environments. The scale economy of construction, pricing capacity, holding cost, signal function, demand increment, and market fluctuation will each affect production decisions and land prices.

Even without considering the phases within the construction or sales process, with the presence of a real estate project pre-sales system, the timing of starts and pre-sales of the project is in fact a key problem within the two-phased sequential decisions. The former starts option is the prerequisite for the subsequent sales decision. Due to the flexibility that can be applied to the timing of sales, combined with the duration of the project, developers can make optimal decisions to maximize the value of the project. For a residential building project, the construction density, building form and decoration standard can all be moderately adjusted in the subsequent phases, within the scope of the relevant permissions.

The classical real estate investment option model generally assumes that future house prices follow the geometric Brown movement. Referring to Bar-Ilan and Strange (1998), the real estate development and sales process can be regarded as a two-phase sequential investment. The beginning and ending point of the first stage, respectively, are the acquisition of land development rights and the attainment of pre-sales conditions. It is also assumed that the duration of this stage is h1. At the beginning of this stage, it is necessary to pay the cost K1 to obtain the development rights and to pay the initial construction cost. Then, after the early land exploration work, scheme design and market analysis, the project can commence when permission is obtained. The timing of the start depends on whether the trigger price has been reached. The second stage includes the follow-up construction and sales of the projects. The project can be sold using a phased-sales strategy, if the pre-sales conditions have been met. The project completion time is the end of the second stage, and the duration is set to h2. The process of the project is in accordance with the nature of irreversible investment. However, developers can choose the timing of both the development and the sales with some degree of flexibility.

Bar-Ilan and Strange (1998) conclude that when suspension is allowed between the first and second phases, that is, when waiting is possible after the completion of the first phase, the trigger price of the two phases can be modified. Their analysis results of a numerical simulation show that, with suspension, the developer may be more interested in starting an investment project in the first phase than completing the project in the second phase. With the ability to delay the second phase, the first phase is worth more to the developer. This implies that, when there is a suspension between the first and second phase, the project is not very sensitive to the normal influences brought about by uncertainty. In our case, the development progress of the project can be adjusted to a certain extent, and the pre-sale license usually only sets the minimum criteria for the construction progress. When the construction conditions meet these criteria, the developer can (rather than must) apply for the pre-sale permit. Developers can delay the start of the second stage. The suspension is incorporated into the timing decision for the start of the second stage. So, we propose the first hypothesis:

Hypothesis 1: In the case of sequential investment, the first stage of construction is more likely to be triggered, so the option effect is not always significant.

The lag length of the two stages will also affect the decision-making behavior. The longer the duration of the first stage is, the more helpful the conditions to trigger exploratory investment will be. According to Bar-Ilan's simulation, as the first stage gets longer, firms that can suspend are more willing to take the associated risk. For real estate development projects, large-scale projects require a long period of approval, planning and design in the early stage, as well as construction. Compared to the construction phase, the sales process is less affected by the size of the project. In this sequential investment scenario, the first phase of large-scale construction is more likely to start. Hypothesis 2 will be tested.

Hypothesis 2: For large-scale projects, the longer the construction period is, the more the delayed option effect of starting in the first stage will weaken.

At the same time, the cost allocation of the two stages is also very important. The lower the cost of the first stage, the more likely the project will be to attract investment. The situation used in this research is similar to the sequential investment model. In the first phase of sequential investment, the cost includes land expenditure and part of the development cost. According to statistics, the land prices account for approximately 40% of the housing prices in China's eastern cities (Zhou et al., 2019). The land costs account for most project development costs, and the land costs of different projects vary greatly. Based on the analysis results of Bar-Ilan, the following hypothesis is put forward according to the available data:

Hypothesis 3: The lower the cost of the first stage is (that is, the lower the cost of the land), the higher will be the probability of triggering the development.

On the other hand, if the cost of the first phase is too high, developers will face huge financial pressure, so they will tend to sell earlier to recover the money. Bar-Ilan's numerical solution also shows that the trigger price of the second phase gradually decreases as the cost of the first phase increases. Hence, we propose Hypothesis 4.

Hypothesis 4: The higher the cost of the first stage is (that is, the higher the cost of the land), the higher will be the probability of triggering the sale.

2.2. Survival analysis model

Survival analysis is a technique used to statistically analyze the probability of a certain event happening within a group in a specific timespan. The model takes the proportional hazard function as the main form, which can usually be written in a form such as the following:

$$h(t) = h_0(t)\exp(\beta' X) = h_0(t)\exp(\beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_m x_m), \quad (1)$$

where: X denotes the covariate matrix; x_i represents the characteristic variables of the plot and the developer, as well as market-related variables, which are defined and measured in detail in the next section; β is the regression coefficient vector; $h_0(t)$ stands for the baseline hazard. That is, at time t, the risk ratio is the nonnegative function without a definite form, which is only related to t. The exponential distribution and Weibull distribution are often used. If specific assumptions cannot be made about the form of $h_0(t)$, the Cox proportional hazard model, proposed by Cox (1972), can be adopted. This is a semi-parametric model, in which $\exp(\beta)$ stands for the proportional hazard, which indicates that the hazard changes with covariate X. The coefficient β_i represents the change of the natural logarithm of the hazard rate when variable x_i changes one unit.

3. Sample data and variables

The data used in this study come from the CREIS (by China Index Academy) and the CRIC (by Yi Ju China). Collecting the relevant information pertaining to a housing project in the city area of Hangzhou started during the period of January 2006, and ran to March 2017. The data dealt with a total of 705 projects, corresponding to 813 plots. The pre-sale information regarding 620 housing projects that received pre-sales permits during the period of January 2006, to December 2016, was also collected. This information corresponds to 2404 pre-sales permits, with an average of four permits being claimed for each project. Because this study is based on monthly data, all pre-sales permits for a project that were issued in the same month are merged into one permit. Also, each pre-sales permit is seen as an individual sales project. The city areas include the main urban area (districts of SC, XC, GS, XH, JG, BJ, ZJ), and the suburban area (districts of XS, YH and DJD). The time when the land is obtained is taken as the observation starting point.

This paper uses the GARCH method, like Bulan et al. (2009), to measure uncertainty, adopting the average transaction price per month of newly-built residential buildings. We adopted the price data of newly-built houses, because the transaction volume of newly-built houses was dominant in the market during the study period. Also, the newly-opened house prices always attracted great attention from the market. First, January 2006 is taken as the base period (price = 100) to preprocess the house price series. Then, the autoregressive equation of house price predictions is built. The results of multiple attempts show that the goodness of fit is best in the sixth lagged period of the autoregressive equation. Then, the standard GARCH (1, 1) model is adopted. The conditional variance is obtained as the proxy variable of market uncertainty, and the result is shown in Figure 1. However, the house price is not the only reflection of market demand. A study conducted by Wang et al. (2016) shows that, in the housing market of Hangzhou, price uncertainty has no significant influence on the timing of development, relative to changes in policy. China's real estate market is always subject to intensive policy regulations. In addition to monetary policies and interest rate adjustments at national level, various regulations also exist at city level. These regulations deal with issues such as limiting house purchasing, adjustments to the down payment ratio and loan interest rates, as well as competition that limits house prices when bidding for the land development rights. In 2017, the transaction price of houses was directly restricted by the setting of price caps. These regulations and control measures are frequently changed and difficult to quantify. However, the trading volume in the housing market is apparently very sensitive to these policy changes. The response of house prices to policy changes in Hangzhou can be a three-month lag in the trading volume on average (Zhang et al., 2017). Berkovec and Goodman (1996) also found that, especially when dealing with monthly or quarterly high frequency data, trading volume can better reflect changes in housing demand than prices can. Therefore, this study uses monthly trading volume as the means to measure changes in the market environment. The volatility of newly-built house transactions is used as an alternative to price volatility as a measure of market uncertainty. In addition, in the sales timing model, the trading volume is directly added to reflect the changes in the market environment. Considering the seasonality of monthly sales units and the possible endogeneity with the dependent variables, we adopt the year-on-year change rate of monthly trading volume of second-hand houses. The volatility of trading volume during the study period is shown in Figure 2. On February 28, 2011, in order to curb the speculative buying of housing, the city government issued a home purchase restriction policy. That is, local families were limited to buying two houses, and non-local families were limited to buying one house. On July 29, 2014, the city government cancelled the purchase restriction policy. On September 18, 2016, the purchase restriction was reinstated. According to the trading volume volatility curve shown in Figure 2, there are obvious inflection points at these three points. That is, when the purchase restriction policy was introduced and reinstated, the volatility dropped significantly, while when the policy was relaxed, the volatility started to rise gradually. Therefore, we believe that the trading volume volatility can capture the potential Poisson jumps that occur due to policy changes. Also, January 2006 is taken as the base period (the trading volume of the base period = 100), and the GARCH model is established. The correlation coefficient between monthly house price volatility and trading volume volatility is calculated as –0.1387, and the cross-correlation coefficient between trading volume volatility and 12-month leading house price volatility is 0.3489.

Developer characteristics have an important impact on decision-making (Ong & Cheng, 1996). Shen and Pretorius (2013) and Dong and Sing (2017) both found that a developer's development capabilities affect development timing decisions, as well as judgments regarding option value. Developers are able to develop large-scale or high-risk projects when they become stronger, under demand uncertainty. The type of corporation involved in the development will also have an impact on project behavior. On the one hand, listed

Figure 1. Volatility of monthly house prices

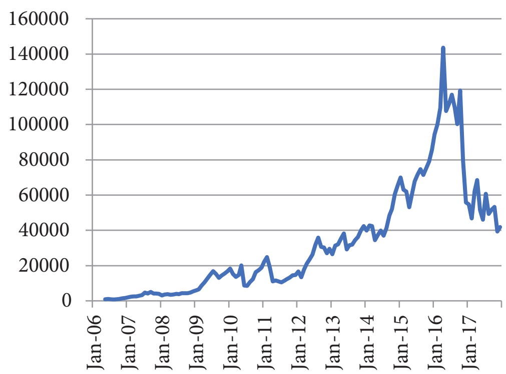

Figure 2. Volatility of monthly trading volume

companies face stricter supervision. These companies must pay greater attention to their social responsibility and the development's influence. As such, the possibility of illegally delaying the development (and sales) is relatively small. On the other hand, state-owned enterprises often have sufficient funds and a relatively strong ability to absorb risks. In recent years, with the intensification of both competition and risk in the real estate market, many enterprises have opted to find well-known enterprises as joint investment partners. The partners may be asked to take over the acquisition of the land, or they may join forces with the stronger partner and develop the whole project together. Based on the above analysis, the developer characteristic variables include pricing capacity, whether the company is listed or a state-owned enterprise, and whether the venture involves joint investment. Of the above characteristics, in this study, the pricing capacity is represented by a dummy variable. This is done by choosing the annual top ten real estate enterprises in Hangzhou's annual property sales in 2014, 2015 and 2016. This method resulted in a total of 17 enterprises being assigned a value of 1. Using the existing project location data, this paper examines the impact of local competition in the project area on the timing of developers' development decisions. According to the real estate sectors divided by the CRIC and the number of projects, 52 sectors are merged into seven geographical regions. Within three months before and after the start dates, the number of competitive projects in the same region is counted. The characteristic variables of the project include the floor area ratio and whether the houses are decorated. The location characteristics of the project include two distance variables, namely distance to West Lake and distance to Qianjiang New Town. West Lake is a famous landmark in Hangzhou, and is in the center of the core urban area. Proximity to West Lake has a significant impact on house prices (Wen et al., 2010). Meanwhile, Qianjiang New Town is the new CBD of the city, and this area has a significant impact on the spatial structure of the housing market. In addition, the risk-free rate of interest variable is indicated by the rate of one-year treasury bonds. Based on myopia expectations, the growth rate of one lagged period is used to indicate the expected growth rate of house prices.

In the study of the timing of sales, information noise is introduced. Because of the incomplete nature of information in the real estate market, investors can not accurately estimate the true value of their investment (Mayor et al., 1999; Childs et al., 2001). Referring to Wang (2012), we use a simplified method to describe the market information by adopting the number of construction projects within a certain range (the same range used in the competition variable) six months prior to development. We believe that, in an area where the number of existing buildings is quite large, price information is relatively sufficient, and the level of information noise is relatively small. We set a 0,1 dummy variable to indicate information level. When the number of existing projects in the observation area prior to the start of a new development is higher than the average level, the dummy variable is 1; otherwise, it is 0.

The descriptive statistics of the main variables under the two samples (the timing of the development and sales) are shown in Table 1.

Table 1. The descriptive statistics of the variables

Variables	Definition	Sample of development timing				Sample of sales timing			
		Main urban area		Suburban area		Main urban area		Suburban area	
		Mean	S dev.	Mean	S dev.	Mean	S dev.	Mean	S dev.
HP-vol	House price volatility	275.86	108.35	252.55	108.56	201.80	154.12	136.50	81.94
TV-vol	Trading volume volatility	5.64e-6	1.24e-7	35824	30428	36075	31286	48974	32125
Rate	Risk-free interest rate	2.69	0.80	2.77	0.79	2.68	0.82	2.85	0.69
Ratio	Floor area ratio	2.73	1.08	2.47	1.00	2.58	0.81	2.34	0.99
Dis-WL	Distance to West Lake/km	8.85	4.73	16.78	6.60	9.64	5.16	16.27	5.82
Dis-CBD	Distance to CBD/km	10.15	4.61	18.05	6.24	10.75	4.62	18.04	5.78
Exp growth	Expected growth rate/%	0.53	0.50	0.55	0.50	0.57	0.50	0.60	0.49
Compete	Number of competitive projects	6.29	3.43	7.24	4.45	6.47	3.40	7.71	4.58
Capacity	Pricing capacity of the developer	0.33	0.47	0.21	0.41	0.42	0.49	0.23	0.42
Listed	Developed by listed company or not	0.51	0.50	0.40	0.49	0.57	0.50	0.43	0.50
State-owned	Developed by state-owned company or not	0.29	0.45	0.14	0.35	0.31	0.46	0.17	0.38
Joint	Joint investment or not	0.12	0.32	0.08	0.27	0.13	0.34	0.09	0.29
Decorated	Decorated or not	0.33	0.47	0.17	0.38	0.23	0.42	0.15	0.35
Days l-st	Days from taking land to start	568	442	573	548	515	383	484	455
Days l-sa	Days from taking land to sale					1068	554	1051	655
Inform	Market information					0.48	0.50	0.47	0.50
Period	Number of sales periods					5.15	3.28	7.78	3.78
Sectv	The year-on-year change rate of monthly trading volume of second-hand houses					0.61	1.13	0.58	0.93

Note: The definition of a decorated house in the government guidance document is that, before the house is delivered, the fixed surfaces of all functional spaces are fully paved or painted, and the basic equipment of the kitchen and bathroom are all installed. The degree of decoration and price can be different, but there must be a clear agreement in the developer's housing sales contract.

4. Empirical study on development timing decisions

Because the projects in two suburban districts, XS and YH account for a large proportion of the whole sample (41.70%), the distribution may have an impact on the results. This section takes the samples of the main urban area and suburban area as the research objects, and analyzes the influence of uncertainty and other covariates on project start.

4.1. Differences between the main urban areas and suburban areas

The results indicate that, under the basic conditions of the main urban areas listed in Table 2, Columns (1) to (3), the probability of land development is not significantly affected by either house price uncertainty or demand volatility. Columns (4) to (7) show the regression results of expected future price growth and decline. In the case of expected price growth, one standard deviation in price volatility (94.94) will delay the development by 25.5%[1]. The volatility of trading volume will also significantly delay the development, and one standard deviation (16100.3) will reduce the probability of development by 13.9%. This result is very similar to Bulan and Somerville's and Cunningham's results. Those studies show that the probability of development drops by 13% and 11%, respectively, for each unit of standard deviation increase in market uncertainty. However, when the expected price falls, the impact of house price volatility is not significant, while the volatility of trading volume will cause the timing of the development to start 13.94% earlier. Therefore, in the main urban area, when the market is good, the waiting option effect is obvious; developers are willing to wait for the opportunity to gain greater value. When the market disimproves, they choose early commencement, in order to reduce risk. If a COX proportional risk model is used (instead of the Weibull distribution hypothesis) to perform the regression, the results in Table 2 change slightly. In Columns (1) and (3), price movements become significantly negative at the 5% and 10% levels, respectively.

Table 3 shows the regression results of the suburban areas covered by this study. The price volatility will increase the probability of starts. Although the trading volume volatility shows negative signs in Columns (2) and (3), after introducing the competition factors, the demand uncertainty still leads to the early effect. When considering the combined effects of competition and uncertainty,

Table 2. Results of survival analysis of timing of development in main urban areas in Hangzhou

Variables	House price volatility (1)	Trading volume volatility (2)	Price & volume volatility (3)	Expected to rise (4)	Expected to decline (5)	Expected to rise (6)	Expected to decline (7)
Hp-vol	−1.57e-3	/	−1.63e-3	−3.10e-3*	−1.09e-3	/	/
Tv-vol	/	3.96e-6	4.33e-6	/	/	−9.28e-6**	9.23e-6***
Rate	0.056	0.103	0.047	0.121	0.063	0.102	0.111
Capacity	0.062	0.062	0.060	0.052	0.122	−0.053	0.110
Listed	0.477***	0.474***	0.465***	0.698***	0.247	0.757***	0.252
State-owned	−0.092	−0.104	−0.086	−0.078	−0.015	−0.085	−0.055
Joint	−0.291*	−0.309**	−0.289*	−0.268	−0.236	−0.279	−0.224
Ratio	−0.038	−0.040	−0.030	−0.059	−0.009	−0.057	−0.022
Decorated t	−0.009	−0.013	−0.026	0.061	−0.187	0.145	−0.205
Dis-WL	0.045***	0.048***	0.045***	0.060***	0.047**	0.063***	0.055**
Dis-CBD	−0.019	−0.026	−0.021	−0.024	−0.034	−0.020	−0.045
Exp growth	0.074	−0.182	−0.206	−1.624	0.285	−2.50**	0.293
Current price	−3.70e-5	−2.02e-5	−3.10e-5	−3.65e-5	−2.96e-5	8.38e-6	−3.54e-5
Competitor	−0.002	0.034*	0.005	−0.038	−0.055	0.040*	0.006
*Competitor * vol*	1.31e-4	−6.02e-7	−6.63e-7	3.59e-4	1.48e-4	/	−9.88e-7**
Weibull p	/	1.443	1.440	1.509	1.456	1.529	1.471
Log likelihood	−523.236	−524.841	−522.491	−273.662	−241.269	−271.985	−239.074
LR chi2 (13)	51.36	48.13	52.83	48.73	18.63	52.09	23.02
Prob > chi2	0.0001	0.000	0.000	0.000	0.179	0.000	0.060
Num. of obs.	456	456	456	238	209	238	210

Note: The coefficient of interaction *Competitor * vol* in Column (3) refers to interaction between *Competitor* and *Tv-vol*. In Column (6), the interaction item is not included, because neither the transaction volatility nor the interaction item is significant if it is included. The constant terms are all significant, which are not shown here; ***, **, * represents the significant level of 1%, 5% and 10%, respectively.

[1] The influence of a unit standard deviation of price volatility is calculated by $e^{\sigma \cdot \beta} - 1$, where β represents the estimated coefficients in Table 2.

market uncertainty will increase the probability of development, and one standard unit of deviation volatility of house price and trading volume will advance the development start time by 13.14% and 2.5%, respectively. In the case of expected price growth, one standard unit of deviation price and trading volume volatility will advance the development by 8.9% and 3.3%, respectively. In the case of an expected decline in price, the advancing effect on development timing is more obvious, which reaches 20.7% and 4.2%, respectively. In suburbs, the significant competition effect limits the play of the development option. In recent years, the suburbanization of cities and the development of suburban housing markets interact with each other. The local governments have increased the supply of suburban land and improved transportation facilities, in order to improve the development of the city and to attract more residents. Many real estate developers are optimistic about the economic development and real estate prospects of Hangzhou. Therefore, they choose the high turnover mode to seize the largest possible market share of the suburban market. This phenomenon leads to a weakening of the delay option in the suburb.

By comparing Table 2 and Table 3, the competition variable is not significant in most of the main city models. However, the competition variable and competition interaction items are significant in all of the suburban models. When the expected price drops, the competition variables have a greater impact on the timing of the development. Considering the interaction with house price or trading volume volatility, with every one unit of increase in competitors, the start possibilities will be increased by 2.3% or 3.6%, respectively. When the expected housing price goes down, the expected growth rate variable under the suburban sample is significant and positive. This finding is consistent with the theoretical prediction. In the context of China's immature real estate market, developers are risk-averse. Therefore, when the market is expected to deteriorate, they choose to develop early, in order to recover funds. Significant spatial differences exist in decoration variables, and in the suburban sample, the performance is significant. Decorated projects are more likely to develop in advance. The floor area ratio variable is significant and negative in most cases in the suburbs. In the main urban model, the listed variable is significant positive at a 1% level in most cases. Especially in the case of expected growth, the probability that the projects developed by listed companies will increase is over 100% more than those of non-listed companies. However, this effect is not significant in suburban areas. The distance to West Lake is significantly positive in the main urban area. The closer to West Lake a property is, the more significant is the value of the waiting option. These differences indicate that, in suburbs with relatively greater market risk and looser market regulations, projects with greater flexibility tend to be developed earlier.

The combined results of both areas validate Hypothesis 1. The volatility of both housing price and trading volume has significant impacts on the timing of starts only

Table 3. Results of survival analysis of the timing of development in suburban areas in Hangzhou

Variables	House price volatility (1)	Trading volume volatility (2)	Price & volume volatility (3)	Expected to rise (4)	Expected to decline (5)	Expected to rise (6)	Expected to decline (7)
Hp-vol	4.49e-3***	/	3.00e-3*	4.26e-3***	5.68e-3***	/	/
Tv-vol	/	−2.39e-5***	−1.53e-5**	/	/	−2.44e-5***	−3.98e-5***
Rate	0.058	−0.048	0.111	0.060	0.143	0.018	−0.043
Capacity	0.089	0.044	0.034	0.235	−0.075	0.205	−0.078
Listed	0.220*	0.262*	0.229*	0.159	0.024	0.190	0.127
State-owned	0.166	0.241	0.225	0.161	−0.030	0.294	0.049
Joint	0.111	0.127	0.074	0.227	−0.146	0.091	−0.029
Ratio	−0.144**	−0.093	−0.117*	−0.090	−0.190**	−0.034	−0.157*
Decorated t	0.360***	0.308**	0.346***	0.146	0.778***	0.071	0.682***
Dis-WL	0.014	0.013	0.015	0.015	0.017	0.016	0.018
Dis-CBD	−0.024	−0.014	−0.020	−0.023	−0.027	−0.016	−0.017
Exp growth	−0.303	−0.362	−0.44	−1.652	5.464***	−1.772	4.767***
Current price	7.15e-5**	9.03e-5**	9.19e-5**	8.54e-5*	−1.52e-5	1.22e-4**	7.31e-5
Competitor	0.125***	−0.104***	−0.052	0.120**	0.153***	−0.152***	−0.121***
*Competitor * vol*	−4.79e-4***	3.53e-6***	2.97e-6***	−5.29e-4***	−5.00e-4***	3.89e-6***	5.18e-6***
Weibull p	1.235	1.258	1.271	1.249	1.314	1.313	1.331
Log likelihood	−469.932	−464.72	−462.71	−253.334	−206.56	−244.50	−204.846
LR chi2 (13)	40.49	50.93	54.94	18.86	41.20	36.53	44.64
Prob > chi2	0.000	0.000	0.000	0.170	0.000	0.000	0.000
Num. of obs.	357	357	357	195	162	195	162

Note: The coefficient of interaction *Competitor * vol* in Column (3) refers to interaction between *Competitor* and *Tv-vol*. ***, **, * represents the significant level of 1%, 5% and 10%, respectively.

in certain contexts. In many cases, the delay effect of the development option does not work. Also, volatility performs differently in the main city, compared to the suburb. Whether the developer is a listed company, the floor area ratio, whether the houses are decorated, the distance to West Lake, the expected growth rate and the degree of competition are all key variables that have a significant impact on the timing of housing developments.

4.2. The influence of construction scale and land price

The construction scale may have an impact on the timing of investment. Large-scale construction projects offer additional choices in terms of planning and design; large projects also have the scale advantage of cost. Construction progress can be controlled by dividing the various stages and batches of development, and there is also flexibility allowing investors to resist market risks. According to the average building area, the sample in this study is divided into two parts: large- and small-scale construction. The choice of timing to start is investigated respectively. The results indicate that volatility of price and trading volume has a significant impact on the large-scale construction sample, but not on the small-scale construction sample. In the large-scale construction sample, considering the interaction between competition and uncertainty, house price volatility leads to an advance of development, with the probability of development increased by 3.25%. Trading volume volatility, on the other hand, leads to a 9.3% increase in development probability. When the building area variable is added to the model of the small-scale sample, the coefficient is significantly positive. This indicates that, when the building area increases by 10.000 m^2, the probability of early development increases by 2.23%. The regression results verify Hypothesis 2; that is, large-scale projects tend to have an earlier construction start time under the influence of market uncertainty.

The payment of land leasing charges is the primary prerequisite for land development rights. Higher land prices will bring about more financial pressure on developers, and early development is conducive to the quick recovery of funds. On the other hand, there will be higher expectations for the future price of the project. Land cost variables are added to the main urban area sample model. Considering the volatility of house price and trading volume, as well as the interaction of competition, land cost is significantly positive, either in the form of the total land price or floor land price per floor area. This finding indicates that when the land cost increases, the probability of an early start of the project also increases. If we divide the sample into two parts according to the land price of parcels, any uncertainty regarding the house price in the high-priced land sample will lead to a significant delay in development. However, the impact of price uncertainty is not significant in the low-priced land sample. This confirms Hypothesis 3. The volatility of trading volume will lead to a 7% advanced reaction in low-priced land sample, but the change is not significant in high-priced land sample. This result further indicates that developers show characteristics of risk aversion in cases of fluctuating trading volumes. The regression results about the influence of the building area and land price are not shown here, due to space limitations.

5. Empirical study on sales timing decisions

"Property hoarding" under the phased-sale system is essentially an investment timing decision problem. The government has introduced many policies relating to the sales area and housing supply information disclosure. In practice, the developers can adjust the development schedule to meet the pre-sale conditions, so as to adjust the timing of sales. This section takes the main urban area and suburban area, respectively, as samples. Under each range of samples, the first stage (a non-phased project is seen as the first stage developed) and subsequent stage samples are distinguished, and the regression results based on the Weibull risk model are shown in Table 4.

The possibility of sales for projects that open first will increase by 22.1% in the main urban area, for each unit of standard deviation increase in price volatility. For subsequent-stage projects (which have been partially opened in the previous period), the uncertainty of trading volume will bring about a significant delaying effect. When the volatility of trading volume increases by each 1 standard unit of deviation, the probability of sales will decrease by 17.9% in the suburban area. Through a phased-sales strategy, the effect of adjusting the pace of sales pace to mitigate risks is obvious. The coefficients of land price are significantly positive in all cases, indicating that the sales of projects with high land price tend to advance. When we divide the sample according to the land price, the price volatility leads to advancing the sale in the high-priced land sample. However, in the low-priced land sample, the significant delay effect caused by the uncertainty of trading volume will offset the advance effect of price volatility. This is consistent with Hypothesis 4.

In the main urban area, the higher the current price is, the more significant the sales delay will be. For similar reasons, the risk-free interest rate significantly delays the timing of sales in the main urban area, but this is not the case in the suburban area. An increase in the risk-free interest rate will increase the value of the call option (Bulan et al., 2009); the real estate in the main urban area has more of the obvious call option characteristics. Conversely, in suburban areas, the floor area ratio and whether the houses are decorated are two strong significant variables. With permission for large floor area ratios, and with the flexibility to change the decoration specifications of the project during the development process, the developers can adjust their investment strategy based on market changes. The possibility of such adjustments may enable the project to open early, in order to seize the market, and later, the plan can be changed with time. In addition, in the suburban sample, the distance from the CBD variable coefficient is significant. The further away from the CBD

Table 4. Results of empirical research on the timing of sales in main urban and suburban areas

Variables	Main urban area			Suburban area		
	Price & volume volatility (1)	First stage (2)	Subsequent stage (3)	Price & volume volatility (4)	First stage (5)	Subsequent stage (6)
Hp-vol	1.63e-3***	0.97e-3**	1.88e-3***	2.51e-3***	2.29e-3***	2.75e-3***
Tv-vol	–1.46e-6**	1.38e-7	–1.77e-6**	–5.54e-6***	4.02e-6	–5.99e-6***
Rate	–0.182***	–0.053	–0.236***	0.011	–0.214**	0.030
Capacity	0.102	0.155	0.139	–0.025	–0.029	–0.048
Listed	0.154**	0.130	0.206**	0.155**	0.033	0.180**
State-owned	0.198***	0.160	0.236***	0.263***	0.308	0.226**
Joint	–0.263***	–0.132	–0.279***	0.392***	0.379	0.368***
Floor area ratio	–0.006	–0.046	–0.029	0.239***	0.061	0.294***
Decorated	0.004	0.014	–0.069	0.412***	0.548***	0.414***
Dis-WL	0.018**	0.052***	0.014	0.020**	0.012	0.018*
Dis-CBD	–0.003	–0.019	0.001	0.019**	0.023	0.019*
Exp growth	–0.102	0.040	–0.042	–0.352	–0.808	–0.362
Current price	–4.05e-5**	–2.36e-5	–5.03e-5**	5.71e-6	2.46e-5	9.19e-6
Competition	0.004	0.015	–0.004	3.89e-3	0.022	0.002
Inform	0.176***	–0.060	0.323***	–0.187***	–0.349**	–0.186**
Land price	5.04e-5***	4.35e-5***	5.15e-5***	1.68e-4***	1.60e-4***	1.71e-4***
Sectv	–0.099***	–0.131**	–0.082**	–0.085**	–0.232**	–0.046
Weibull p	2.239	1.997	2.480	2.055	1.841	2.197
Loglikelihood	–927.53	–309.19	–563.86	–939.03	–227.64	–671.85
LR chi2 (13)	179.24	50.18	163.36	321.15	69.41	277.80
Prob > chi2	0.000	0.000	0.000	0.000	0.000	0.000
Num. of obs.	1240	367	873	1133	252	881

Note: ***, **, * represents the significant level of 1%, 5% and 10%, respectively.

the development is, the sooner the sales will commence. The difference between the two types of samples is very significant. In the main urban area sample, the pre-sale of projects with low levels of information noise is significantly advanced; the probability of the pre-sale of subsequent-stage projects increased by 39.2% in the sample period. This is consistent with assertion that investors with more information will exercise options earlier (Grenadier, 1999; Ott et al., 2012). However, in suburban areas, the information symbols are significantly negative, which means that projects with low levels of information noise will delay sales. Galster (2001) points out that signal effects may be more important to buyers who are considering buying houses on the edge of the city. In this paper's samples, the mean value of the information variable in the city sample is 0.32, while the main urban sample value is 0.48. In a suburban real estate market with relatively poor maturity, projects with more sufficient information (low information noise) are more confident regarding the future. Therefore, developers will choose to delay sales, in order to obtain the value of the wait option. In the regression results, the possibility of delaying sales in the first phase of a suburban property is greater than in the subsequent stages, which effectively illustrates this same point. The intuitionistic market situation reflected by the change of second-hand house transactions volume has a significant negative impact on the timing of sales. This is consistent with the option effect indicated by the trading volumes volatility.

As can be seen from the significance of the impact on the timing of sales, obvious differences exist between the two types of samples of the main urban and suburban areas. Variables that are significant in the main urban area are less significant in the suburban areas. These variables include a risk-free rate of interest, the current price and so on. Conversely, variables such as floor area ratio, whether the houses are decorated, the distance from the CBD, and the volume of competition are all significant in the suburban area sample, thus indicating the advanced effect. In almost all cases, an increase in the volume of second-hand homes will help delay the timing of sales. The only case where the coefficient is not significant is in the suburban projects with a longer pre-phase stage.

Conclusions

Based on the real option theory, adopting the data of newly-built houses and corresponding plots in Hangzhou, this paper studies the impact of market uncertainty on the timing decisions related to development and sales. The results show that the option effect of start brought by price uncertainty occurs only in the main urban area when expectations are good. However, the delayed effects of trading volume volatility occur not only in main urban areas with rising expectation, but also in suburbs. It's merely that, in the suburbs, the option effect is offset by the competition effect. This finding reflects the market's long-term confidence in the main urban area. The scale of construction has a significant impact on the timing of development. For those developments with a larger building area, the probability of starts increases. Land price is also an important factor affecting the start time of the project. The higher the land price, the more likely the project is to have an early start. However, under uncertain market conditions, those projects with higher-priced land are also more vulnerable to volatility in house prices. This can result in delayed development, in order to obtain the full value of waiting options. The empirical results of sales timing show that, in all conditions, housing price uncertainties are positive and are significant at the level of 1%. However, volatility of trading volume basically causes a negative reaction, except for samples in the first stage.

Compared with previous studies, this paper not only examines the impact of house price volatility on housing investment timing, but also introduces the volatility of trading volume to measure market and policy uncertainty. It turns out that, in the Chinese housing market, which is subject to relatively large policy intervention, the volatility of trading volume has a great impact on the timing of project development and sales. Only considering the uncertainty of price may lead to an error in judgement with regard to the timing of the investment. Another innovation of this paper is that it distinguishes the timing of investment into starts and sales. Previous studies use the actual or estimated time of development to measure the timing of investment, thereby ignoring the value of the compound option. By collecting the data of project starts and phased sales, this paper studies the options of the two sequential decisions under the pre-sale system, and verifies the relationship between them. This information is supplemental to the existing theoretical research. In addition, this paper also finds that the timing of investment in housing projects in different urban areas varies greatly under the influence of market uncertainty, and also identifies the differences between some project characteristics and enterprise characteristics in different regional projects. We have tried to study the impact of the duration from land acquisition to the start on the decision of the next timing. However, the results are ambiguous. This may be because, in the early years, the data of phased development and phased sales did not match well. This issue needs to be demonstrated in the future, based on more accurate data.

Therefore, to solve the problem of land idleness, the government should pay closer attention to the regulation and control of emerging areas and make corresponding legislative adjustments according to the market situation. To solve the problem of small batch sales, the department could build a transparent platform for information disclosure, and regulate the phased sales that occur after the first sale stage, particularly for projects in urban fringe areas. The government could also strengthen the supervision of property quality and the credibility of developers. The most important thing is that, no matter what kind of problem the policy is aimed at, the means of regulation and control should be coherent and time-sensitive.

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Author contributions

Ling Zhang and Xin Chang conceived the study and were responsible for the design and development of the data analysis. Dingyin Shi were responsible for data collection and analysis. Haizhen Wen were responsible for data interpretation. Ling Zhang wrote the first draft of the article.

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