Research on Land Reserve Scale Based on Inventory Theory

Xinxin Li

154976642@qq.com

Shandong Jiaotong University, Jinan, Shandong, China

Abstract. The real estate industry is one of the important pillar industries for the development of China's national economy, and land is an important element of the real estate market. The reasonable scale of land reserves can promote the balanced development of the real estate market to a certain extent. This article analyzes the influencing factors of land scale, applies inventory theory to analyze land scale, and analyzes the impact of land reserve scale on the real estate market. Finally, from the supply side, it proposes land reserve policies for the balanced development of China's real estate market.

Keywords: Land reserve scale, Equilibrium of Real Estate Market, Inventory theory

1 Introduction

According to the experience of regulating the real estate market, it is known that in order for land factors to play a certain role in the macroeconomic regulation of the real estate market, land reserves must reach a certain scale.

There are generally two models for determining the scale of urban land reserves: regular replenishment and early warning monitoring models[1]. The regular replenishment model refers to first reserving land that can be used for a certain period of time (such as 20 years), and then supplementing a certain amount of land at regular intervals (such as 5 years). This method only requires regular inspections and does not require real-time monitoring, which can reduce monitoring costs. At the same time, it is also convenient for investors to make predictions. But this model also has its drawbacks: if the replenishment cycle is too long, the supplied land may not meet the usage requirements, and if the replenishment cycle is too short, the cost of land reserves will increase. To ensure the use of land, the replenishment cycle of this model should generally not be too short. Therefore, this model is generally applicable to countries or regions with abundant land resources, such as Oregon in the United States[2], which uses this model for land reserves. China is short of land resources, which is generally not applicable, but this model can be used for reference in areas with small population density such as Xizang and Xinjiang. The early warning monitoring model refers to setting a minimum warning line for land reserves in advance, and starting to reserve land when the reserve level falls below this warning line. The advantages and disadvantages of this model are opposite to the regular replenishment model.

This article will attempt to use early warning monitoring models to predict the scale of land reserves. When determining the warning line for land reserve scale, multiple factors should be taken into account. Firstly, it is necessary to ensure the effective demand of the land market.

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The supply of land is a situation that cannot be out of stock for the real estate market, because if the effective demand of land cannot be guaranteed, it will cause panic in the real estate market, artificially raising real estate prices. Secondly, it is necessary to consider the cost and time of acquiring land. In addition, the cost of land reserves should also be considered.

2 Factors affecting the scale of land reserve

When determining the scale of land reserves, two factors should be comprehensively considered: land reserve cost and land reserve quantity.

2.1Land reserve quantity

In the process of land reserve, if the scale of land reserve can not meet the normal demand for land, it will lead to the shortage of land in the market, and the price of land will rise, which will affect the normal operation of the real estate market. Therefore, in determining the scale of land reserve, we should ensure the effective demand for land on the basis of reducing the cost of land funds.

2.2Land reserve cost

Land capital cost includes land acquisition cost, land development cost and land reserve cost. Different ways of land acquisition, the cost of its acquisition needs to consider different factors. When the land fund cost is forecasted, it should carry on the investigation to the land parcels possibly involved according to the planning requirement. First of all, distinguish the type of land plots, and then land plots may involve the investigation of residents, enterprises, housing and other conditions, and the possible situation of risk analysis.

Land acquisition cost, development cost and reserve cost should be considered when determining the scale of land reserve. If the reserve is too large, the cost of the land reserve will increase. If the reserve is not sufficient, the acquisition of land may be urgently needed to meet the demand, the acquisition and development costs may increase.

3 Scale model of land reserve

Although the overall land resources in our country are relatively poor, many of the land currently being used have low efficiency. By integrating land, not only can reserve land be obtained, but also land use efficiency can be improved. The land that can be used for reserve includes: industrial and mining enterprise land with lower plot ratio, residential land with lower plot ratio that can be used for old village renovation, unused land purchased by developers, and land with lower rural utilization efficiency or idle land[3].

According to inventory management theory and the basic characteristics of the real estate market, land supply is not allowed to have shortages. The timing of land acquisition varies depending on the type of land supply. Idle land can be reclaimed free of charge, and the acquisition time of such land can be approximated as 0, which is instantaneous procurement[4]. The supply of other land needs to be purchased or requisitioned for agricultural use before development, and land acquisition requires a certain amount of time, which is non-instantaneous procurement. In

the analysis of this article, land reserves are considered as non-instantaneous procurement, and the speed of land acquisition is taken as the weighted average of several acquisition methods. According to whether the demand for land is accurately determined, the land reserve scale model can be divided into two situations.

3.1 Deterministic land reserve model

If the demand for land can be accurately determined, it can be calculated based on a model where the demand is a fixed non-instantaneous purchase and the prohibition of land shortage. In this case, a minimum warning line for land reserves should be set. When the land reserve reaches the minimum reserve, land acquisition and development should start at a certain speed to ensure a certain amount of land storage[5]. At the same time, the land will also be released at another speed to meet the needs of commercial housing construction. Due to the prohibition of land shortage, the speed of acquiring land should be greater than or equal to the speed of land outflow, until the land inventory reaches the maximum inventory level, and then it can be stored according to the demand speed.

Assuming Q is the bulk order of land in one go; T represents the land purchase cycle, and the land acquisition cycle varies depending on the type of land. r1 represents the speed of land entry, and r2 represents the speed of land exit. So $\frac{Q}{r_1}$ is the time required to purchase land, i.e. the land purchase cycle T, therefore: $T = \frac{Q}{r_1}$, $\frac{Q}{r_1} r_2$ represents the quantity of land out of stock within a purchase period. The average land storage capacity is $\frac{Q}{2}\left(1-\frac{r_2}{r_1}\right)$. The unit's land reserve fee is C_1, one-time order fee is C_2, the annual demand for land is R, then the average land storage cost under this model is $\frac{Q}{2}\left(1-\frac{r_2}{r_1}\right)C_1$, the total ordering fee is $\frac{R}{Q}C_2$. As out of stock is not allowed, we do not consider out of stock losses, and the total cost is:

$$C = \frac{Q}{2}\left(1-\frac{r_2}{r_1}\right)C_1 + \frac{R}{Q}C_2 \tag{1}$$

The optimal storage capacity is the minimum order quantity for C. Taking the first derivative of equation (1) yields:

$$Q^* = \sqrt{\frac{2RC_2}{C_1\left(1-\frac{r_2}{r_1}\right)}}$$

The minimum storage cost is:

$$C_{\min} = \sqrt{2RC_1C_2\left(1-\frac{r_2}{r_1}\right)}$$

The optimal number of orders is: $\mu^* = \frac{R}{Q^*}$

The unit land reserve fee (C_1) needs to consider the unit opportunity cost of land (C_1') and the unit capital cost of land acquisition fee (C_1''), and take the smaller value of the two. That is to say: $C_1 = \max(C_1', C_1'')$.One-time ordering fee (C_2) should be determined based on the type of land. If there are multiple types of land, the cost of land acquisition can be taken as the weighted average cost of acquiring each type of land. r_1 and r_2 can be calculated based on transaction data in the land market, that is, the area of land acquired and the area of land sold per unit time (month or quarter) can be calculated based on various data in the land market.

3.2 Random land reserve model

The prerequisite for a deterministic land reserve model is that the demand for land is accurate. The demand for land is based on market transaction data from previous years and predicted using mathematical models, which may have significant uncertainty. The uncertainty in the market has a significant impact on land supply, and every 1σ increase in this uncertainty will reduce the probability of land supply by 42%[6].Therefore, it is necessary to determine the land reserve amount based on a random inventory model with demand and ordering time. For this situation, there are two characteristics in the land supply process. Firstly, due to the random fluctuation of land demand, it leads to the random fluctuation of land storage. Secondly, due to the randomness of various factors, there is a stochastic delay in land supply time. In order to ensure the normal operation of the real estate market, it is necessary to determine a land safety reserve (i.e. the minimum warning line) in advance. When the land reserve decreases to a certain extent, we start to requisition land. This way, even if the land acquisition cannot meet the demand for land, there is still a certain amount of safety reserve as a guarantee.

According to the survey analysis, two hypothetical conditions can be set.

（1） The demand for land follows a Poisson distribution.

$$P(r) = \frac{(\rho t)^r}{r!} e^{-\rho t} \qquad (r = 0,1,\cdots)$$

Here, ρ is the average demand per unit time.

（2） The acquisition time of land (known as the subscription period, which is the length of time from the beginning of preparing to acquire land to the actual acquisition of land) is randomly continuous, assuming a normal distribution. The probability density function of land acquisition time x is: $$P(x) = \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{(x-\mu)}{2\sigma^2}}$$

Here, μ is the average land acquisition time, and σ is the mean square deviation. Assuming that the land inventory decreases to B and we begin to acquire land, the time of land acquisition

is assumed to be $x_1, x_2, \cdots, x_n$, then: $\mu = \frac{1}{n}\sum_{i=1}^{n} x_i$. If the demand for land during the average land acquisition time is D, then $D = \mu\rho$.

When $B = D + S$, the probability of causing out of stock is: $P_B = \sum_{x=1}^{n} P(x) Fx(B)$

Here, $P(x) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\frac{x-\mu}{\sigma}} e^{-\frac{t^2}{2}} dt$, $Fx(B) = \sum_{r>B} \frac{(\rho x)^r}{r!} e^{-\rho x} = 1 - \sum_{r=0}^{B} \frac{(\rho x)^r}{r!} e^{-\rho x}$

The expected value of out of stock loss for batch n is nC_3P_B, where C_3 is the out of stock loss per unit of land.

Due to the consideration of the delay time in land purchase at this time, the optimal quantity of land can be determined without considering the time of land purchase, and can be calculated based on the instantaneous purchase situation. In this way, the optimal land order quantity calculated is: $Q_1^* = \sqrt{\frac{2RC_2}{C_1}}$

In this way, if the average storage capacity of the land at any time is $\frac{Q_1^*}{2} + S$ and the optimal number of orders is $n_0 = \frac{R}{Q_1^*}$, then the storage cost is $(\frac{Q_1^*}{2} + S)C_1$. Since $\frac{Q_1^*}{2} C_1$ is deterministic, when calculating the total cost, it can be assumed that $C' = n_0 C_3 P_B + C_1 S$. Based on the different values of B and S, the corresponding total cost C' can be calculated, and the minimum cost can be found to determine the optimal B and S. Land reserves affect the real estate market from a supply perspective, and the impact of different land supply conditions on the real estate market varies. The international and national supply situation will have a macro impact on housing prices, and the impact of regions and enterprises on the real estate market will be more manifested at the micro level, with a more direct impact. Therefore, when selecting the scale of land reserves, more consideration should be given to regional conditions, and regional data should be collected and determined using the aforementioned theoretical formulas.

4 The impact of land reserve scale on the equilibrium of the real estate market

In the actual economic production process, if there is randomness between demand and supply, in order to ensure the sustainable operation of production, it is often necessary to ensure a certain amount of safety stock. As mentioned earlier, in most cases, there is a significant randomness in land supply and demand. To ensure the balanced and healthy operation of the real estate

market, and not to have adverse effects on the real estate market due to a lack of land supply, land reserves need to ensure a certain amount of safety reserves. The amount of land security reserve can be determined by drawing on the concept of safety stock in econometrics. The simplest method to determine the amount of safety stock is to determine it based on the probability distribution of demand, using the "3σ criterion". That is to say, if the probability distribution of demand is determined, the safety stock quantity is: $d=3\sigma$. Because $P(|\xi-a|<3\sigma)\geq 99.73\%$, that is, when the land reserve decreases to d, we need to seize the time to expand the land reserve quantity. By doing so, the probability of land shortage during the operation of the real estate market is 0.27%, and it can be approximately assumed that the phenomenon of insufficient land supply is almost impossible to occur.

If the probability distribution of land demand cannot be accurately determined, the average land demand for each year can be calculated based on the transaction data $x_i(i=1,2,\cdots,n)$ of the land market at each time point in a certain region over the years. Then, determine its mean square deviation. Namely: $S=\sqrt{\sum_{i=1}^{n}(x_i-\bar{x})^2}$, The amount of land safety inventory can be estimated as $d=3S$. When determining the safety stock of land, it is also necessary to consider the operational status of the regional land and real estate markets. When regional land resources are scarce and land reserve costs are high, the safety stock of land can be slightly reduced. For example, you can choose $d=2S$, but this will make $P(|\xi-\bar{x}|<2S)\geq 95.45\%$, which will increase the likelihood of land shortage to 4.55%. If you choose $d=S$, then $P(|\xi-\bar{x}|<S)\geq 68.27\%$ increases the likelihood of land shortage to 31.73%. It is recommended to maintain the safety stock of land between $[2S, 3S]$[7]. In this way, it can ensure that the probability of shortage of land supply is very low, so that the real estate market will not operate abnormally due to insufficient land supply; And it won't increase storage costs due to the excessive backlog of land.

When determining the scale of land reserves, the range of land demand should be determined based on the demand for new houses, taking into account the reasonable range of the ratio of floor area and the ratio to inventory of real estate enterprises. In order to prevent the occurrence of risk events, a certain amount of surplus reserves (elastic reserves) should be determined. However, due to excessive land reserves, it can lead to high costs. Therefore, it is not advisable to have too much surplus reserves (elastic reserves). It is best to use information reserves, which can not only ensure the demand for land but also reduce costs[8].

5 Land reserve scale policy

The scale of land reserves affects the operation of the real estate market from the supply side. When determining the scale of land reserves, the following aspects need to be considered:

5.1 Ensure sufficient land reserve scale

According to the experience of foreign land systems, land reserves can only play a role in regulating the real estate market if they have sufficient scale and need to be implemented in the long term. To ensure that land supply is in a state of no shortage, general land reserves should ensure a safety reserve, and inventory should always be greater than or equal to the safety reserve, in order to reduce the occurrence of risks.

5.2 Expand land reserve channels

To obtain sufficient land reserve scale, it is necessary to ensure basic agricultural land, and the overall supply of land is certain. Therefore, it is necessary to consider how to expand the channels for land acquisition. The main channels for expanding land reserves include:: firstly, timely recovery of land that real estate development companies fail to develop on time; Secondly, according to the requirements of urban planning, explore the construction of new urban areas and the renovation of old urban areas; Thirdly, for land that cannot be sold for a long time, find ways to package it, such as increasing the construction of surrounding infrastructure, in order to increase the value of the land and sell it in a timely manner[9].

5.3 Consider land reserve costs

Although land reserves must reach a certain scale to play a role in regulating the real estate market, they cannot expand indefinitely. On the one hand, land resources are scarce, with a fixed total amount that cannot expand indefinitely. On the other hand, reserving land resources incurs costs. When determining whether to reserve a piece of land, it is important to weigh the opportunity cost of land reserves and the benefits they bring.

In addition, reducing the cost of land reserves can also be achieved by setting up flexible land reserves and information reserves. By collecting basic data on the operation of the real estate market, the scale of basic land reserves can be determined. In addition to considering certain safety reserves, a certain amount of elastic reserves can be used to meet a small amount of abnormal demand in the market. To ensure the demand for land in the real estate market, it is also necessary to establish an information reserve. When the real estate market really needs it, in addition to using safety stock, accelerating the acquisition process based on information reserves may increase procurement costs, but it can avoid a large amount of reserve costs.

5.4 Considering land use efficiency

When determining the scale of land reserves, it is also necessary to consider the efficiency of land use to ensure that land can be intensively utilized. While ensuring the effective demand for building area, the issue of plot ratio should also be considered. Due to the large population in our country, especially the rapid increase in urban population brought about by the acceleration of urbanization at the current stage, the plot ratio cannot be too low. When providing land, it is advisable to build a supply of low plot ratio land as much as possible, but also to meet people's living needs.

To ensure the efficiency of land use, it is necessary to increase the treatment of idle land. Because idle land not only reduces land utilization efficiency, but also reduces the regulatory role of land in the real estate market. As a means of regulation, land must ensure that "one entry and one exit" in order to play a role in the real estate market. Therefore, the phenomenon of real

estate developers hoarding land must be severely cracked down on[10]. If the land is idle for more than one year, it must be confiscated without compensation to avoid market speculation on the land.

6 Conclusions

Based on the goal of ensuring balanced development of the real estate market, this article analyzes the scale of land reserves and proposes several reasonable models for land reserve scale. Finally, policies on the scale of land reserves were proposed from several aspects, including land reserve costs, reserve channels, and land use efficiency. This article is mainly based on the analysis of the current situation of land resource utilization in China. Other countries or regions with relatively scarce land resources can refer to the early warning and monitoring model used in this article. For countries or regions with relatively abundant land resources, regular replenishment models can be used for analysis.

References

[1] Zhang Jing. The regulatory impact of land reserve management mechanism on the development of the real estate market [J]. Industrial Economy，2022 (34)：66-68.

[2]Andrew J.Clark,Herbert Scarf.Optimal Policies for a Multi-Echelon Inventory Problem[J].Management Science,2004,50(12)：1782-1790.

[3]Li Yaoyao, Zhu Daolin, Zhang Lixin. Study on the Time Delay Relationship between Land Reserve, Land Supply, and Real Estate Market Supply: A Case Study of Beijing [J]. China Development,2018,18(2):52-56.

[4]Zeng Xiaoyi. The Impact of Land Reserve System on the Real Estate Market and Countermeasures[J]. Operating Wisdoms，2023(2)：193-195.

[5]Diressen J P C, Peng H, Van houtum G J. Maintenance optimization under non-constant probabilities of imperfect inspection[J].Reliability Engineering and System Safety, 2017,165:115-123.

[6] Maryam Akbari Kaasgari,Din Mohammad Imani,Mehdi Mahmoodjanloo.Optimizing a vendor managed inventory (VMI) supply chain for perishable products by considering discount：Two calibrated meta-heuristic algorithms[J].Computers & Industrial Engineering,2017,103：227-241

[7]Fu Yiman, Zhou Jianjun, Sun Qianqian, Li Wenjun. Diversified Urbanization, Threshold Effect, and Real Estate Inventory: Theoretical Explanation and Empirical Testing[J].Financial Theory and Practice, 2018,39(3):127-133.

[8] Liu Chunqiang, Xiao Minji Shunwei, Li Jingtao.On the Innovation of Provincial Reserve Mechanism under the Background of Entrusted Agency[J].Chinese land, 2023(11):56-57.

[9]Hadi Mokhtari，Mohammad Taghi Rezvan.A single-supplier，multi-buyer，multi-product VMI production-inventory system under partial backordering[J].Operational Research，2020，20（1）：21-22.

[10]Wang Yifan, Li Tiange, Wang Fantasy, Wang Zhengyan, Wei Lin.Reflection on the Construction and Existing Problems of Land Reserve System in Henan Province[J].Chinese market，2023（29）：33-36.