

An Evolutionary Game Analysis of the Construction of Affordable Housing

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Abstract: The development and construction of affordable housing is a major livelihood project, and as an important model for the construction of affordable housing, the provision of commercial housing with affordable housing can greatly relieve the government's dual pressure on funds and land. However, in the course of practice, the government is the formulation and regulator of the policy model, and the developer is the executor of the policy model. There is a conflict of interest between the two, which leads to a game. Based on the evolutionary game theory to discuss this issue, the study found that the interaction between the developer and the government will have an important impact on the result of the entire evolutionary game. The developer's active participation in the construction of affordable housing not only depends on the rationality of government supervision and punishment, and the scientificity of relevant policy formulation, but also depends on the developer's own knowledge and understanding of the nature of the construction of affordable housing as a livelihood project, and put forward relevant suggestions based on the results to better promote the process of social housing construction.

1. Introduction

The prosperity of the real estate industry has boosted China's economic growth, but at the same time rising housing prices have also put pressure on the general public, especially the low- and middle-income groups, to buy houses. In order to alleviate this situation, the government has continuously promoted the trend of China's real estate to gradually tilt towards affordable housing. As a part of a complete structured housing supply pattern, affordable housing lays the foundation for building a harmonious society, developing a prosperous economy, and promoting national stability. Commercial housing with affordable housing is an important model for the construction of affordable housing in my country. The implementation of government policies provides a positive solution to the dream of housing for low- and middle-income families. However, due to the low profit level of the affordable housing model, developers have a negative impact on commercial housing. The impact of diversion and the suppression of commercial housing prices have resulted in the inability to meet the needs of interests and lack of enthusiasm and motivation, which restricts the construction and development of affordable housing. Therefore, how to balance the enthusiasm

of the government and developers on the issue of the provision of affordable housing is an issue that we urgently need to consider and solve.

2. Literature Review

Affordable housing is a housing that is built, operated and provided to low- and middle-income groups by the government department as the implementation leader, with restrictions in terms of standard, price or rent. To a certain extent, it alleviates the housing difficulties of low- and middle-income groups facing high housing prices, solves the housing problem of some urban residents, and makes further efforts towards the goal of a well-off society in an all-round way. The matching construction model of affordable housing refers to the allocation of land for commercial housing with a portion of land for affordable housing in the land transfer link, and finally the developer who purchases the land is responsible for the construction, that is, a certain number of affordable housing will be built during the construction of the commercial housing.

Aiming at the research on the allocation of affordable housing, Sunarti emphasized the difficulty of housing market prices to meet the housing needs of low-income communities[1]; Huang used the entropy weight optimization model to conduct a quantitative study on the allocation structure of affordable housing, which provided a theoretical reference for the government to formulate the construction plan of affordable housing; Ding et al. conducted basic research on the game theory of affordable housing distribution[2]; Zhang et al. constructed an investment compensation model for the construction of rental affordable housing based on satisfactory decision-making[3]; Gu combined Swedish experience and game theory to study the development strategy of energy-efficient housing in China from the perspective of an architect[4]; I believe that only by forming profitable partnerships with other government departments and private sector community housing and real estate developers can local governments truly play a key role in formulating reasonable affordable housing strategies, partnerships, and actual projects, thereby giving These people provide suitable affordable housing[5]; Katrina pointed out that affordable housing policies are increasingly being formulated and implemented through a complex policy network composed of the state, non-profit and for-profit institutions[6].

3. Construction of Evolutionary Game Model of Guaranteed Housing Distribution

3.1 Stakeholder Relationship Definition

In this article, it is assumed that the parties involved in the construction model of affordable housing are bounded rationality. Because for participants in real economic life, the conditions of complete rationality and complete information of participants are difficult to achieve[7]. The complexity of the economic environment and the game problem itself leads to incomplete information and limited rationality of participants. The problem is obvious.

The government and developers, as the starting point for the policy implementation of the security housing construction model, are the most core stakeholders: changes in minority interests are likely to cause moral hazard, while the consequences caused by the transfer of benefits have a wide range of impacts. The game relationship between this pair of stakeholders mainly revolves around whether the developer actively participates in the provision of security housing, whether the government strictly supervises and punishes it, and discusses the game relationship of the allocation model. The main strategy set is whether developers will have low enthusiasm in the process of implementing the provision of affordable housing, and the quality and distribution of affordable housing are not high, leading to criticism or even fines under the supervision of the government to actively promote the construction of affordable housing. However, the intensity of government

supervision Whether it is positive and strict or not, it will change the probability of the construction of affordable housing, which will escape the fines, and will also get high returns, and the fines will be uncertain.

3.2 Game Model Elements

The game model is mainly composed of participants, the strategic set of participants and other elements. Under the mode of commercial housing with affordable housing, the players in the game between the developer and the government mainly include the developer and the local government (all assumed to have the thinking of a rational economic man). Participants' strategy set, the government actively or not actively promotes the provision of affordable housing, developers enter the government-related transformation project set through active or inactive behavior, and local governments strictly or not strictly supervise and punish.

3.3 Game Model Hypothesis

The government aims to promote the construction of affordable housing and promote social harmony and stability, and has a positive attitude towards the construction of affordable housing and the mode of construction of affordable housing; The developer's goal is to pursue high profits. The restraint of affordable housing for commercial housing will reduce the price of commercial housing and reduce the developer's enthusiasm for the provision of affordable housing. The two goals are not consistent, resulting in a game relationship, and the following hypotheses are formed: (1)Both the developer and the government are boundedly rational. In the evolutionary game process, the developer and the government will match randomly and repeatedly play the game; (2)The government and the developer have different utility goals and will make decisions based on the principle of maximizing their own utility; (3)The government will weigh economic benefits and social reputation. On the one hand, in order to maintain social reputation and improve social welfare and improve people's livelihood, it will implement strict supervision and punishment. On the other hand, in order to reduce the economic cost of supervision, we choose not to strictly supervise and punish; (4)On the one hand, developers may be able to obtain additional economic benefits, or they may be pressured by the government to actively participate in the construction of guaranteed housing. On the other hand, the construction of guaranteed housing may reduce the profits obtained, so they choose not to actively participate in the construction of housing; (5)Both the government and developers have strong learning and decision-making capabilities, and will choose behavioral strategies with greater returns through longer-term games and comparisons.

3.4 Benefit Matrix Construction

The parameters are set as follows:

(1) p : The probability that the developer actively participates in the construction of security housing, the probability of not being active is $1 - p$;

(2) q : The probability that the government strictly supervises and punishes, then the probability that it is not strict is $1 - q$;

(3) $R1$: Developers actively participate in the benefits of security housing construction;

(4) $R2$: Developers do not actively participate in the income from the construction of guaranteed housing. Although the construction of guaranteed housing will have certain preferential measures such as land to reduce costs, the profit of the construction of guaranteed housing is much lower than that of commercial housing, so $R2 > R1$;

(5) $S1$: Under the non-strict government supervision, developers actively participate in the protection of the reputation benefits obtained by housing construction, such as enhancing brand value;

(6) $R3$: Under strict government supervision, developers actively participate in guaranteeing additional benefits from housing construction;

(7) $C1$: The government strictly supervises the cost of whether developers carry out the construction of guaranteed housing. Supervision is the responsibility of the government, so there is no benefit;

(8) $C2$: The government does not strictly supervise the cost of whether or not developers carry out the construction of guaranteed housing, $C2 < C1$;

(9) F : Under strict government supervision and punishment, the developer was investigated and punished for not actively supporting construction. The punishment belongs to the government;

(10) $S3$: Developers do not actively carry out the construction of affordable housing, and the government does not strictly supervise and punish, which causes reputational damage to the government;

(11) $S4$: The government does not strictly supervise and punish, but developers actively participate in the construction of guaranteed housing, which brings reputation benefits to the government;

(12) $S5$: The developer was investigated and punished for not actively participating in the construction of guaranteed housing, which caused reputational damage to the developer.

Establish payment matrix as shown in Table 3.1.

Table 3 1 the Interest Matrix of the Evolutionary Game between the Government and the Developer

government	Developer	
	Actively participate in the construction of affordable housing (p)	Not actively participating in the construction of affordable housing ($1 - p$)
Strict supervision and punishment(q)	$-C1, R1 + R3$	$-C1 + F, R2 - F - S$
Lax supervision and punishment($1 - q$)	$-C2 + S4, R1 + S1$	$-C2 - S3, R2 - S5$

4. Analysis of Evolutionary Game Model of Guaranteed Housing Distribution

4.1 Developer's Evolutionary Stability Strategy

According to the benefit matrix, the adaptability of the developers when they actively participate and when they do not actively participate in the construction of guaranteed housing are as follows:

$U_1 = q(R1 + R3) + (1 - q)(R1 + S1)$	(1)
$U_2 = q(R2 - F - S5) + (1 - q)(R2 - S5)$	(2)

The average fitness of the developer is:

$\bar{U} = pU_1 + (1 - p)U_2$	(3)
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Therefore, the repetitive dynamic equation that developers choose to actively participate in the provision of security housing can be obtained by copying the dynamic equation, the adaptability of the developer's active participation in the provision of security housing, and the average adaptability of the developer as follows:

$F(p) = \frac{dp}{dt} = p(U_1 - \bar{U}) = p(1-p)(U_1 - U_2)$ $= p(1-p)(R1 + S1 - R2 + S5 + q(R3 - S1))$	(4)
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Let $\frac{dp}{dt}$ to get:

$p_1^* = 0, p_2^* = 1, q^* = \frac{R + S - R + S}{S - R - 3}$	(5)
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According to the stability theorems of differential equations and the properties of evolutionary stability strategies, when $F'(p^*) < 0$, p^* is an evolutionary stability strategy.

When $q^* = \frac{R + S - R + S}{S - R - 3}$, $F(p)$ is always 0, that is, when the probability of strict government supervision and punishment reaches q^* , the initial proportion of developers who actively participate in the construction of affordable housing or not actively participate in the construction of affordable housing is stable.

When $q > q^*$, $F'(0) > 0$, $F'(1) < 0$, $p_2^* = 1$ is the only evolutionary stable strategy, that is, the developer actively participates in the construction of affordable housing and the government's strict supervision and punishment formation Good interaction, and gradually reach the Pareto optimal state. When $q < q^*$, $F'(0) < 0$, $F'(1) > 0$, $p_1^* = 0$ is the only evolutionary stable strategy, that is, when government supervision and punishment are not strict enough, actively participate in the construction of affordable housing. The number of developers will gradually decrease, and it will be a group choice for developers not to actively participate in the construction of affordable housing.

The above results can show that the symbol of $F(p)$ is related to $R1 + S1 - R2 + S5 + q(R3 - S1)$. The developer actively participates in guaranteeing the additional income $R3$ from the provision of construction under strict supervision, the developer actively participates in guaranteeing the reputation income $S1$ of the housing construction, and the government's strict supervision and The probability q of punishment is closely related to whether the developer actively participates in the construction of security housing. The greater the value of q and $R3 - S1$, the greater the possible loss faced by developers who do not actively participate in the construction of guaranteed housing, and the developer will choose to actively participate in the construction of guaranteed housing. Therefore, the government should increase supervision and punishment, improve relevant laws and regulations, and increase the incentives for snowball developers that meet the conditions of insured housing, so as to form a strong external constraint and incentive mechanism for developers to actively participate in the construction of affordable housing. At the same time, the difference between the developers' active and non-active participation in the construction of affordable housing also has a significant impact on the developer's strategic choice. The government should increase the preferential policies for the construction of affordable housing to increase the profit of developers' Developers actively participate in the construction of affordable housing.

4.2 The Government's Evolutionary Stability Strategy

Similar to the calculation of the developer's repeated dynamic equation, the government chooses to strictly supervise and punish the repeated dynamic equation:

$G(q) = \frac{dq}{dt} = q(M_1 - \bar{M}) = q(1-q)(M_1 - M_2)$ $= q(1-q)(F + C2 + S3 - C1 - p(S4 + F + S3))$	(6)
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Let $\frac{\phi}{d}$ to get:

$q_1^* = 0, \quad q_2^* = 1, \quad p^* = \frac{F + C + S_2 - C}{S_4 + F + S_3}$	(7)
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When $p^* = \frac{F + C + S_2 - C}{S_4 + F + S_3}$, $G(q)$ is always 0, that is, when the developer's probability of

actively participating in the construction of security housing reaches p^* , the initial proportion of the government that is strictly regulated and punished or not strictly regulated and punished is stable.

When $p > p^*$, $F'(0) < 0$, $F'(1) > 0$, $q_1^* = 0$ is the only evolutionary stable strategy, that is, developers actively participate in the construction of affordable housing and the formation of strict government supervision and punishment Positive interaction, and gradually reach the Pareto optimal state. When $p < p^*$, $F'(0) > 0$, $F'(1) < 0$, $q_2^* = 1$ is the only evolutionary stable strategy, that is, when developers do not actively participate in the construction of affordable housing, the government will strengthen supervision and The intensity of punishment, strict supervision and punishment will be the government's choice.

The above results can show that the symbol of $G'(q)$ is related to $F + C_2 + S_3 - C_1 - p(S_4 + F + S_3)$. When the government does not strictly establish the relationship, the developer actively or not actively participates in the guarantee of housing construction to the government's reputation and benefits S_4 , reputation loss S_3 , and not actively being investigated The fine F resulting from participation and the probability of developers actively participating in the construction of guaranteed housing are closely related to whether the government strictly supervises and penalizes. The larger the value of p and $S_4 + F + S_3$, the smaller the possible loss faced by the government that does not strictly supervise and punish, and the government will choose not to strictly supervise and punish. However, in the evolution of non-strict supervision and punishment, developers will gradually reduce their enthusiasm for participating in the construction of guaranteed housing, which may adversely affect the reputation of the government, and the government will gradually choose strict supervision and punishment. Therefore, the government strictly supervises and punishes whether developers actively participate in the construction of guaranteed housing, which has economic and social motives.

4.3 Model Equilibrium Point and Stability Analysis

The final evolutionary game result between the developer and the government is not a certain evolutionary stable strategy choice of the developer or the government, but requires the relationship between the developer and the government to reach a stable state at an equilibrium point. Based on this, the five evolutionary games are obtained. Balance point: $E_1(0,0)$, $E_2(0,1)$, $E_3(1,0)$, $E_4(1,1)$, $E_5(p^*, q^*)$. p^* and q^* are the thresholds for the change of the characteristics of the phase diagram of the evolutionary game between the developer and the government. Because the process of system evolution is slow, there will be a strict or non-strict government supervision or punishment for a long period of time, and the developer is actively or Not actively participating in the cross-existence of security housing construction.

5. Conclusion

Based on the evolutionary game analysis between the developers and the government in the selection of security housing construction, this paper concludes that the developer chooses to actively participate in the construction of security housing, and the government chooses strict

supervision and punishment as an ideal state; the other is that the developer chooses not to actively participate in the construction of security housing, the government does not strictly supervise and punish the undesirable state. At the same time, the difference in income obtained by the developers actively and not actively participating in the construction of guaranteed housing, the reputation loss of the government's non-strict supervision, and the amount of punishment are important results that affect the evolutionary game. The interaction between the developer and the government will also have an important impact on the outcome of the entire evolutionary game. The developer's active participation in the construction of affordable housing not only depends on the rationality of government supervision and punishment, and the scientificity of relevant policy formulation, but also depends on the developer's own knowledge and understanding of the nature of the construction of affordable housing as a livelihood project.

Based on the above research results, the following suggestions will be made:

First, it is necessary to clarify the government's dominant position in the construction of affordable housing. The government is the formulation and leader of social housing construction policies. It should increase supervision and punishment to improve the efficiency and level of supervision, regulate the management of social housing, and form strong constraints on developers.

Second, improve relevant policies, laws and regulations. Clarify the unclear problem definition and judicial system in the social housing policy, improve relevant incentives and preferential policies, and increase the implementation efforts at the same time.

Third, rationally plan the proportion of security housing construction. Compared with commercial housing, the income from the construction and construction of affordable housing is still relatively low, and may not reach the developer's expected target income. If the proportion of supporting construction is too large, it will put greater pressure on the developer's capital and operation. If the proportion of construction is too small, it will lead to the increase of the developer's later property management costs. Therefore, the government should formulate a long-term plan for the construction of affordable housing on the basis of full research on the scope of the insured group, decompose the target year by year, and set a reasonable range of allocation and construction ratios, which can not only give developers enough room for profit, but also It can also ensure the realization of the goal of social housing construction.

Fourth, establish a scientific performance evaluation system to standardize the behavior of developers. By setting scientific evaluation indicators, conducting comprehensive evaluations on developers, and publicly disclosing the evaluation results in local media, through the evaluation information disclosure mechanism, the developers' original hidden information can be transformed into public information, so that the developers can take into account the impact of reputation. On the basis of this, continuously improve the enthusiasm to participate in the construction of affordable housing.

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