Analysis of the Transformation Mode of Old Industrial Area Based on Game Theory

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Abstract: In the old industrial area renovation project, the conflict of interests of all parties involved in the project (local government, original enterprises, investors) is highlighted, so how to find out the balance of interests of all parties involved in the project, and maximize the satisfaction of the interests of all parties is of great significance. Based on the method of evolutionary game theory, this paper establishes a game model for the transformation of old industrial areas by sorting out the conflict of interests of the main parties in the transformation of old industrial areas, and analyzes three transformation modes of old industrial areas by combing the extended form of the model.

Keywords: old industrial area; transformation model; equilibrium analysis; game theory

1 Introduction

In the process of carrying out old industrial projects, there are significant conflicts of interest among the parties involved in the projects (local governments, former enterprises and investors), which may affect the implementation of the projects and prevent them from being completed as expected, or prevent the completed projects from operating normally, resulting in the interests of all parties being jeopardized. Analysis of this phenomenon reveals that it is mainly related to the following factors: firstly, government departments tend to consider from a macro perspective, and are committed to integrating regional economic development, environmental protection, etc., so as to achieve the highest comprehensive benefits; investors are mainly concerned about the benefits obtained, and expect to minimize the costs while maximizing the benefits; and the original enterprises are mainly concerned about their own development and the optimal living environment. In order to maximize their own interests, all parties will inevitably lead to serious conflicts of interest. If the interests of all parties cannot be effectively balanced, the interests of all parties can be reasonably satisfied, so that all parties can reach a consensus on their interests, the implementation of the final project will not be realized.

Therefore, it is of great importance to find out how to balance the interests of all parties involved in the project (local government, original enterprise, investor) and maximize the satisfaction of their interests when the conflict of interests of all parties involved in the project (local government, original enterprise, investor) comes to the forefront. In this study, the interests of the government, the developer and the original enterprise in the transformation are analyzed in depth, and a game model for the transformation of old industrial areas is constructed, and three modes of transformation of old industrial areas are designed in combination with the results of the study, so as to provide the necessary guidance for the implementation of the actual project.

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2 Analysis of the Interests of the Main Body of the Transformation of Old Industrial Areas

With the continuous development of cities, the transformation of old industrial areas has aroused widespread concern and is an inevitable problem in the development of industrial transformation. The process of transforming old industrial areas involves a number of different parties, and there are often obvious conflicts of interest between them. The government is a key player and needs to consider the impact of old industrial areas on the urban environment and social security. At the same time, due to the high cost of renovation, it is not possible to accomplish the task of renovation through its own development. Thus, social forces may be brought in to participate, and developers may be attracted to participate through the introduction of some preferential policies, which may lead to the intensification of conflicts between the original enterprises and the developers. Developers both see the land resources provided to the city after the transformation of old industrial areas, which helps to alleviate the problem of urban land tension [1]. However, there are many uncertainties in the transformation, and the normal benefits may be offset by higher transaction costs. For the original enterprises, they are mainly worried about the inability to guarantee their own compensation benefits, and they may not support or cooperate with the implementation of the transformation project. Based on the above analysis, it can be seen that the conflict of interests between the parties in the transformation of old industrial areas is significant, thus forming a three-party (the government, the original enterprise and the developer) game situation. In order to effectively solve the above problems, it is necessary to carry out a game analysis of the relationship between the subjects and parties in the transformation of old industrial areas, and then to achieve a balance of the interests of all parties, and ultimately achieve the goal of win-win situation.

3 Establishment of the Game Model for the Transformation of Old Industrial Areas

3.1 Concepts of Games and Game Theory

A game is an abstract expression of the state of interaction between different individuals under "strategic interdependence" [2] . Therefore, in a game situation, the benefits received by an individual will be affected by the behavior of other individuals, not only related to their own behavior. On the basis of game research, game theory is gradually formed, which is mainly used to study the behavior of game participants, and formulate the optimal strategy to meet their own interests by combining the behavioral changes of other participants.

3.2 Modeling of the Transformation of Old Industrial Areas

3.2.1 Participants

Participants refer to the decision-making subjects in the game, which will take certain strategies or actions in combination with their own interests. In the case of this study on the transformation of old industrial areas, the participants involve the developer, the government and the original enterprise. The specific introduction is shown below.

(1) Government

The government is the leading party in the transformation of old industrial areas, and it needs to formulate certain policies to intervene or guide the transformation process, which will inevitably affect the activities and behaviors of other participants in the process. The government is an important beneficiary of the transformation of old industrial areas because it can provide scarce land resources, improve the appearance and image of the city, and enhance the credibility of the government.

(2) Former Enterprises

The interests of the original enterprises will be directly affected by the transformation of the old industrial area, which is a key part of the game model, and they are particularly concerned about the work after the transformation as well as the life and other issues related to their personal interests, which will also affect their own activities and behaviors.

(3) Developers

The transformation of the old industrial area is a huge project, often hundreds of millions of dollars, just rely on the government or the original enterprise is difficult to complete the task of transformation. Therefore, the introduction of new developers has become an inevitable choice, which also brings significant benefits to the developer, which belongs to the essential components of the game model.

3.2.2 Strategies of the Participants

A strategy is a basis or rule for a participant to take a specific action at a specific time, typically developed after analysis based on an established set of information, which provides guidance for the implementation of specific behaviors. It is known that the specific strategy of individual i is denoted as Si , while the set of possible strategies it may adopt is Si = {si}, s=(s1 ...si ... . sn) represents a portfolio of strategies (n-dimensional) [3] .

(1) Government Action and Its Choices

Within the game model, there are two ways in which the government G can act to provide, and not provide, preferential policies, which can be expressed as Sg = (provide, do not provide). The government usually determines the specific strategy by taking into account the local finance and other aspects. If Sg (do not provide) is chosen, and the transformation of old industrial areas can still be successful, the government is equivalent to obtaining benefits on the basis of the minimum input, and thus higher benefits can be achieved. In fact, there are still many problems in the transformation of old industrial areas, which cannot be solved by relying on the developers and the original enterprises, especially some problems related to land ownership, which can only be solved through the coordination and intervention of the government [4] . The participation of developers will also be driven by interests, in the case of the government to implement some preferential policies can fully mobilize the enthusiasm of developers, but the lack of such policies or measures, the willingness of developers to participate in the lower, which will have a negative impact on the implementation of the renovation project. Therefore, the government tends to choose Sg (provide), when the government expenditure is relatively low, including project subsidies, etc., basically will not exceed the scope of the government's affordability. After the developer's participation, it is relatively abundant in terms of capital as well as

technology, and synergistic cooperation with the original enterprise and other parties will enhance the level of transformation of old industrial areas. On balance, the government's first choice is still to provide preferential policies.

(2) The Actions of the Original Enterprise and Its choices

Within the game model, the original enterprise P belongs to the important participants, and its actions are also divided into two types, which are supportive and non-supportive of the retrofit, which is expressed as Sp = (supportive, non-supportive). The original firm determines its actions based on the size of the utility function, which also has a direct impact on the implementation of the retrofit program. If the utility function is above zero or the gap is small, support is often chosen. However, if the gap is too large, it means that the original enterprise does not get the expected benefits and cannot solve its basic demands, then it will certainly resist or oppose the transformation of the old industrial area, and even obstruct the implementation of the project through different ways of action, which is not only difficult to carry out the work of transformation of the old industrial area, but also detrimental to the stability of the society.

(3) Developers' Actions and Their Choices

Within the game model, the actions of developer D are also divided into two types, namely participation and non-participation. The developer is a key player because it is difficult to meet the requirements of the old industrial area transformation by relying only on the government and the original enterprise, lack of capital and technology, etc., which can be solved by the developer's intervention. However, the developer's decision to intervene is based on its expected utility, i.e., it will intervene only when its profit can meet its own requirements. On the one hand, they need to make sure that the project is profitable (Ud >0), and on the other hand, they will compare the project with other projects and choose the one that is more profitable. Assuming that developers can choose to participate in the two projects of suburban incremental land development and transformation of old industrial areas, there are significant differences between the two in terms of implementation cycle as well as costs and benefits, etc. Compared with the former, the latter has lower profit margins and longer cycles, and may involve complex conflict of interest relationships with the original enterprises and other parties, so the willingness to participate in this type of project is not high. In response to these problems, the Government, in addition to adopting the approach of introducing beneficial policies, also needs to impose appropriate restrictions on incremental land projects, through which it can change developers' choices of action so that they will participate more actively in renovation projects.

(4) The Strategic Mix of Participants

The original enterprise's action choice is closely related to the government, and will generally be combined with the government's action to make a strategy, which is divided into three types, namely:Sd = [(provide, support), (provide, do not support), (do not provide, support), (do not provide, do not support)], and the developer combines the action choices of the above two participants to make a choice. Considering the case that the original enterprise chooses not to support, at this point, it will create a huge obstacle to the remodeling project, thus, making the game terminate. Based on the above analysis, the final formation includes six, as shown below.

$$Sd = \begin{cases} \text{(provide, support, intervene)} \\ \text{(provision, support, non-involvement)} \\ \text{(offered, not supported)} \\ \text{(non-provision, support, intervention)} \\ \text{(non-provision, support, non-involvement)} \\ \text{(not available, not supported)} \end{cases}$$

3.2.3 Utility (Payment) Functions of Subjects

The utility represents the determined level of utility obtained by the subject under a certain strategy combination, and the utility level of subject i is denoted as Ui . For the old industrial area renovation problem in this study, firstly, it is assumed that the three parties are rational economic beings; secondly, the urban environment improvement and so on are regarded as the quantifiable economic factors, from which we can obtain the utility function of each party. The specific analysis is shown below:

(1) The Government's Expected Utility Function

Based on the previous analysis, it can be seen that the government has three choices of actions, so the corresponding expected utility function Ug is as follows.

$$U_g = \begin{cases} = \varphi(E), S_g = \text{not provide for} \\ = \varphi(E) - I_1, I_1 < A, S_g = \text{provide (the developer bears the renovation cost)} \\ = \varphi(E) - I_2, I_2 < A, S_g = \text{provide (the government bears the renovation cost)} \end{cases} \tag{1}$$

Within the above formula, A represents the maximum expenditure limit of the government, i.e. the maximum investment in the renovation project.φ(E) represents the benefits brought to the government by the implementation of the renovation project, including the improvement of the city's appearance and image and the resulting enhancement of the government's credibility, etc.; A represents the maximum expenditure limit of the government's financial resources, i.e. the maximum investment in the renovation project;I_1 A represents the maximum expenditure limit of the government finance, i.e. the maximum input in the renovation project; B represents the maximum expenditure limit of the government finance, i.e. the maximum input in the renovation project;I_2 Representing the government to bear the entire expenditure of the renovation cost, which involves the implementation of ex gratify measures as well as the compensation for demolition and relocation.

(2) The Expected Utility Function of the Original Firm

Based on the previous analysis, it can be seen that the original firm also has two action options, corresponding to the utility function Up as follows.

$$U_P = \begin{cases} w + m - n - ak, S_g = \text{support} \\ 0, S_g = \text{nonsupport} \end{cases} \tag{2}$$

Within the above equation, w represents the compensation for demolition and relocation, which is mainly provided to the original enterprise; k represents the estimation of the risk of future life,

and a is the corresponding coefficient, which takes the value of 0-1; m represents the increase in utility for the original enterprise to enjoy the same treatment as the urban residents, which involves the aspects of education, health care, and employment; and n represents the loss of the original enterprise caused by the transformation.

(3) Expected Utility Function of the Developer

Based on the previous analysis, it can be seen that the developer also has two choices of actions, corresponding to the expected utility function Ud as shown below.

$$U_d = \begin{cases} v - c, S_g = \text{intervene} \\ 0, S_g = \text{noninvolvement} \end{cases} \tag{3}$$

Within the above equation, v represents the benefits received by the developer for participating in the remodeling project; c represents the various expenditures during the remodeling process, which involve construction costs as well as related taxes and fees.

3.2.4 Extended Form of the Old Industrial Area Transformation Game

According to the previous analysis, the game problem of this study actually belongs to the dynamic game of incomplete information, that is, the order of action of each subject is different, the first to act on the subject can only estimate the subsequent action of the subject, while the later action of the subject is able to predict the activities taken by the subject of the first action. Combined with the above information can be obtained transformation game of the extended form, that is, in the government to develop a strategy on the basis of the original enterprises, developers in the development of their own strategy, specific can be expressed as:

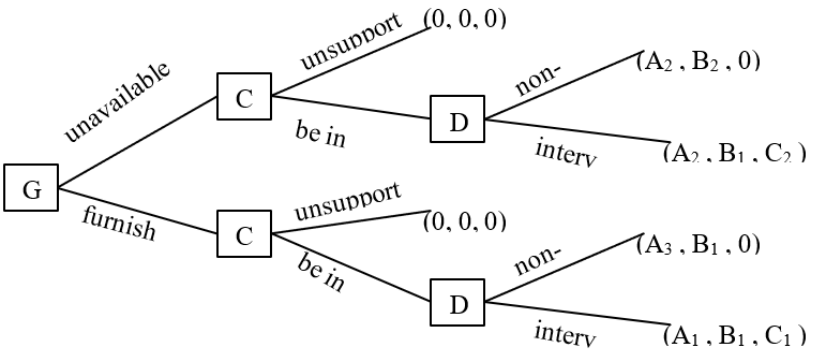

Figure 1: Structural Tree Model of the Transformation Model of Old Industrial Areas

In the figure 1, $A_1 = \varphi(E) - I_1; A_2 = \varphi(E); A_3 = \varphi(E) - I_2; B_1 = w + m - n - \alpha k; B_2 = m - n - \alpha k, C_1 = v - c_1, C_2 = v - c_2$, $A_2 > A_1 > A_3, B_1 > B_2, C_1 > C_2$.

From the above game tree, the six strategies and the expectation function for the transformation model are derived.

S1 (provide, support, intervene) = (A1 ,B1 ,C1)=[$\varphi(E) - I_1, w + m - n - \alpha k, v - c_1$]

S2 (provide, support, do not intervene) = (A3 ,B1 ,0)=[$\varphi(E) - I_2$, $w + m - n - \alpha k$, 0]

S3 (offered, not supported) = (0,0,0)

S4 (no offer, support, intervention) = (A2 ,B1 ,C2)=[$\varphi(E)$, $w + m - n - \alpha k$, $v - c_2$]

S5 (not available, supported, not involved) = (A2 ,B2 ,C2)=[$\varphi(E)$, $m - n - \alpha k, v - c_2$]

S6 (not available, not supported) = (0,0,0)

S1 represents the participation of three parties (the government, developers, and former enterprises) in the process of transformation of old industrial zones; S2 represents the participation of the government and former enterprises only, in which the expenditures required for the transformation are taken care of by the former; S4 represents the participation of the former enterprises and the developers only, with the cooperation of the two together in the transformation of old industrial zones; and S5 represents that only the former enterprises themselves have carried out the transformation of the enterprises in which they are located. In addition to the above four types, S3 (provided, not supported) and S6 (not provided, not supported) represent the difficulties in properly carrying out the transformation of old industrial zones, which are mainly related to the lack of support from the former enterprises.

4 Equilibrium Analysis of the Transformation Model

Based on the previous statement, the decision-making order of each participant in the process of transformation of old industrial areas is different, and the government can only predict the probability of the other two subjects' strategic choices when formulating strategies, but cannot accurately judge the chosen strategies. However, the strategy of the former enterprises and developers will be significantly affected by the government's strategy, and both of them will formulate strategies that are favorable to their own development according to the government's strategy. When the government provides incentives, the developer is more likely to participate in the renovation project and is more likely to receive support from the original firm. On the other hand, if the government does not provide preferential policies, developers will have a lower chance to participate in the project and it will be difficult for them to get support from the original enterprises, which makes the transformation of old industrial areas more difficult. Considering all factors, the government usually chooses the strategy of providing preferential policies. After the government's strategy is determined, the original enterprise and the developer will also be based on the government's strategy to make further judgments, in which the original enterprise weighs its own benefits and losses and makes a decision whether to support it or not. If they do not support it, then it will be more difficult for them to remodel, and the utility of each party will be zero. If it chooses to support it, its utility is always B1 , independent of the specific developer. For the developer, the same will be combined with the government's strategy to weigh the interests, when the government introduced preferential policies, at the same time to limit the incremental development of land, it is bound to increase the enthusiasm of the developer to participate in the renovation project [5] . However, at this time, they will also consider other factors, such as the location of the renovation, the cost of renovation and sales prospects. If it is in the remote suburbs, even if the land price is low and the cost of remodeling is not high, the willingness of developers to participate in the project is still low due to the low profit margin and poor sales prospect. On the other hand, when the remodeling area is in the inner city, although the cost may be higher, it is easy to sell and the profit margin is high, so it

is easier to attract developers to intervene. In summary, when all parties are "rational economic man", the strategic combination S (provide, support, intervention), S (provide, support, do not intervene) is the equilibrium result of the game, for the latter, in the case of the developer does not intervene, according to the main body of the renovation costs can be further divided into two cases, that is, renovation costs are borne by the original enterprise or the government. or the government.

5 Conclusion

This paper carries out a study on the transformation mode of old industrial areas based on game theory, combining the results of the study, it can be seen that in the transformation of old industrial areas can be taken in different modes, mainly including the government's total transformation, the original enterprise independent transformation, the original enterprise, developers, the government three-party combination of transformation modes, etc., which corresponds to the type of government transformation in the model of the second strategic combination of S2 (Provide, support, do not intervene) = (A3 , B1 , 0) In the original enterprise transformation type and the first strategy combination S1 (provide, support, intervene) = (A1 , B1 , C1), the participating subjects as well as the implementation effects of each model are different. Among them, the original enterprise, developer, the government tripartite combination of transformation mode is currently most of the old industrial areas to take the mode, in this mode the three parties have their own roles and work together, in which the government is mainly to provide a certain degree of policy support, the developer to bear the cost of transformation, the original enterprise to support and actively cooperate with, to ensure that the transformation of the work can be implemented smoothly, through this way to achieve the goal of the three win-win-win situation.

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