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Investigation the Incentive Mechanism of Prefabricated Building from Numerical Simulation of Evolutionary Game

Abstract: The prefabricated building is significance to promote high-quality transformation of construction industry on the building. However, the development of prefabricated market on building are restricted due to unsound management system and inadequate policy implementation. This paper investigates the dynamic strategy choices among the government, construction units and component companies in promoting the prefabricated buildings from the perspective of government incentives, by introducing the evolutionary game theory. The dynamic evolution paths of both players under different factors are investigated through MATLAB numerical simulation. Correspondingly, the incentive mechanism of prefabricated building is discussed based on the obtained numerical simulation results. Finally, the scientific and reasonable formulation of incentive policies for the prefabricated buildings are provided based on the theoretical analysis and numerical simulation results.

Keywords: Prefabricated Building; Construction Units; Component Companies; Evolutionary Game; Incentive Mechanism; MATLAB Numerical Simulation.

I. INTRODUCTION

As a pillar industry of China's national economy, the construction industry on building currently faces many problems such as extensive production methods, low labor efficiency, high energy and resource consumption, low industrialization level, and insufficient technological innovation. As a result, the construction industry is regarded as a typical resource-intensive and labor-intensive industry. The prefabricated construction, on the other hand, has advantages in energy saving and emission reduction, improved production efficiency, enhanced quality and safety, and labor savings, which has a great significance for promoting the sustainable development of China's construction industry and high-quality transformation on building industry [1-4].

At present, the development of China's prefabricated construction market is immature, and the market penetration rate is needed to be improved urgently. Furthermore, scholars at home and abroad have carried out in-depth researches on the economic benefits, social benefits, ecological benefits, and life cycle construction costs of prefabricated construction, owing to fact that the economic factors have a significant effect on the development of prefabricated construction. The obtained results demonstrate that the factors, including the supply chain inconsistency, inadequate management systems and supporting standards, inadequate policy implementation, and immature technology, are all have restrictions on the development of prefabricated construction [5-10]. Based on the unfavorable effect of these factors on the development of prefabricated construction, the government has optimized top-level design and introduced relevant policies, to adjust the market structure to stimulate the coordinated development of the prefabricated industry chain in recent years. Moreover, scholars in China have also conducted extensive investigations on the effect of government incentive policies on the development of prefabricated construction. Such as, Wang et al. [11] used a system dynamics model to study the influence of government's incentive strategies on the construction units. Huo et al. [12], Lu et al. [13], and Li et al. [14] used the evolutionary game methods to investigate the effect of different factors on the evolutionary path, thereby proposing the countermeasures and suggestions for game-agent to choose prefabricated construction strategies. Liu et al. [15] and Chen et al. [16] demonstrated that of the lagging policy tools, in the industrial chain dimension, are not conducive to the development of prefabricated construction, based on the investigation on the existing policy tools in China.

The multidimensional investigations on the development of the prefabricated construction, cost controls of prefabricated construction and government policies, were widely reported in the existing literatures [15-17]. Especially, the different evolutionary models were proposed and the corresponding numerical simulations were conducted by MATLAB, to proposed the optimum incentive policy according to numerical simulations [16,17]. In fact, to efficiently promote the development of prefabricated construction from different perspectives, the MATLAB numerical simulation is essential, due to many interaction influencing factors. Such as, Zhou and Luo

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[18] draws the conclusion that high-quality development of prefabricated building depends on technological research and development, complete industrial chain, and implementing industry-university-research cooperation, according to MATLAB numerical simulation from the perspective of population ecology. Yin et al [19] suggested that the project efficiency enhancing and costs reducing of prefabricated construction is highly dependent on the on-site lifting, based on MATLAB numerical simulation on the constructed model. As a result, the numerical simulation is an effective method to optimize the decision for the contracted multi-factor models, and it is widely applicated to the strategy making on the development of prefabricated construction.

Considering that there are still some limitations on the influencing factors on the development of prefabricated construction. In China, the prefabricated construction market is mainly dominated by the supply side, i.e., the construction units, construction companies, and the prefabricated component enterprises [20]. Moreover, the supply capacity of construction units and the infrastructure capacity represented by the production capacity of component enterprises, have more remarkable influences on promoting large-scale development of prefabricated construction [20]. However, as key player in the prefabricated construction market, there are less investigations on the government's incentive policies targeting the key stakeholders on the supply side. As a result, this study introduces the evolutionary game theory to investigate the game relationship between the government and construction units, as well as between the government and component enterprises. Meanwhile, the study examines the strategic choices of both players under the influence of different factor coefficients through theoretical calculations and numerical simulation (MATLAB), aiming to provide feasible recommendations for promoting the development of prefabricated construction.

II. EVOLUTIONARY GAME ANALYSIS BETWEEN THE GOVERNMENT AND CONSTRUCTION UNITS

A. *Assumptions of Evolutionary Game Model*

1) Model Assumptions: The game involves the government and construction units as rational but bounded rationality players. Under background of vigorously promoting the development of prefabricated construction in recent years, the government's strategy selection of "incentive" and "no incentive", are assumed with corresponding probabilities of "x" and "1-x" ($0 \le x \le 1$), respectively. The construction units' strategy selection of "prefabricated" and "cast-in-place" with corresponding probabilities of "y" and "1-y" ($0 \le y \le 1$), respectively.

2) Parameter Values and Explanations: The government's benefits include direct economic benefits, such as the tax revenue and administrative penalties, as well as indirect benefits related to ecological environment and public awareness when promoting prefabricated construction. The construction units' benefits primarily consider various policy incentives and the incremental construction costs compared to cast-in-place construction. The parameter values and explanations are shown in Table. 1.

Table 1 Parameter Values and Explanations

Parameter	Explanation
a_1	Incremental benefits in terms of social and ecological aspects when construction units adopt prefabricated construction.
a_2	Government's cost of formulating policies, regulations, and other management costs (coefficient α) for incentive strategies.
a_3	Government's financial and policy rewards (coefficient β) for construction units when implementing incentive strategies.
a_4	Government's fines (coefficient τ) imposed on the construction units for non-compliance with indicators when implementing incentive strategies.
a_5	Excessive tax revenue (coefficient θ) levied by the government on construction units using traditional cast-in-place construction.
a_6	Punishment by administrative authorities for the government's "no incentive" strategy.
b_1	Total cost for construction units when using the traditional cast-in-place construction.
b_2	Total revenue for construction units when using the traditional cast-in-place construction.
b_3	Incremental cost for construction units when adopting prefabricated construction.
b_4	Incremental revenue for construction units when adopting prefabricated construction.

Table 2 Payoff Matrix for the Government and Construction Units

Strategy	Government	Construction Units
(Incentive, Prefabricated)	$a_1-\alpha a_2-\beta a_3$	$b_2+b_4-b_1-b_3+\beta a_3$
(Incentive, Cast-in-Place)	$\tau a_4+\theta a_5-\alpha a_2$	$b_2-b_1-\tau a_4-\theta a_5$
(No Incentive, Prefabricated)	a_1-a_6	$b_2+b_4-b_1-b_3$
(No Incentive, Cast-in-Place)	θa_5-a_6	$b_2-b_1-\theta a_5$

B. Construction of Evolutionary Game Model

1) Game Payoff Matrix: Based on the above assumptions, the payoffs for both players under different strategy combinations are analyzed, resulting in the payoff matrix for the government and construction units are shown in Table. 2.

2) Replicator Dynamics Equation: When the government chooses the "incentive" and "no incentive" strategies, the expected payoffs are denoted as $E(x_1)$ and $E(x_2)$, respectively. And the average expected payoff is denoted as $\bar{E}(x)$, the calculation values are expressed by Equation (1) as follows:

$$\begin{cases} E(x_1) = y(a_1 - \alpha a_2 - \beta a_3) + (1-y)(\tau a_4 + \theta a_5 - \alpha a_2) \\ E(x_2) = y(a_1 - a_6) + (1-y)(\theta a_5 - a_6) \\ \bar{E}(x) = xE(x_1) + (1-x)E(x_2) \end{cases} \tag{1}$$

The expected payoffs for the construction units when choosing the "prefabricated" and "cast-in-place" strategies are denoted as $E(y_1)$ and $E(y_2)$, respectively. And the average expected payoff is denoted as $\bar{E}(y)$. The calculation values are expressed by Equation (2) as follows:

$$\begin{cases} E(y_1) = x(b_2 + b_4 - b_1 - b_3 + \beta a_3) + (1-x)(b_2 + b_4 - b_1 - b_3) \\ E(y_2) = x(b_2 - b_1 - \tau a_4 - \theta a_5) + (1-x)(b_2 - b_1 - \theta a_5) \\ \bar{E}(y) = yE(y_1) + (1-y)E(y_2) \end{cases} \tag{2}$$

Therefore, the replicator dynamics equations for the behavior choices of the government and construction units are shown in Equation (3):

$$\begin{cases} F(x) = \dfrac{dx}{dt} = x(E(x_1) - \bar{E}(x)) = x(1-x)(E(x_1) - E(x_2)) \\ \quad = x(1-x)[-y(\beta a_3 + \tau a_4) - \alpha a_2 + \tau a_4 + a_6] \\ F(y) = \dfrac{dy}{dt} = y(E(y_1) - \bar{E}(y)) = y(1-y)(E(y_1) - E(y_2)) \\ \quad = y(1-y)[x(\beta a_3 + \tau a_4) - b_3 + b_4 + \theta a_5] \end{cases} \tag{3}$$

C. Solving the Evolutionary Game Model and Stability Analysis

1) Model Solution: To analyze the system's stable states, let F(x) = 0 and F(y) = 0. The solutions are obtained as shown in Equation (4):

$$\begin{cases} x = 0,\ x = 1,\ x^* = \dfrac{b_3 - b_4 - \theta a_5}{\beta a_3 + \tau a_4} \\ y = 0,\ y = 1,\ y^* = \dfrac{-\alpha a_2 + \tau a_4 + a_6}{\beta a_3 + \tau a_4} \end{cases} \tag{4}$$

There are four pure strategy equilibrium points in the system, which are (0, 0), (0, 1), (1, 0), and (1, 1). When the parameters satisfy $0< x^* <1$ and $0 < y^* < 1$, there is also a possibility of a fifth mixed strategy equilibrium point (x^*, y^*).

2) System Evolution Stability Analysis: The mixed strategy equilibrium point is not evolutionarily stable equilibrium point in an asymmetric game. Therefore, it is sufficient to discuss the asymptotic stability of pure strategy equilibrium points. The values of the Jacobian matrix are calculated as shown in Equation (5):

By substituting the coordinate values of the pure strategy equilibrium points (0, 0), (0, 1), (1, 0), and (1, 1) into the Jacobian matrix, the eigenvalues can be calculated, where the eigenvalues are $\lambda_1=J_{11}$ and $\lambda_2=J_{22}$. The results of the eigenvalues for each pure strategy equilibrium point are shown in Table. 3.

$$\begin{cases} J_{11} = \dfrac{\partial F(x)}{\partial x} = (1-2x)[-y(\beta a_3 + \tau a_4) - \alpha a_2 + \tau a_4 + a_6] \\ J_{12} = \dfrac{\partial F(x)}{\partial y} = -x(1-x)(\beta a_3 + \tau a_4) \\ J_{21} = \dfrac{\partial F(y)}{\partial x} = y(1-y)(\beta a_3 + \tau a_4) \\ J_{22} = \dfrac{\partial F(y)}{\partial y} = (1-2y)[x(\beta a_3 + \tau a_4) - b_3 + b_4 + \theta a_5] \end{cases} \tag{5}$$

Combining the Lyapunov stability conditions, if two eigenvalues are both less than 0, the pure strategy equilibrium point is an asymptotically stable point, and the asymptotic stability conditions for equilibrium points are shown in Table. 4. Taking the equilibrium point (1, 1) as an example, when the government faces higher penalties from the higher-level authorities for not actively promoting the prefabricated construction than costs of management and policies for actively promoting it, as well as the policy subsidies for the construction units developing prefabricated construction can cover their incremental costs, both players will tend to choose the strategy (Incentive, Prefabricated). This represents the optimal stable strategy in the early stage of development.

Table 3 Eigenvalues of Jacobian matrices for each equilibrium point

Equilibrium Point	Eigenvalue (λ_1)	Eigenvalue (λ_2)
(0, 0)	$-\alpha a_2+\tau a_4+a_6$	$\theta a_5-b_3+b_4$
(0, 1)	$-\alpha a_2-\beta a_3+a_6$	$-\theta a_5+b_3-b_4$
(1, 0)	$\alpha a_2-\tau a_4-a_6$	$\beta a_3+\tau a_4+\theta a_5-b_3+b_4$
(1, 1)	$\alpha a_2+\beta a_3-a_6$	$-\beta a_3-\tau a_4-\theta a_5+b_3-b_4$

Table 4 Stability conditions for system equilibrium points

Equilibrium Point	Stability Conditions
(0, 0)	$-\alpha a_2+\tau a_4+a_6<0$; $\theta a_5-b_3+b_4<0$
(0, 1)	$-\alpha a_2-\beta a_3+a_6<0$; $-\theta a_5+b_3-b_4<0$
(1, 0)	$\alpha a_2-\tau a_4-a_6<0$; $\beta a_3+\tau a_4+\theta a_5-b_3+b_4<0$
(1, 1)	$\alpha a_2+\beta a_3-a_6<0$; $-\beta a_3-\tau a_4-\theta a_5+b_3-b_4<0$

III. Evolutionary Game Analysis of the Government and Component Enterprises

A. Assumptions of Evolutionary Game Model

1) Model Assumptions: The players in the game are the government and component enterprises, and they are bounded rationality for both sides. It is assumed that the government's strategy set consists of "incentive" and "no incentive" with corresponding probabilities “m” and “1-m” ($0\leq m\leq 1$), respectively. The strategy set of component enterprises consists of "innovation" and "no innovation," with corresponding probabilities “n” and “1-n” ($0\leq n\leq 1$), respectively. Where, innovation refers to optimizing the production technology, while no innovation represents maintaining the existing production technology capabilities.

2) Parameter Values and Explanations: Component enterprises are the core entities in the supply of prefabricated building materials. Their decision to innovate and optimize production technology mainly considers the factors such as the policy incentives, cost optimization, and the enhancement of core competitiveness through innovation. The parameter values and explanations are shown in Table. 5.

B. Construction of Evolutionary Game Model

1) Payoff Matrix: Based on the above assumptions, the payoffs for both players under different strategy combinations are analyzed, resulting in the payoff matrix for the government and the component enterprises, as shown in Table. 6.

2) Replicator Dynamics Equation: The expected payoffs for the government when choosing "incentive" and "no incentive" strategies are denoted as $E(m_1)$ and $E(m_2)$, respectively. And the average expected payoff for the government is denoted as $\overline{E}(m)$. The calculation is shown in the following equation (6):

Table 5 Loss and gain parameter values and explanations for the two players in the game

Parameter	Explanation
c_1	Government's cost of formulating policy standards and regulations, and cost of supervision (regulation coefficient δ)
c_2	Government's direct economic subsidies to component enterprises (subsidy coefficient ε) when promoting
c_3	Government's penalties (punishment coefficient μ) for component enterprises without innovation under incentives
c_4	Benefits for the government from social and technological competitiveness when component enterprises innovate
c_5	Social losses (resource waste, etc.) caused by component enterprises' inability to meet construction demands
c_6	Punishment from higher-level authorities when the government does not provide incentives
d_1	Additional expenses for equipment updates and research and development investments when component enterprises innovate
d_2	Improvement in technological capabilities and core competitiveness of enterprises when component enterprises innovate
d_3	Reduction in production costs (scale, standardization, etc.) when component enterprises innovate

Table 6 Payoff matrix for the government and component enterprises

Strategy	Government	Construction Units
(Incentive, Innovation)	$-\delta c_1-\varepsilon c_2+c_4$	$\varepsilon c_2-d_1+d_2+d_3$
(Incentive, No Innovation)	$-\delta c_1+\mu c_3-c_5$	$-\mu c_3$
(No Incentive, Innovation)	c_4-c_6	$-d_1+d_2+d_3$
(No Incentive, No Innovation)	$-c_5-c_6$	0

$$\begin{cases} E(m_1)=n(-\delta c_1-\varepsilon c_2+c_4)+(1-n)(-\delta c_1+\mu c_3-c_5) \\ E(m_2)=n(c_4-c_6)-(1-n)(c_5+c_6) \\ \overline{E}(m)=mE(m_1)+(1-m)E(m_2) \end{cases} \tag{6}$$

The expected payoffs for the component enterprises when choosing "innovation" and "no innovation" strategies are denoted as $E(n_1)$ and $E(n_2)$ respectively. And the average expected payoff for component enterprises is denoted as $\overline{E}(n)$. The calculation is shown in the following equation (7):

$$\begin{cases} E(n_1) = m(\varepsilon c_2 - d_1 + d_2 + d_3) + (1-m)(-d_1 + d_2 + d_3) \\ E(n_2) = -m\mu c_3 \\ \overline{E}(n) = nE(n_1) + (1-n)E(n_2) \end{cases} \tag{7}$$

Therefore, the replicator dynamics equations for the behavior selection of the government and component enterprises are given by the following equations (8):

$$\begin{cases} F(m) = \dfrac{dm}{dt} = m(E(m_1) - \overline{E}(m)) = m(1-m)(E(m_1) - E(m_2)) \\ \quad = m(1-m)[-n(\varepsilon c_2 + \mu c_3) - \delta c_1 + \mu c_3 + c_6] \\ F(n) = \dfrac{dn}{dt} = n(E(n_1) - \overline{E}(n)) = n(1-n)(E(n_1) - E(n_2)) \\ \quad = n(1-n)[m(\varepsilon c_2 + \mu c_3) - d_1 + d_2 + d_3] \end{cases} \tag{8}$$

C. Solution and Stability Analysis of the Evolutionary Game Model

1) Model Solution: Let F(m)=0, F(n)=0 to analyze the system's stable states. The solutions are given by following equation (9):

As a result, there are four pure strategy equilibrium points in the evolutionary system of the government and component enterprises, namely (0,0), (0,1), (1,0), and (1,1). When the parameters satisfy 0< m^*<1 and 0< n^*<1, there is also a possible mixed strategy equilibrium point (m^*, n^*).

$$\begin{cases} m = 0, m = 1, m^* = \dfrac{d_1 - d_2 - d_3}{\varepsilon c_2 + \mu c_3} \\ n = 0, n = 1, n^* = \dfrac{-\delta c_1 + \mu c_3 + c_6}{\varepsilon c_2 + \mu c_3} \end{cases} \tag{9}$$

2) Stability Analysis of the System Evolution: Calculate the values of the Jacobian matrix for the evolutionary game model as shown in the following equation (10):

$$\begin{cases} J_{11} = \dfrac{\partial F(m)}{\partial m} = (1-2m)[-n(\varepsilon c_2 + \mu c_3) - \delta c_1 + \mu c_3 + c_6] \\ J_{12} = \dfrac{\partial F(m)}{\partial n} = -m(1-m)(\varepsilon c_2 + \mu c_3) \\ J_{21} = \dfrac{\partial F(n)}{\partial m} = n(1-n)(\varepsilon c_2 + \mu c_3) \\ J_{22} = \dfrac{\partial F(n)}{\partial n} = (1-2n)[m(\varepsilon c_2 + \mu c_3) - d_1 + d_2 + d_3] \end{cases} \tag{10}$$

Substitute the coordinate values of the equilibrium points (0,0), (0,1), (1,0), and (1,1) into the Jacobian matrix to solve for the eigenvalues. The calculation results for the eigenvalues of each pure strategy equilibrium point are shown in Table. 7.

Table 7 Eigenvalues of equilibrium points for the Jacobian matrix

Equilibrium Point	Eigenvalue (λ_1)	Eigenvalue (λ_2)
(0, 0)	$-\delta c_1+\mu c_3+c_6$	$-d_1+d_2+d_3$
(0, 1)	$-\delta c_1-\varepsilon c_2+c_6$	$d_1-d_2-d_3$
(1, 0)	$\delta c_1-\mu c_3-c_6$	$\varepsilon c_2+\mu c_3-d_1+d_2+d_3$
(1, 1)	$\delta c_1+\varepsilon c_2-c_6$	$-\varepsilon c_2-\mu c_3+d_1-d_2-d_3$

Table 8 Stability conditions for equilibrium points in the system

Equilibrium Point	Stability Conditions
(0, 0)	$-\delta c_1+\mu c_3+c_6<0$; $-d_1+d_2+d_3<0$
(0, 1)	$-\delta c_1-\varepsilon c_2+c_6<0$; $d_1-d_2-d_3<0$
(1, 0)	$\delta c_1-\mu c_3-c_6<0$; $\varepsilon c_2+\mu c_3-d_1+d_2+d_3<0$
(1, 1)	$\delta c_1+\varepsilon c_2-c_6<0$; $-\varepsilon c_2-\mu c_3+ d_1-d_2-d_3<0$

Based on the Lyapunov stability condition, the asymptotic stability conditions for the equilibrium points are shown in Table. 8. Taking the equilibrium point (1,1) as an example, when the government's punishment from higher-level authorities for not implementing incentives exceeds the cost of active management and policies, as well as the policy subsidies and competitiveness enhancement from component enterprises' innovation and optimization can cover the incremental costs, both sides tend to choose the strategy of (incentive, innovation). It is also the optimal stable strategy in the early stage of prefabricated building development.

IV. Numerical Simulation Analysis

The previous section has obtained the asymptotic stability conditions for equilibrium points in the evolutionary game through theoretical calculations. In this chapter, the coefficient of influencing factors as variables will be selected to study the changes in evolutionary stable states under different parameter values. Moreover, the MATLAB software will be used for numerical simulation and visualization of the results.

A. Government and Construction Entities

Assuming the initial probabilities for the government and construction entities to choose the "incentive" and "prefabricated" strategies are both 0.5. Moreover, the other parameter values will be held constant when investigating a specific parameter. The evolutionary paths under different values of the management coefficient α, reward coefficient β, punishment coefficient τ, and tax coefficient θ ranging from 0.0 to 1.0 are obtained, as shown in Fig. 1 to Fig. 4.

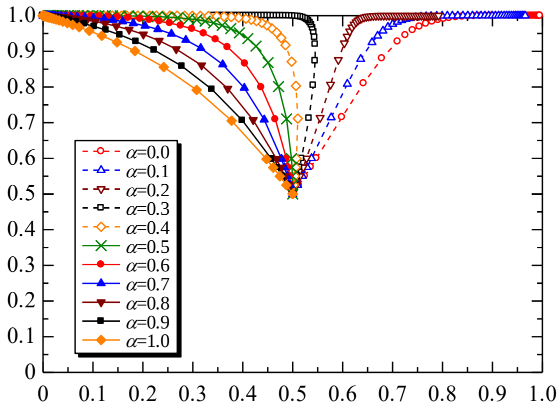

Figure 1 Evolutionary paths with different α values

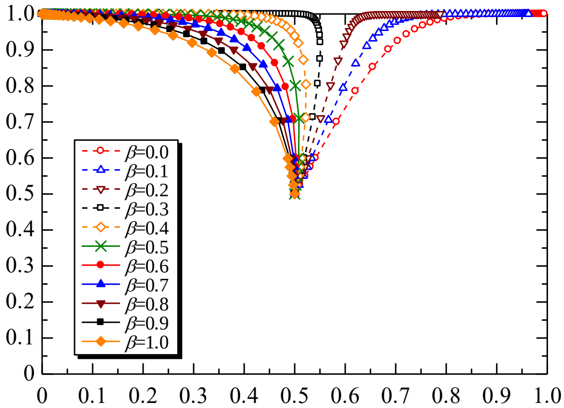

Figure 2 Evolutionary paths with different β values

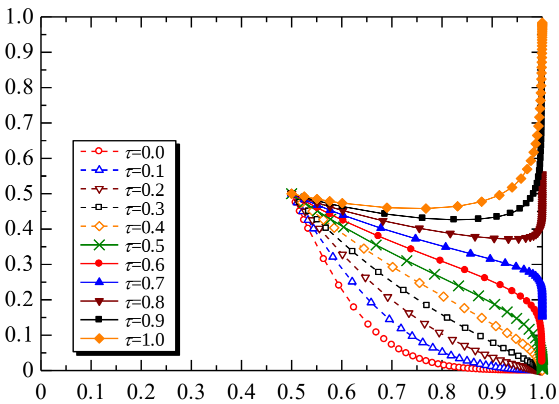

Figure 3 Evolutionary paths with different τ values

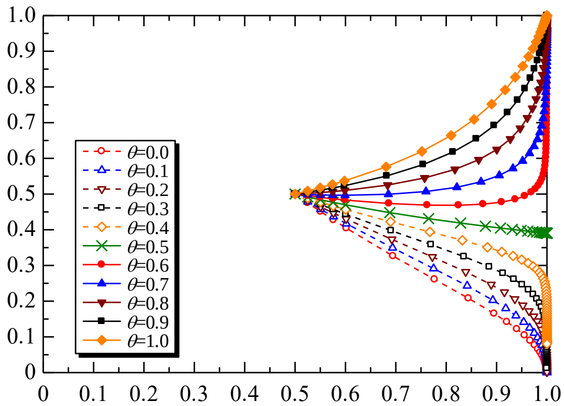

Figure 4 Evolutionary paths with different θ values

The management coefficient α represents the government's intensity in policy formulation and regulation, the reward coefficient β represents the degree of policy favoritism towards the construction entities, the punishment coefficient τ represents the government's management intensity over construction entities benefiting from preferential policies, and the tax coefficient θ represents the excessive tax penalty for the construction entities not responding to prefabricated construction. From the evolutionary path curves of the government and construction entities shown in the above Figures, it can be observed that increasing the management coefficient and the reward coefficient can accelerate the rate of equilibrium point evolution for both players. However, it also leads to increase the government management and financial pressure. Therefore, it is necessary to raise these coefficients within a reasonable range. On the other hand, increasing the punishment coefficient and tax coefficient enhances the sensitivity of construction entities to the policy response, and it is beneficial to increase these coefficients within a reasonable range for the positive evolution of strategies for both players.

B. Government and Component Enterprises

Assuming the initial probability values for the government and component enterprises to choose the "incentive" and "innovation" strategies are both 0.5. And the other parameter values will be held constant while studying a specific parameter. The evolutionary paths under different values of the regulatory coefficient δ, subsidy coefficient ε, and punishment coefficient μ ranging from 0.0 to 1.0 are obtained, as shown in Fig. 5 to Fig. 7.

The regulatory coefficient δ represents the government's intensity in standard formulation and regulation, the subsidy coefficient ε represents the degree of economic assistance provided by the government to the component enterprises, and the punishment coefficient μ represents government's management intensity over the component enterprises' benefiting from the policy preferences. From the changes in the evolutionary path curves of the government and component enterprises shown in the above Figures, it can be observed that increasing the regulatory coefficient δ can accelerate the rate of equilibrium point evolution for both players. However, it also leads to increased administrative management pressure on the government. As a result, the regulatory coefficient should be raised within a reasonable range. Besides, increasing the subsidy coefficient ε and punishment coefficient µ directly affects the economic benefits of the enterprises, and raising these coefficients within a reasonable range is beneficial for the faster evolution of positive strategy combinations for both players.

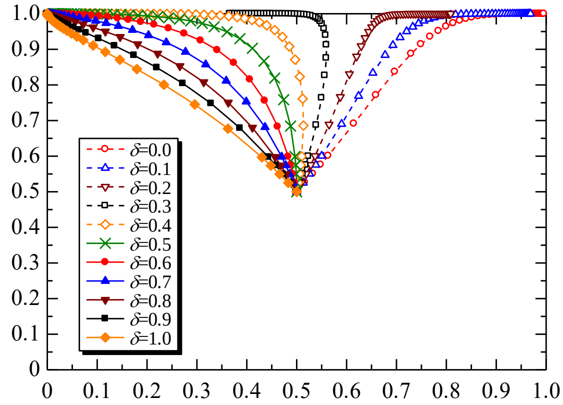

Figure 5 Evolutionary paths with different δ values

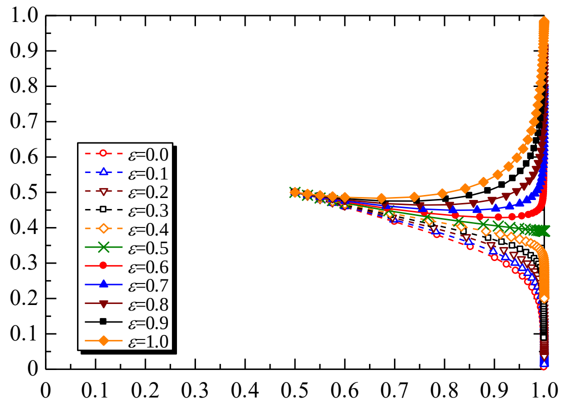

Figure 6 Evolutionary paths with different ε values

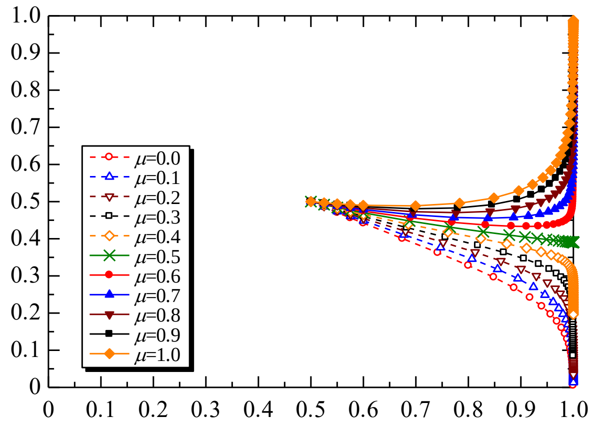

Figure 7 Evolutionary paths with different μ values

V. CONCLUSIONS

According to the investigation on the dynamic evolution paths of both players under different factors through MATLAB numerical simulation, the following detailed government incentives can be introduced to promote the development of prefabricated construction.

Improving the standard regulatory system and controlling regulatory costs scientifically. High costs of the policy formulation, standard specification, and supervision implementation will result in a lack of government involvement in the development of prefabricated construction. Therefore, the government should control regulatory costs scientifically, encourage excellent enterprises and professionals to participate the formulation and regulation of the standards in the prefabricated construction market, and strength the professional training for management and practitioners to reduce management costs.

Increasing the policy support appropriately. For construction companies, the implicit benefits brought by the policy favoritism and the direct economic benefits from subsidies, are advantageous in compensating for market defects and covering the incremental construction costs of prefabricated construction. However, excessive policy support costs will increase the fiscal burden, which will hinder the government incentive actions. Therefore, the policy support should be increased in a reasonable range, including the planning approvals, fiscal and financial support, and other multi-faceted policies.

Increasing the supervision and punishment appropriately. The construction companies are highly sensitive to government punishment actions, and the excessive punishment intensity will lead to fluctuations in strategy choices for both players. Therefore, it is necessary to plan dynamic reward and punishment mechanisms, to increase penalties for companies that fail to comply with standard requirements within a reasonable range.

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