

Game Research Based on Social Responsibility of Major Engineering

Yan Zou, Yao Wen*

School of economics and management, Southwest Petroleum University, Chengdu 610500, China

Abstract: In order to solve the problem of major engineering accidents caused by the lack of social responsibility, a tripartite evolutionary game model of government, social capital and the public is constructed, and the strategy selection and equilibrium conditions of the three parties are analyzed through simulation. The research shows that the greater the government's supervision, the higher the cost of social capital performing social responsibility, and the greater the loss of failure to perform social responsibility, and the more incentives for public participation, the three-party strategy choice will evolve to an ideal state. Based on this, provide suggestions for the government's policy formulation and the strategy choice of social capital and the public to give full play to the role of the public to achieve a win-win situation for all three parties and promote the sustainable development of major engineering.

Keywords: Major engineering, Social responsibility, Game model, Simulation analysis.

1. Introduction

With the increasing demand for major infrastructures in China, the state pays more and more attention to the planning and development of major projects, and a number of strategic, fundamental and leading major projects have been identified in the Outline of the 14th Five-Year Plan. In the context of the "Belt and Road" initiative and sustainable development strategy, China's major projects are facing an unprecedented period of strategic opportunity, environmental sensitivity and value reconstruction [1]. Major projects are extensive, have a close relationship with the public, and the main body of decision and investment is usually the state, featuring large scale, long period, complex natural environment and many participating subjects, which have important influence on regional social-economic environment [2]. Major projects are widely used in different fields such as water conservancy projects, rail transportation and highways, such as the Three Gorges Project, the South-North Water Transfer Project and the Hong Kong-Zhuhai-Macao Bridge, which are successful cases of major engineering practice in China and have significantly promoted the development of China's regional economy and substantially improved the quality of life of residents.

However, during the construction and operation of major projects in China, the problem of lack of social responsibility has gradually emerged and needs to be solved, resulting in labor conflicts, ecological damage and cultural risks, and even triggering some mega-engineering accidents and mass incidents, such as the stoppage of the Chongqing Chengdu Expressway, which is the "most delayed expressway in history", the PX incident in Kunming, Yunnan Province, and the Guangdong Boluo waste incineration plant site selection, etc.[3]. The complexity, one-time and dynamic nature of major projects bring great challenges to the sustainable development of the whole life cycle of projects, and social responsibility problems such as information asymmetry and opportunistic behavior can easily occur, which bring irreversible losses to major projects themselves and the social, economic and natural environment closely related to the projects. Therefore, theoretical and practical research on

social responsibility of major projects has become more and more important, and it is worthwhile to clarify the social responsibility relationship among stakeholders of major projects and how to fulfill social responsibility to mitigate the conflicts among stakeholders.

2. Literature Review

With the social responsibility of major projects becoming increasingly prominent, many scholars at home and abroad began to pay attention to this field and carry out research. In 1988, Merrow introduced the idea of social responsibility to major engineering projects for the first time [4], and later scholars conducted a series of explorations and researches on it, and it was not until 2015 that Zeng S X et al. gave a definition of social responsibility of major engineering and constructed the "whole life cycle-stakeholder-social responsibility" three-dimensional conceptual model of social responsibility of major projects[5], which laid the theoretical foundation for the subsequent research. Chinese scholars, such as Liu, believe that the evolution of social responsibility of major projects is influenced by four core influencing factors: regulatory pull, ethical push, economic support and political foundation, and constructed a model for the evolution of social responsibility of major projects [1]. Many scholars have also studied the game model problem of major projects. Sun Lei established a game model of two-two correlation among local government, project legal person and farmers to study the influence of the optimal offer on the final benefit split ratio among these three parties, and also introduced arithmetic examples to analyze and study the final benefit gained by the three parties [6]. Miao introduced Gaussian white noise to reflect the random disturbance factors in the process of subject's behavior, and constructed the evolutionary game model of project owner and contractor to interpret the change of system stability under the random disturbance [7]. Zeng studied the mechanism of behavior evolution and regulation mechanism of public-private cooperation in major engineering projects under PPP mode by constructing evolutionary game model[8]. In addition, some scholars added a third party to the traditional two-party game to construct a three-party evolutionary game model. He

introduced the prospect theory into the tripartite evolutionary game process of government, social capital and the public in major engineering projects, and studied the game strategy selection and its behavior analysis among three interest subjects[9]. Li introduces public supervision in the construction stage of major projects and constructs a tripartite evolutionary game model of government, contractors and third-party social public to solve the problem of major engineering accidents caused by negative supervision of supervisory departments[10].

In summary, the existing literature mostly focuses on theoretical research on social responsibility of major projects, and there is little research on the game evolution strategy of social responsibility actors of major projects. Due to the complexity, information asymmetry and cognitive level of major projects, the government can promote the social responsibility of social capital with the power of the public while supervising the social responsibility of social capital.

Based on this, construct a three-party evolutionary game model of "government-social capital-public", reveal the dynamic game evolution law between them, analyze the social responsibility behavior of each party in major projects, emphasize the importance of public participation, analyze the strategy choice and system evolution results of the three parties based on data simulation in Matlab, and make suggestions.

3. Model Building

The social responsibility of major projects involves many stakeholders. In order to study the stability of major projects system and the interaction mechanism of each participating subject, construct a social responsibility system of major projects composed of three game subjects: "government - social capital - public", whose relationship is shown in Figure 1.

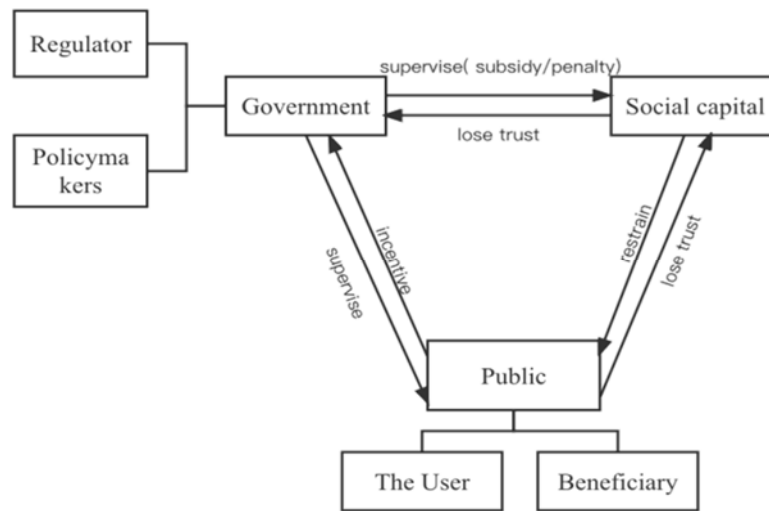


Figure 1. Diagram of the relationship between the three parties of the game

First, the government is the policy maker and regulator of major projects. In the process of construction of major projects, the government not only assumes the function of providing public products and services to the public, but also needs to supervise the whole process of major projects. At present, the government actively promotes and implements PPP mode to solve the capital and operation problems of major projects by leveraging the capital, technology and management advantages of social capital. Under the active supervision of the government, the construction of major projects is completed with high quality, and the government can not only promote the quality and efficiency of public services, but also maximize the economic, social and political interests. However, if the government does not do its corresponding supervisory duties, its credibility is bound to be affected.

Secondly, social capital, as the construction subject of major projects, is one of the core stakeholders in PPP mode. As major projects have large risks, if social capital lacks social responsibility awareness or has opportunistic behavior, it may gain temporary benefits in the short term, but in the long term, it will not only lose public trust, but also affect the sustainable development of the whole project.

Thirdly, the public is the user and actual beneficiary of

major projects. Therefore, it is necessary for the public to participate in the decision-making and management of major projects to play a positive role in promoting the government and social capital, supervising and restraining them, promoting the open and transparent operation of the projects, and ensuring the realization of public interests. However, at present, public participation is mostly manifested as symbolic participation at a lower level, with little attention and willingness to participate, which does not give full play to the role of common governance.

3.1. Model Assumptions

Hypothesis 1: The game subjects are the government, social capital and the public, all of which are limited rational decision makers.

Hypothesis 2: The government's strategy is (regulate, do not regulate). On the one hand, the government regulates social capital in order to maintain social interests, and on the other hand, it may connive at social capital's failure to fulfill its social responsibility for economic interests or to reduce the cost of regulation. The strategy of social capital is (fulfill, don't fulfill). Social capital chooses to fulfill its social responsibility for economic benefits or due to the pressure from the government and the public, but the cost increases

due to the human and material resources required, and social capital may choose not to fulfill its social responsibility for temporary benefits. The public's strategy is (participation, non-participation), the public actively participate in major projects for their own personal interests and to improve the quality of life, but due to the current public participation mechanism is not strong operability, limited power and single way, the public is not active enough, the supervision of the government and social capital is not put into practice.

Hypothesis 3: The probability that social capital chooses to fulfill its social responsibility is x , $0 \leq x \leq 1$; the probability that the government chooses to regulate is y , $0 \leq y \leq 1$; and the probability that the public chooses to participate is z , $0 \leq z \leq 1$.

3.2. Parameter variable setting

The benefit when social capital does not fulfill its social responsibility is R_{11} , and when social capital fulfills its social responsibility, it gains additional benefit R_{12} , which is expressed as increased brand value and social influence, etc. The cost of fulfilling social responsibility is C_1 . Under the government's supervision, when social capital fulfills its social responsibility, the government gives it certain incentives W , such as financial subsidies and tax concessions,

etc. If social capital does not fulfill its social responsibility, the government fines it F . When social capital does not fulfill its social responsibility and is exposed by the government or the public, the economic and reputation loss is L_1 .

When the government adopts a regulatory strategy, the cost of regulation is C_2 , where $F > C_2$. When social capital fulfills its social responsibility, the government also gains additional economic and social benefits R_2 . When the government adopts a non-regulatory strategy, the credibility decreases and the credit and reputation loss is L_2 .

When the public participates in major projects, the participation cost is C_3 , and the government gives them a certain incentive G , where, $G > C_3$. When social capital fulfills its social responsibility, the additional benefit to the public is R_3 . When social capital does not fulfill its social responsibility leading to the degradation of the quality of major projects, the loss to the public is L_3 .

3.3. Construction of payment matrix

According to the above assumptions and parameter settings, the game payment matrix can be obtained when social capital, government and public choose different strategies, as shown in Table 1.

Table 1. Payment matrix of the evolutionary game between social capital, government and the public

Game strategy		Public (Participation) z	Public(no participation) $1-z$
Social Capital (fulfillment of social responsibility) x	The government (regulation) y	$R_{12}-C_1+W$ R_2-C_2-G-W R_3+G-C_3	$R_{12}-C_1+W$ R_2-C_2-W R_3
	The government (No regulation) $1-y$	$R_{12}-C_1$ R_2-L_2 R_3-C_3	$R_{12}-C_1$ R_2-L_2 R_3
	The government (regulation) y	$R_{11}-L_1-F$ $F-C_2-G$ $G-C_3-L_3$	$R_{11}-L_1-F$ $F-C_2$ $-L_3$
Social Capital (Non-compliance with social responsibility) $1-x$	The government (No regulation) $1-y$	$R_{11}-L_1$ $-L_2$ $-C_3-L_3$	$R_{11}-L_1$ $-L_2$ $-L_3$

4. Tripartite Evolutionary Stability Analysis

4.1. Replication dynamic equation analysis of social capital

The expected return for social capital to fulfill its social responsibility is U_{11} , the expected return for not fulfilling its social responsibility is U_{12} , and the average expected return is \bar{U}_1 .

$$U_{11} = yz(R_{12} - C_1 + W) + y(1-z)(R_{12} - C_1 + W) + (1-y)z(R_{12} - C_1) + (1-y)(1-z)(R_{12} - C_1) \quad (1)$$

$$U_{12} = yz(R_{11} - L_1 - F) + y(1-z)(R_{11} - L_1 - F) + (1-y)z(R_{11} - L_1) + (1-y)(1-z)(R_{11} - L_1) \quad (2)$$

$$\bar{U}_1 = xU_{11} + (1-x)U_{12} \quad (3)$$

The dynamic equation of social capital replication is:

$$F(x) = x(U_{11} - \bar{U}_1) = x(1-x)(U_{11} - U_{12}) = x(1-x)[y(W+F) + R_{12} - R_{11} - C_1 + L_1] \quad (4)$$

Dynamic analysis of social capital replication:

Let $F(x) = 0$, we can get $x_1=0$ and $x_2=1$,

$$y^* = \frac{C_1 + R_{11} - R_{12} - L_1}{W + F}. \text{ Again } y^* = \frac{C_1 + R_{11} - R_{12} - L_1}{W + F},$$

the details are discussed as follows:

(1)When $y = y^* = \frac{C_1 + R_{11} - R_{12} - L_1}{W + F}$, there is

$F(x) = 0$ constant, for any value of x is a stable strategy.

(2)When $y > y^*$, $y(W+F) + R_{12} - R_{11} - C_1 + L_1 > 0$, $F'(0) > 0$ and $F'(1) < 0$, it is known that $x_2=1$ is a stable strategy, i.e., social capital fulfills social responsibility.

(3)When $z < z^*$, $y(W+F) + R_{12} - R_{11} - C_1 + L_1 < 0$, $F'(0) < 0$ and $F'(1) > 0$, it is known that $x_1=0$ is a stable strategy, i.e., social capital does not fulfill social responsibility.

4.2. Replication dynamic equation analysis for government

The expected return for government regulation is U_{21} , the expected return for no regulation is U_{22} , and the average expected return is \overline{U}_2 .

$$U_{21} = xz(R_2 - C_2 - G - W) + x(1-z)(R_2 - C_2 - W) + (1-x)z(F - C_2 - G) + (1-x)(1-z)(F - C_2) \quad (5)$$

$$U_{22} = xz(R_2 - L_2) + x(1-z)(R_2 - L_2) - (1-x)zL_2 - (1-x)(1-z)L_2 \quad (6)$$

$$\overline{U}_2 = yU_{21} + (1-y)U_{22} \quad (7)$$

The dynamic equation of government replication is:

$$F(y) = \frac{dy}{dt} = y(U_{21} - \overline{U}_2) = y(1-y)(U_{21} - U_{22}) \quad (8)$$

$$= y(1-y)[-zG - x(W + F) + F - C_2 + L_2]$$

Dynamic analysis of government replication:

Let $F(y)=0$, we can get $y1=0$ and $y2=1$, $z^* = \frac{-x(W+F)+F+L_2-C_2}{G}$. Again

$F'(y)=(1-2y)[-zG-x(W+F)+F-C_2+L_2]$, the details are discussed as follows:

(1) When, there is constant, for any value of y is a stable strategy.

$$(2) \text{ When } z = z^* = \frac{-x(W+F)+F+L_2-C_2}{G},$$

$F(y)=0$ and, it is known that $y2=1$ is a stable strategy, i.e., government regulation.

(3) When $z > z^*$, $-zG-x(W+F)+F-C_2+L_2 > 0$, $F'(0) > 0$ and $F'(1) < 0$, it is known that $y1=0$ is a stable strategy, i.e., the government does not regulate.

4.3. Replication dynamic equation analysis for the public

The expected benefit of public participation is U_{31} , the expected benefit of non-participation is U_{32} , and the average expected benefit is \overline{U}_3 .

$$U_{31} = xy(R_3 + G - C_3) + x(1-y)(R_3 - C_3) + (1-x)y(G - C_3 - L_3) + (1-x)(1-y)(-C_3 - L_3) \quad (9)$$

$$U_{32} = xyR_3 + x(1-y)R_3 - (1-x)yL_3 - (1-x)(1-y)L_3 \quad (10)$$

$$\overline{U}_3 = zU_{31} + (1-z)U_{32} \quad (11)$$

The dynamic equation of public replication is:

$$F(z) = \frac{dz}{dt} = z(U_{31} - \overline{U}_3) = z(1-z)(U_{31} - U_{32}) \quad (12)$$

$$= z(1-z)(yG - C_3)$$

Dynamic analysis of public replication:

Let $F(z)=0$, we can get $z1=0$ and $z2=1$, $y^* = \frac{C_3}{G}$. Again

$F'(z)=(1-2z)(yG-C_3)$, the details are discussed as follows□

(1)When $y = y^* = \frac{C_3}{G}$, there is $F(z)=0$ constant, for any value of z is a stable strategy.

(2)When $y > y^*$, $yG - C_3 > 0$, $F'(0) > 0$ and $F'(1) < 0$, it is known that $z2=1$ is a stable strategy, i.e., public participation.

(3)When $y < y^*$, $yG - C_3 < 0$, $F'(0) < 0$ and $F'(1) > 0$, it is known that $z1=0$ is a stable strategy, i.e., the public does not participate.

4.4. System evolutionary stability analysis

When the system of replicated dynamic equations is equal to zero, it indicates that the evolutionary game system reaches a relatively stable equilibrium, so that, the following eight equilibria are obtained: $E_1(0, 0, 0)$, $E_2(1, 0, 0)$, $E_3(0, 1, 0)$, $E_4(0, 0, 1)$, $E_5(1, 1, 0)$, $E_6(1, 0, 1)$, $E_7(0, 1, 1)$, $E_8(1, 1, 1)$. According to Friedman's conclusion [11], the stability of the evolutionary equilibrium point of the system can be judged by the Jacobi matrix. Based on this, the Jacobi matrix is constructed as follows:

$$J = \begin{bmatrix} \frac{dF(x)}{dx} & \frac{dF(x)}{dy} & \frac{dF(x)}{dz} \\ \frac{dF(y)}{dx} & \frac{dF(y)}{dy} & \frac{dF(y)}{dz} \\ \frac{dF(z)}{dx} & \frac{dF(z)}{dy} & \frac{dF(z)}{dz} \end{bmatrix} = \begin{bmatrix} J_{11} & J_{12} & J_{13} \\ J_{21} & J_{22} & J_{23} \\ J_{31} & J_{32} & J_{33} \end{bmatrix} \quad (13)$$

$$J_{11} = (1-2x)[y(W+F) + R_{12} - R_{11} - C_1 + L_1]$$

$$, J_{12} = x(1-x)(W+F), J_{13} = 0$$

$$J_{21} = -y(1-y)(W+F),$$

$$J_{22} = (1-2y)[-zG - x(W+F) + F - C_2 + L_2],$$

$$J_{23} = -y(1-y)G$$

$$J_{31} = 0, \quad J_{32} = z(1-z)G,$$

$$J_{33} = (1-2z)(yG - C_3)$$

From the Liapunov stability theory [12], it is known that the system is stable at the equilibrium point when the eigenvalues of the Jacobi matrix are all negative. The stability of each equilibrium point is obtained by bringing each of the eight equilibrium points into the Jacobi matrix, finding the corresponding eigenvalues, and judging their positive and negative values, as shown in Table 2.

Table 2. Eigenvalues of equilibrium points and stability judgment

Equilibrium point	The eigenvalue	Stability
E1(0, 0, 0)	$\lambda_1 = R_{12} - R_{11} - C_1 + L_1$	Saddle point
	$\lambda_2 = F - C_2 + L_2$	
	$\lambda_3 = -C_3$	
E2(1, 0, 0)	$\lambda_1 = R_{11} + C_1 - R_{12} - L_1$	Unknown
	$\lambda_2 = L_2 - W - C_2$	
	$\lambda_3 = -C_3$	
E3(0, 1, 0)	$\lambda_1 = R_{12} - R_{11} - C_1 + L_1 + W + F$	Saddle point
	$\lambda_2 = C_2 - L_2 - F$	
	$\lambda_3 = G - C_3$	
E4(0, 0, 1)	$\lambda_1 = R_{12} - R_{11} - C_1 + L_1$	Instability point
	$\lambda_2 = F - C_2 + L_2 - G$	
	$\lambda_3 = C_3$	
E5(1, 1, 0)	$\lambda_1 = R_{12} - R_{11} - C_1 + L_1 + W + F$	Instability point
	$\lambda_2 = W + C_2 - L_2$	
	$\lambda_3 = G - C_3$	
E6(1, 0, 1)	$\lambda_1 = R_{11} + C_1 - R_{12} - L_1$	Instability point
	$\lambda_2 = L_2 - C_2 - W - G$	
	$\lambda_3 = C_3$	
E7(0, 1, 1)	$\lambda_1 = W + F + R_{12} - R_{11} - C_1 + L_1$	Unknown
	$\lambda_2 = G + C_2 - L_2 - F$	
	$\lambda_3 = C_3 - G$	
E8(1, 1, 1)	$\lambda_1 = R_{12} - R_{11} - C_1 + L_1 + W + F$	Unknown
	$\lambda_2 = G + W + C_2 - L_2$	
	$\lambda_3 = C_3 - G$	

Since there are cases with positive eigenvalues in E_1 , E_3 , E_4 , E_5 , and E_6 , which do not satisfy the Lyapunov stability theory, there are three evolutionary stable states for this replicated dynamic equation.

(1) When $R_{11} + C_1 - R_{12} - L_1 < 0$ and $L_2 - W - C_2 < 0$, $E_2(1, 0, 0)$ is the evolutionary stabilization strategy, when social capital chooses to fulfill its social responsibility, the government chooses not to regulate, and the public adopts the non-participation strategy.

(2) When $W + F + R_{12} - R_{11} - C_1 + L_1 < 0$ and $W + F + R_{12} - R_{11} - C_1 + L_1 < 0$, $E_7(0, 1, 1)$ is the evolutionary stabilization strategy, when the government adopts a regulatory strategy and the public chooses to participate, but social capital does not fulfill its social responsibility.

(3) When $R_{11} + C_1 - R_{12} - L_1 - W - F < 0$ and $G + W + C_2 - L_2 < 0$, $E_8(1, 1, 1)$ is the evolutionary stable strategy, when the government chooses to regulate, the public chooses to participate, and social capital fulfills its social responsibility, which is the ideal state for tripartite evolution.

5. Numerical Simulation and Simulation Analysis

In this paper, Matlab software is used to numerically simulate and analyze the game model in order to observe the evolutionary trend more intuitively. In order for the model to reach the ideal state (1, 1, 1), the stability conditions of $R_{11} + C_1 - R_{12} - L_1 - W - F < 0$ and $G + W + C_2 - L_2 < 0$ need to be satisfied. The initial values of the parameters in this paper are set as follows: $R_{11} - R_{12} = 7$, $C_1 = 6$, $L_1 = 8$, $W = 3$, $C_2 = 4$, $L_2 = 10$, $F = 6$, $C_3 = 1$, and $G = 2$.

5.1. Analysis of the influence of the initial values of x, y, z on the evolution of the strategy

5.1.1. Analysis of social capital evolutionary strategies

Assuming the initial probability of social capital $x = 0.3$, 10 groups of government and public strategies y and z were randomly generated as a way to analyze the influence of government and public group decisions on government

decisions, so as to obtain the evolutionary path of x values. As shown in Figure 2, there is a decline in x at the early stage of evolution, which indicates that the number of social capital choosing to fulfill social responsibility decreases at that stage, probably because the government does not adopt certain

regulatory strategies and the public participation is not strong enough. In the later stage, with the passage of time, x eventually tends to 1, indicating that social capital eventually chooses to fulfill its social responsibility under the regulation of the government and the public.

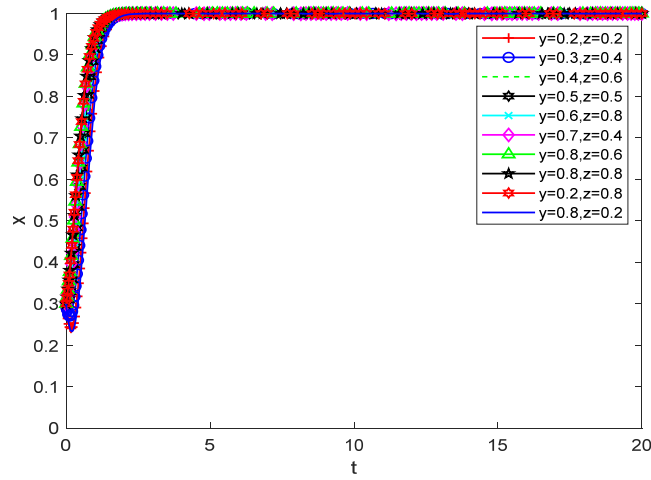


Figure 2. Analysis of social capital evolution strategy

5.1.2. Analysis of government evolution strategy

Assuming the initial probability of the government $y=0.3$, 10 groups of social capital and public strategies x and z are randomly generated as a way to analyze the influence of social capital and public group decisions on government decisions, so as to obtain the evolutionary path of y values.

As shown in Figure 3, during the evolution process, the convergence rate of y changes with time and finally stabilizes at 1, i.e., the government adopts the regulatory strategy. It indicates that with the increase of the number of social capital and public participation in fulfilling social responsibility, the government will eventually choose the regulatory strategy.

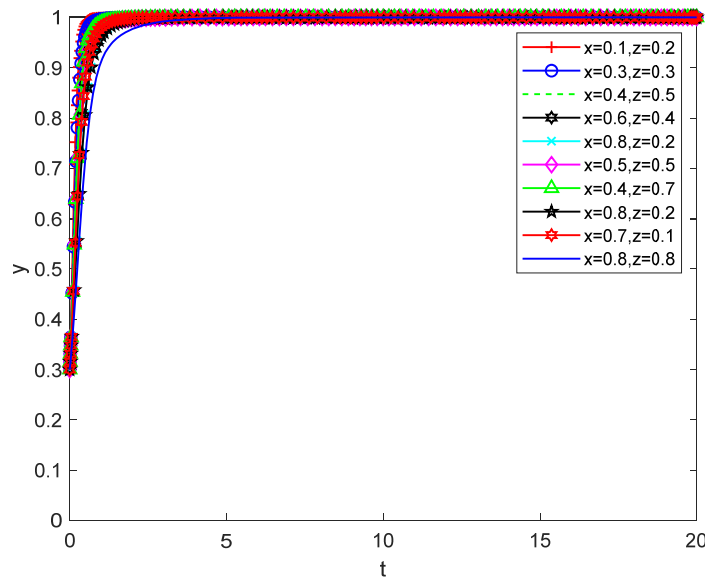


Figure 3. Analysis of government evolution strategy

5.1.3. Analysis of public evolution strategy

Assuming the initial probability of the public $z = 0.3$, 10 groups of social capital and government strategies x and y were randomly generated as a way to analyze the influence of social capital and government group decisions on public decisions, so as to obtain the evolutionary path of z values. As can be seen from Figure 4, z values are not monotonically

increasing, and there is also a decrease in z at the early stage of evolution, indicating that public participation is not high at that stage, probably due to the lack of government incentives. However, as time goes on, z eventually tends to 1, indicating that as government regulation increases and social capital fulfills its social responsibility, the public eventually chooses to participate in the strategy of major projects.

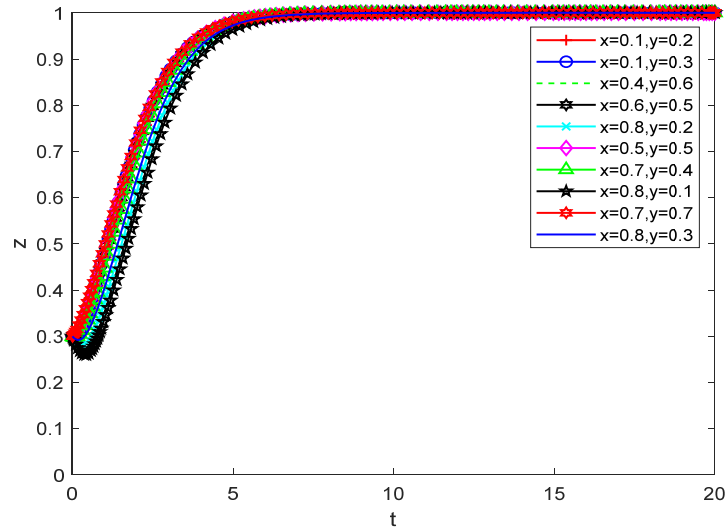


Figure 4. Analysis of public evolution strategy

5.2. Analysis of the influence of parameters on strategy evolution

The above parameters are adjusted and simulated to obtain 3 key parameters, C_1 , L_1 and G . Since the major projects are related to the nation's livelihood, the government will pay more attention to the supervision, so set the probability in the initial state as $x=0.6$, $y=0.5$ and $z=0.5$.

5.2.1. The impact of cost C_1 on the game for social capital to fulfill its social responsibility

The cost of fulfilling social responsibility is an important

factor that influences whether social capital chooses to fulfill social responsibility. In this paper, the values of C_1 are taken as 0, 3, 6 and 9 respectively, and its influence on the evolutionary strategy of social capital is shown in Figure 5. As C_1 increases, the value of x appears to decrease, indicating that some social capital may not fulfill social responsibility as the cost of fulfilling social responsibility increases. Government regulation and public supervision have a facilitating effect on social capital to fulfill social responsibility when they have a significant impact on social capital.

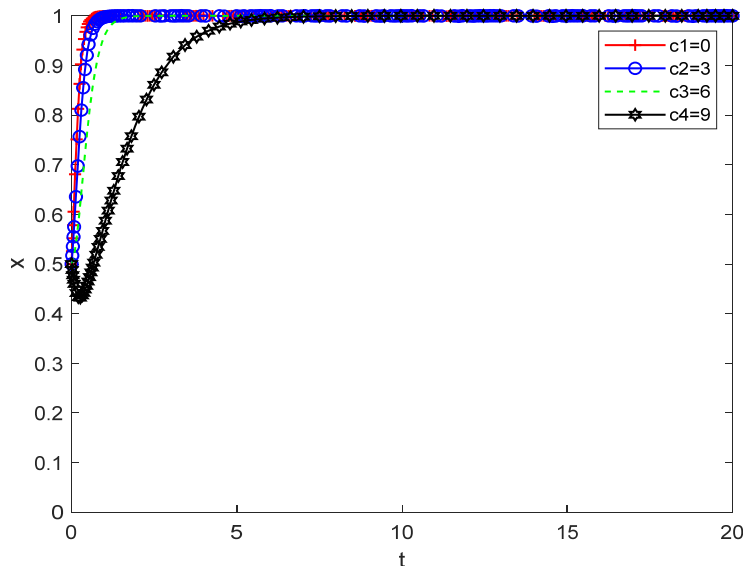


Figure 5. Effect of cost C_1 on the evolutionary path of social capital

5.2.2. The impact of the loss of social capital not fulfilling social responsibility L_1 on the game

When social capital does not fulfill its social responsibility, the brand value and corporate image will suffer a certain loss. In this paper, we take values 5, 7, 9 and 11 for L_1 respectively,

and the impact of its evolutionary strategy is shown in Figure 6. As L_1 decreases, the value of x decreases, indicating that social capital may appear to not fulfill social responsibility when the loss of not fulfilling social responsibility is below a certain threshold; on the contrary, the higher the loss, the more social capital tends to fulfill social responsibility.

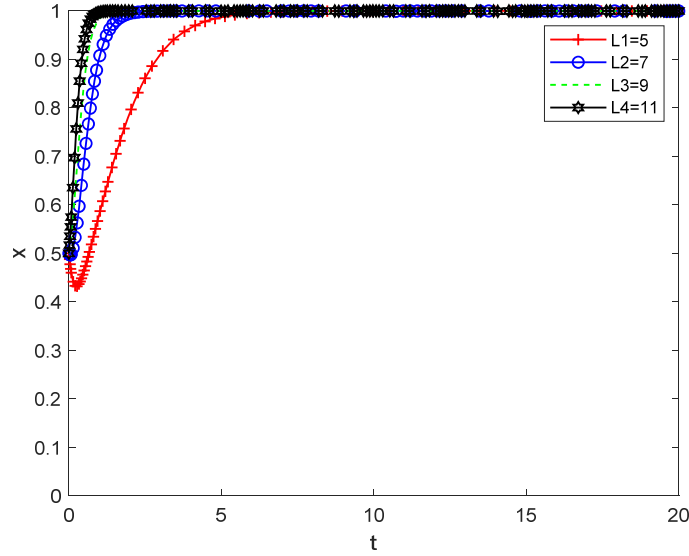


Figure 6. Effect of loss L_1 on the evolutionary path of social capital

5.2.3. The effect of government incentives G given to the public on the game

In order to promote the active participation of the public in the construction and management process of major projects, the government needs to adopt certain incentive measures. In this paper, we take values of 0, 1, 2 and 3 for G respectively, and its influence on the public's evolutionary strategy is shown in Figure 7. In the evolutionary process, the public's

strategy choice evolves from non-participation to participation, and when G is greater than a certain threshold, the larger G is, the faster the public's evolutionary rate is. This indicates that the public is less motivated to participate when the rewards they receive are not enough to cover the cost of their participation; as the government increases the rewards for public participation, the rate of public participation increases.

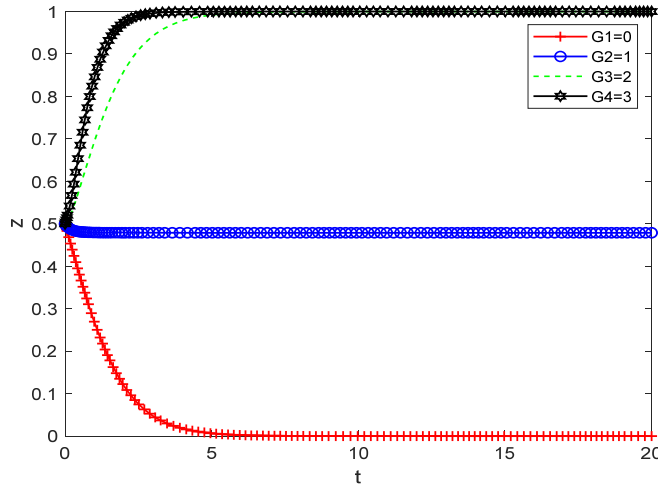


Figure 7. Effect of reward G on public evolutionary path

6. Conclusion

This paper combines the development of major projects, constructs a three-party game evolution model of government, social capital and the public, analyzes the stability and evolution results under different strategies, and uses Matlab for data simulation analysis, and draws the following conclusions.

(1) In the process of system evolution of government, social capital and public, the strategy choices of three interest subjects influence each other, and the evolution and trend of each subject's behavior are closely related to the other two interest subjects.

(2) The cost of social capital performing social

responsibility and the loss of not performing social responsibility as well as the government's reward when the public participates are important factors that affect the game outcome. The three-party game evolves to the ideal state when the economic and political gains obtained by the government when regulating are higher than the subsidies it gives to social capital and the rewards it gives to the public, when the additional gains obtained by social capital when fulfilling its social responsibility are higher than its costs of fulfillment, and when the rewards from the government when the public participates are higher than its costs of participation, i.e., social capital fulfills its social responsibility, the government regulates, and the public participates.

Therefore, the following recommendations are made in

response to the conclusions.

(1) The government plays a leading role in the construction process of major projects, and should balance efficiency and fairness to promote all parties to reach a balance of interests. Firstly, it should standardize the entry criteria of social capital, examine and select social capital to ensure that it has good credibility, advanced technology, strong management ability and other good qualifications, so as to improve the quality and efficiency of the project; secondly, it should improve the supervision efficiency and supervision level, constrain social capital by formulating corresponding laws and regulations, strengthen the supervision of social capital's fulfillment of social responsibility, and make full use of media and Finally, a system combining rewards and punishments should be established to give subsidies and rewards to social capital that consciously fulfills its social responsibility and to the public that actively participates, and to increase the punishment for social capital that does not fulfill its social responsibility. However, too low penalties are not binding for social capital, and too high rewards will put a burden on the government itself; therefore, reasonable thresholds of rewards and penalties should be determined to ensure the effectiveness of rewards and penalties.

(2) The fulfillment of social responsibility depends not only on government supervision and public monitoring, but also on social capital's own awareness and understanding of social responsibility. Therefore, social capital should first raise its own awareness of responsibility, consciously and actively take up social responsibility while pursuing profit maximization, establish a big picture concept, consider problems from a long-term perspective, internalize the concept of sustainable development, and actively cooperate with government departments and the public in their inspections. The credibility of the enterprise should also be announced to the society to form a top-down accountability system.

(3) To increase public participation in major projects, it is not enough to rely on government supervision alone, but to give full play to the advantages of social supervision. At present, public participation is still low. Although major projects concern the immediate interests of the public, public attention to them is not high enough, so it is necessary to vigorously promote them and broaden the channels and ways of public participation. In addition to rewarding the public who actively participate in major projects, we can also use big data and network information technology to build a public participation platform and disclose the project progress and its related information in real time to increase the transparency of the project in order to solve the problem of

information asymmetry.

References

- [1] Liu Zeming, Sui Yue, Jin Zhizhou, Yang Xu: Evolution of social responsibility of major infrastructure projects in the international perspective, *Journal of System Management*, Vol. 27(2018) No.1, p.101-108.
- [2] Sheng Z: Fundamental theories of mega infrastructure construction management: theoretical considerations from chinese practices (Springer, Switzerland, 2017), p.492.
- [3] He Shoukui: Logic of social responsibility behavior of multiple investment subjects of major projects and networked governance, *Enterprise Economy*, Vol. 40 (2021) No.3, p.5-14+2.
- [4] Marrow E W, Mc Donnell L, Argüden R Y: Understanding the Outcomes of Megaprojects: A Quantitative Analysis of very Large Civilian Projects (CA: Rand Corporation, Santa Monica,1988).
- [5] Deng S X, Ma H Y, Lin H: Social responsibility of major infrastructure projects in China, *International Journal of Project Management*, Vol. 33 (2015) No.3, p.537-548.
- [6] Sun Lei, Sun Shaorong: Research on the conflict of interest and governance mechanism triggered by major infrastructure projects, *Journal of Management Engineering*, Vol. 30 (2016) No.1, p.34-42.
- [7] Miao Junxia, Huang Dechun, Zhang Changzheng: Game and simulation analysis of major engineering project subject's behavior based on stochastic evolutionary game, *Practice and Understanding of Mathematics*, Vol. 49 (2019) No.10, p.106-113.
- [8] Zeng Xiaoling, He Shoukui: Research on public-private interest conflict and behavior evolution game in PPP mode of major engineering projects, *Construction Economics*, Vol. 40 (2019) No.12, p.66-72.
- [9] He Shoukui, Liang Gongwen, Meng Jianbo: Mechanism of interest game and behavior evolution of multiple subjects in major projects based on prospect theory, *Science and Technology Management Research*, Vol. 40 (2020) No.5, p.207-214.
- [10] Li Haomiao, Zhang Lin: Research on the evolutionary game of major infrastructure project supervision based on third-party supervision, *Journal of Engineering Management*, Vol. 35 (2021) No.4, p.99-104.
- [11] Friedman A: A simple testable model of double auction markets, *Journal of Economic Behavior and Organization*, Vol. 15 (1991) No.1, p.47-70.
- [12] Lyapunov A M: The general problem of the stability of motion, *International Journal of Control*, Vol. 55 (1992) No.3, p.531-773.