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Analysis of Zombie Enterprises' Retention and Departure Based on Game Theory

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Abstract: Zombie enterprises, predominantly found in state-owned heavy industries and labor-intensive sectors, have emerged as a crucial challenge in recent years' supply-side structural reforms. To address this issue, this study constructs an evolutionary game model involving enterprises, banks, and the government. By employing replicated dynamic equations, the analysis examines the impact of factors such as the cost of enterprise exit, implicit benefits after bankruptcy, on the decision-making of enterprises to stay or exit. The research indicates that the cost of continuing operations for zombie enterprises, bankruptcy costs, corporate income tax rates, the magnitude of implicit benefits from continuing operations, bank loan interest rates, and the expected returns from diverting loan amounts to other purposes can influence the outcomes of the game. Ultimately, from a government perspective, relevant recommendations are proposed to provide insights into effectively addressing the problem of zombie enterprises.

Keywords: tripartite game, zombie company, government intervention, bank loans

1. Introduction

The issue of zombie enterprises has persisted for a long time, becoming increasingly chronic. With the continuous advancement of supply-side structural reforms in recent years, the question of whether zombie enterprises should stay or exit has once again become a priority. In 2018-2019, the National Development and Reform Commission issued a series of documents emphasizing the need to "deepen the supply-side structural reforms and actively and prudently handle 'zombie enterprises'" and to "accelerate the resolution of 'zombie enterprises.'" Since 2020, the three-year action plan for state-owned enterprise reforms has been fully implemented. The 20th National Congress of the Communist Party of China report highlighted the importance of "deepening the reform of state-owned assets and state-owned enterprises, accelerating the optimization and restructuring of the state-owned economy, promoting the strength, excellence, and growth of state-owned capital and state-owned enterprises, and enhancing the core competitiveness of enterprises," providing significant directives for the restructuring and revitalization of zombie enterprises, particularly those owned by the state.

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Due to the wide scope of zombie enterprises, existing statistical data indicates that the proportion of zombie enterprises in China's industrial sector was highest around 30% in 2000. This proportion gradually declined and stabilized after 2004, with the percentage of zombie enterprises in the industrial sector reaching approximately 7.51% in 2013 [1]. Despite some reduction in the proportion of zombie enterprises in recent years due to deepening reforms, the sheer size and high output value of industrial sector enterprises, as evident from publicly available statistical data by the National Bureau of Statistics, still pose a significant challenge, with over 55,000 industrial enterprises reporting losses in 2019 [2]. This underscores the fact that the problem of zombie enterprises remains a crucial aspect of supply-side structural reforms.

The repeated mention of the zombie enterprise issue can be attributed to the fact that these enterprises have lost their ability to generate independent profits. Unlike companies facing temporary difficulties due to market or asset-related issues, zombie enterprises rely on government subsidies and bank loans for long-term survival. This reliance inevitably hampers the development of a healthy market-oriented process. Specifically, zombie enterprises distort the normal order of market competition, slow down the elimination of outdated technologies and production systems, and lead to disorderly competition within industries. This is manifested by zombie enterprises occupying a significant share of market resources and increasing industry entry barriers. Moreover, zombie enterprises pose risks to the banking system, as the inability to repay "zombie loans" will consume a considerable amount of credit resources. This not only reduces banks' profitability but also squeezes the survival space of healthy enterprises.

In the face of the still substantial population of zombie enterprises, effectively achieving their transformation and addressing the dilemma of whether they should stay or exit remains a challenging task in the realm of economic reforms. Therefore, this paper will focus on the tripartite game relationship among enterprises, banks, and the government, analyze the factors contributing to the formation of zombie enterprises, and propose possible solutions based on new policies and the emerging landscape of the new era.

2. Literature Review

The concept of zombie enterprises was initially introduced by Kane, referring to financially insolvent financial institutions in the United States during the 1980s [3]. Subsequently, scholars such as Hoshi expanded this concept to describe enterprises that are unable to cover their liabilities and rely on support from government and bank creditors to survive. The causes of zombie enterprises are complex, but existing research generally adopts a trilateral perspective involving the government, banks, and enterprises [4]. From a government perspective, some scholars argue that the existence of special government-business relationships, driven by the need for social stability and GDP growth [5], has led to improper intervention and excessive protection of enterprises, contributing to the formation of zombie enterprises [6]. From a bank perspective, Qian analyzed data from Chinese listed companies between 2000 and 2016 and proposed that competition among banks influences the formation of zombie enterprises through two paths: credit subsidy signaling and price distortion [7]. Wang suggests that government control over state-owned enterprises and commercial banks is an inherent source of non-performing loans [8]. From an enterprise perspective, factors such as enterprise type and micro-level internal factors may influence the formation of zombie enterprises [9]. Low operational efficiency, prolonged inventory turnover, and asset turnover time make manufacturing and state-owned enterprises more susceptible to becoming zombie enterprises [10]. Factors such as decision-making and management mode choices [11], as well as inappropriate strategies based on comparative advantages [12], also have an impact.

Evolutionary game theory, as an analytical tool that examines the strategy adjustments of different game entities from the perspective of bounded rationality, aims to achieve stable optimal strategies

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[13]. It is widely applied in the analysis of incentive mechanisms, management strategies, and other areas involving multiple game entities. Wang et al. used a trilateral dynamic game model to demonstrate the influence of the risk level after enterprise closure on government and bank decision-making [5]. Chen et al., based on evolutionary game theory, concluded that special subsidy strategies accelerate the exit of large state-owned zombie enterprises [14]. Huang et al. used an evolutionary game model to determine that the costs of enterprise reform and the government's reward-punishment mechanism for zombie enterprises influence their strategic choices [15]. Based on the aforementioned studies, this paper adopts an evolutionary game approach to construct a trilateral game model involving enterprises, banks, and the government. It investigates the influence of different strategic choices and parameter settings by each party, under bounded rationality conditions, on the decision of whether zombie enterprises should stay or exit. The findings aim to provide insights for effectively addressing the issue of zombie enterprises.

3. Evolutionary Game Model of Government, Banks and Enterprises

3.1. Three-party Payment Matrix Construction

In the analysis of the retention of zombie enterprises, three game subjects are involved: enterprises, government and banks. Assuming that all game subjects are rational and aim at maximizing their own interests, the three-party game is analyzed.

The strategy set of the enterprise is {declare bankruptcy, do not declare bankruptcy}, "declare bankruptcy" means that the zombie enterprise, regardless of whether it receives government subsidies and bank loans, has to declare bankruptcy because it is difficult to maintain its operation, and then it needs to bear the bankruptcy cost C2, which includes the cost of depreciation, social cost and procedure cost. In the case of "not declaring bankruptcy", the zombie enterprise will actively reform its management model or internal factors, such as technology, and will have to bear the cost of maintaining its business C1, in which the profit π differs when the government and banks adopt different strategies.

The bank's strategy set is {loan, no loan}. "Loan" means that the bank chooses to lend to the zombie enterprise for reasons such as improper government intervention, soft budget constraint, or low default cost of state-owned enterprises, assuming that the loan amount to be paid is I. If the enterprise is not bankrupt, it receives interest F. If the enterprise declares bankruptcy, the bank loses γ. "Do not lend " i.e., the bank refuses to provide the loan for reasons such as distrust of the zombie enterprise's ability to repay the loan, and can put the loan amount into other uses thus the expected return X can be obtained.

The government's strategy set is {subsidy, no subsidy}. "Subsidy" means that the government provides subsidies to zombie enterprises for the purpose of maintaining stability and promoting enterprise reform. The amount of subsidy needs to be provided G. If the enterprise is not bankrupt, it will receive tax revenue under the corporate income tax rate of t and the potential benefit S from maintaining stability. If the enterprise is bankrupt, it will face the risk cost S from instability [16].

In this game, enterprise, bank and government make strategic decisions based on their personal desires. Assuming a enterprise decides to declare bankruptcy with a probability of x, then the likelihood of opting not to declare is 1-x. If a bank decides to lend money with a probability of y, then if it decides not to, the probability is 1-y. The likelihood that the government will choose to subsidize is z, while the likelihood that it will not choose to subsidize is 1-z. Based on the above assumptions and parameter settings, the payoff matrices are shown as Table 1 and Table 2. Table 3 displays the game's parameter settings.

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Table 1: Payment matrix for the game of government subsidies.

Government: Subsidies (z)			
		Bank	
		Loan (y)	No loan (1-y)
Enterprise	Declare bankruptcy (x)	$(G + I - C_2, -I - \gamma, -G - S)$	$(G - C_2, X, -G - S)$
	Don't declare bankruptcy (1-x)	$((1-t)\pi_1 - C_1 + G + I - F, -I + F, -G + S + t\pi_1)$	$((1-t)\pi_2 - C_1 + G, X, -G + S + t\pi_2)$

Table 2: Payment matrix for the game of without government subsidies.

Government: No subsidies (1-z)			
		Bank	
		Loan (y)	No loan (1-y)
Enterprise	Declare bankruptcy (x)	$(I - C_2, -I - \gamma, -S)$	$(-C_2, X, -S)$
	Don't declare bankruptcy (1-x)	$((1-t)\pi_3 - C_1 + I - F, -I + F, S + t\pi_3)$	$((1-t)\pi_4 - C_1, X, -S + t\pi_4)$

Table 3: Parameter setting of the game.

Parameter setting
G: the amount of government subsidies for zombie enterprises
I: the amount of bank loans for zombie enterprises
π_1: the profit that the zombie enterprise can get after not declaring bankruptcy, receiving government subsidies and bank loans
π_2: the profit that the zombie enterprise can get after not declaring bankruptcy and only receiving government subsidies
π_3: the profit of the zombie enterprise after it doesn't declare bankruptcy and only obtains bank loans
π_4: the profit of a zombie enterprise that doesn't declare bankruptcy but doesn't receive bank loans or government subsidies ($\pi 4<0$)
t: corporate income tax rate ($0<t<1$)
C_1: cost required for the enterprise to maintain its business without declaring bankruptcy (including the cost of carrying out reform, technology research and development, etc.)
γ: the loss of the bank after providing the loan to the subsequent bankrupt enterprise ($\gamma>0$)
C_2: cost required for the enterprise to declare bankruptcy (including costs of depreciation, social problems and formalities, etc.)
F: the sum of principal and interest required to be paid by the enterprise to the bank (F>I)
S: the implicit benefits of stabilization brought by zombie enterprises not declaring bankruptcy, also in the amount of the cost of risk brought by the bankruptcy of zombie enterprises
X: the expected return from putting the loans into the financial market

3.2. Trilateral Evolutionary Stabilization Strategy Solving

According to the above payment matrix of the game, the expected utility of a firm declaring bankruptcy is U_{E1}:

$$U_{E1} = yz(G + I - C_2) + z(1-y)(G - C_2) + y(1-z)(I - C_2) + (1-y)(1-z)(-C_2) \quad (1)$$

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The expected utility of a firm not declaring bankruptcy is U_{E2}:

$$U_{E2} = yz[(1-t)\pi_1 - C_1 + G + I - F] + z(1-y)[(1-t)\pi_2 - C_1 + G] + y(1-z)[(1-t)\pi_3 - C_1 + I - F] + (1-y)(1-z)[(1-t)\pi_4 - C_1] \quad (2)$$

The average expected utility of the firm is $\overline{U_E}$:

$$\overline{U_E} = xU_{E1} + (1-x)U_{E2} \quad (3)$$

The expected utility of a bank loan is U_{B1}:

$$U_{B1} = xz(-I-\gamma) + z(1-x)(-I+F) + x(1-z)(-I-\gamma) + (1-x)(1-z)(-I+F) \quad (4)$$

The expected utility of a bank not lending is U_{B2}:

$$U_{B2} = xzX + z(1-x)X + x(1-z)X + (1-x)(1-z)X \quad (5)$$

The average expected utility of the bank is $\overline{U_B}$:

$$\overline{U_B} = yU_{B1} + (1-y)U_{B2} \quad (6)$$

The expected utility of the government subsidy is U_{G1}:

$$U_{G1} = xy(-G-S) + x(1-y)(-G-S) + y(1-x)(-G+S+t\pi_1) + (1-x)(1+y)(-G+S+t\pi_2) \quad (7)$$

The expected utility of no government subsidy is U_{G2}:

$$U_{G2} = xy(-S) + x(1-y)(-S) + y(1-x)(S+t\pi_3) + (1-x)(1-y)(-S+t\pi_4) \quad (8)$$

The average expected utility of the government is $\overline{U_G}$:

$$\overline{U_G} = zU_{G1} + (1-z)U_{G2} \quad (9)$$

By applying the theory of replication dynamics in the evolutionary game to the game situation as above, assume that the replication dynamics equation for the firm choosing to declare bankruptcy is F(x), the replication dynamics equation for the bank choosing to lend is F(y), and the replication dynamics equation for the government choosing to subsidize is F(z).

By applying the theory of replication dynamics in evolutionary games to the game situation as above, the replication dynamics equation for the firm's choice to declare bankruptcy is:

$$F(x) = \frac{dx}{dt} = x(U_{E1} - \overline{U_E}) = x(1-x)\{C_1 - C_2 + yF - (1-t)[yz\pi_1 + z(1-y)\pi_2 + y(1-z)\pi_3 + (1-y)(1-z)\pi_4]\} \quad (10)$$

The replication dynamic equation for the bank's loan is:

$$F(y) = \frac{dy}{dt} = y(U_{B1} - \overline{U_B}) = y(1-y)[-I - X - x\gamma + (1-x)F] \quad (11)$$

The replication dynamic equation for the government's subsidy is:

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$$F(z) = \frac{dz}{dt} = z(U_{G1} - \overline{U_G}) = z(1-z)\{-G + (1-x)[-2Sy + yt\pi_1 + (1-y)\pi_2 - yt\pi_3 - (1-y)t\pi_4\} \quad (12)$$

3.2.1. Game Equilibrium Analysis of Enterprises

Assuming $z_0 = -\frac{C1-C2-yF+(1-t)[y\pi3+(1-y)\pi4]}{(1-t)[y(\pi1-\pi3)+(1-y)(\pi2-\pi4)]}$, when $z = z_0$, $F(x) = 0$. It implies that the chance of a company's declaration of bankruptcy does not alter over time, regardless of what it may be. When $z \neq z_0$, assuming that $F(x) = 0$, then get x=0 or x=1 as two stable points. The derivative of F (x) can be obtained that when $z < z_0$, $F'(0) > 0$, $F'(1) < 0$, and $x = 0$ is the evolutionary stability strategy. When $z < z_0$, $F'(0) < 0$, $F'(1) > 0$, and $x = 1$ is the evolutionary stability strategy. As the probability z rises, the likelihood x falls. Figure 1 depicts the phases of the enterprise's strategic evolution.

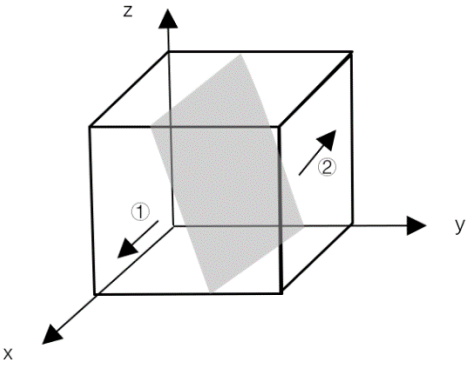

Figure 1: Phase of the enterprise's strategic evolution.

3.2.2. Game Equilibrium Analysis of Bank

Assuming $x_0 = \frac{F+I-X}{\gamma+F}$, when $x = x_0$, $F(y) = 0$. It implies that the chance of a bank's loan does not alter over time, regardless of what it may be. When $x \neq x_0$, assuming that $F(y) = 0$, then get y=0 or y=1 as two stable points. The derivative of $F(y)$ can be obtained that when $x > x_0$, $F'(0) > 0$, $F'(1) < 0$, and $y = 0$ is the evolutionary stability strategy. When $x < x_0$, $F'(0) < 0$, $F'(1) > 0$, and $y = 1$ is the evolutionary stability strategy. As the probability x rises, the likelihood y falls. Figure 2 depicts the phases of the bank's strategic evolution.

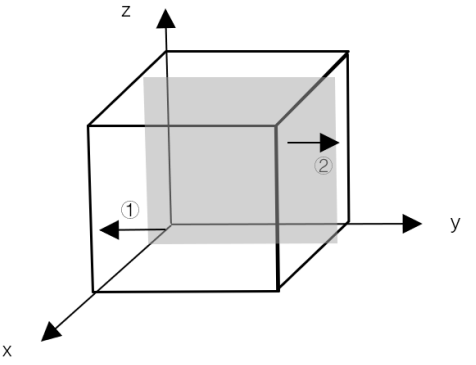

Figure 2: Phase of the bank's strategic evolution.

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3.2.3. Game Equilibrium Analysis of Government

Assuming $y_0 = \frac{G-(1-x)*[2*S+t*(\pi 2-\pi 4)]}{(1-x)*[-2*S+t*(\pi 1-\pi 2-\pi 3+\pi 4)]}$, when $y = y_0$, $F(z) = 0$. It implies that the probability of starting government subsidies does not alter over time, regardless of what it may be. When $y \neq y_0$, assuming that $F(z) = 0$, then get z=0 or z=1 as two stable points. The derivative of $F(z)$ can be obtained that when $y > y_0$, $F'(0) > 0$, $F'(1) < 0$, and $z = 0$ is the evolutionary stability strategy. When $y < y_0$, $F'(0) < 0$, $F'(1) > 0$, and $z = 1$ is the evolutionary stability strategy. As the probability y rises, the likelihood z falls. Figure 3 depicts the phases of the government's strategic evolution.

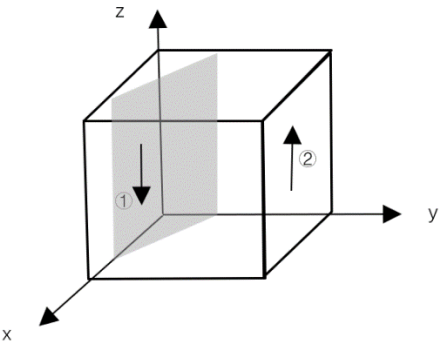

Figure 3: Phase of the government's strategic evolution.

3.2.4. Stability Analysis of Equilibrium Point of Tripartite Evolutionary Game System

Assuming $F(x) = 0, F(y) = 0$ and $F(z) = 0$, there are 13 equilibrium points when $x, y, z \in [0,1]$, including 8 pure strategy equilibrium and 4 mixed strategy equilibrium. The tight Nash equilibrium in asymmetric games is pure strategic equilibrium, not mixed strategy equilibrium. Evolutionary game equilibrium in asymmetric games is evolutionary stable equilibrium which must be strict Nash equilibrium. Consequently, in line with Ritzberger and Weibull [17], this paper only discusses the gradual stability of pure strategic equilibrium points E1 (0, 0, 0), E2 (0, 0, 1), E3 (0, 1, 0), E4 (1, 0, 0), E5 (1, 1, 0), E6 (1, 0, 1), E7 (0, 1) and E8 (1, 1, 1) [18]. As shown in Table 4.

Table 4: Jacobian characteristic value of each equilibrium point.

Equilibrium	Characteristic value λ_1, λ_2 and λ_3
E1	F-I-X, 2S-G+tπ_2-tπ_4, C_1-C_2-π_4+tπ_4
E2	-G, -I-X-γ, C_2-C_1+π_4-tπ_4
E3	tπ_1-G-tπ_3, I-F+X, C_1-C_2 + F-π_3+tπ_3
E4	F-I-X, C_1-C_2-π_2+tπ_2, G-2S-tπ_2+tπ_4
E5	-G, I+X+γ, C_2-C_1 − F+π_3-tπ_3
E6	G, -I-X-γ, C_2-C_1+π_2-tπ_2
E7	G-tπ_1+tπ_3, I-F+X, C_1-C_2 + F-π_1+tπ_1
E8	G, I+X+γ, C_2-C_1-F+π_1-tπ_1

According to Lyapunov's first method: a point is asymptotically stable when every characteristic value in the Jacobian matrix of an equilibrium point has a negative real part. An equilibrium point is an unstable fixed point if the characteristic value of the Jacobian matrix of the point has at least one positive real part. A point is in a critical condition when all of the real parts of the characteristic values

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of the Jacobian matrix at an equilibrium point consist of 0 or negative parts. Therefore, the stability strategy of each equilibrium point under different parameter conditions is analysed. By assuming $G, I, X, \gamma \in [0, +\infty)$, therefore, the Jacobian matrix characteristic values of the four equilibrium points E2, E5, E6 and E8 all contain 0 or positive real parts, and it is impossible to achieve the ESS state. The conditions that the parameters need to meet when the remaining four equilibrium points meet the ESS are shown in Table 5.

Table 5: Evolutionary stabilization strategy under different parameter settings.

State	Condition	The equilibrium point consistent with the stability conclusion is ESS.
(1)	F-I<X， G>t(π_2-π_4)+ 2S， $-C_2$<(1 − $t)\pi_4 - C_1$	E1
(2)	F-I>X ， G>t($\pi_1 - \pi_3$)， (1-t) π_3 − C_1 −F>$-C_2$	E3
(3)	F-I<X， $G < t(\pi_2 - \pi_4) + 2S$， C_1 +(1-t) $\pi_2 > -C_2$	E4
(4)	F-I>X ， G<t(π_1-π_3)， -C_2 <(1-t) π_1 − $C_1 - F$	E7

Analysis state (1), when *F-I<X*， *G<t(π_2-π_4) +2S*， C_1-C_2<*(1-t)* π_4, E1(0,0,0) is the evolutionary stability strategy (ESS). At this time, when banks find that the income from choosing loans is less than the expected income from not lending, they choose "not lending" no matter what strategy enterprises or governments adopt. When the government believes that the price of subsidies is larger than implicit benefits and taxes that enterprises can bring by maintaining their operations, it chooses "no subsidies" no matter how the other two act. Companies choose "not to declare bankruptcy" no matter what the other two do when they believe that the cost of continuing to operate without financial help from banks and the government is less than the cost of declaring bankruptcy. State (1) reflects the cost C when banks and governments do not intervene and zombie enterprises continue to operate C_1 smaller, exit cost C_2 when it is large, zombie companies will choose to continue to operate.

Analysis state (2), when *G>t(π_1-π_3)*， *F-I>X*， *(1-t)* π_3-C_1-*F*>-C_2A, E3(0,1,0) is the ESS. At this time, t is small, the government finds that the cost of subsidies is greater than the difference between the tax paid by enterprises in the case of government subsidies and no subsidies, then the government chooses "no subsidies"; The interest earned by banks on loans is greater than the expected return on loans, and banks choose "loans"; Enterprises believe that when the net profit of operation is greater than the cost of bankruptcy without government subsidies and bank loans, they will choose not to declare bankruptcy. State (2) reflects the effect of the enterprise income tax rate t on the choices of government and enterprises. When t is relatively small, the government "does not subsidize" and zombie enterprises "do not declare bankruptcy" have become the strategic choices under limited rationality.

Analysis state (3), when *F-I<X*， $G < t(\pi_2 - \pi_4) + 2S$， *(1-t)* $\pi_2 - C_1 > -C_2$, E4(0,0,1) is the ESS. At this time, the interest earned by banks providing loans is greater than the expected return of no loans, and banks choose "no loans"; The government found that the amount of subsidies was less than the implicit income and tax revenue from maintaining the operation of enterprises, and the government chose "subsidies"; Enterprises choose "not to declare bankruptcy" when they believe that the net profit obtained only via reliance on governmental subsidies is bigger than expenditure of bankruptcy. State (3) reflects the impact of s on government decision-making. When s is relatively large, "subsidy" becomes the strategic choice of government. Under this condition, if the net profit of

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enterprise operation is greater than the bankruptcy cost, then (no bankruptcy declaration, no loan, subsidy) becomes ESS.

Analysis state (4), when$F-I>X$, $G<t(\pi_1-\pi_3)$, $-C_2<(1-t)\pi_1-C_1-F$, E7(0,1,1) is the ESS. This state reflects that when the expected return of no loan is relatively small compared with the interest received by the loan, banks will choose "loan" regardless of the other two strategies, while enterprises and governments choose "not declaring bankruptcy" and "subsidy" to have greater returns than the other strategy, which constitutes ESS (not declaring bankruptcy, loan, subsidy) in this state.

3.3. Numerical Simulation and Simulation

Based on the above replication dynamic equations, in order to further analyze the evolution process of the tripartite game among enterprises, banks and governments and the sensitivity of typical parameters, MATLAB is used to analyze the parameter simulation [18]. The parameter assignment is shown in Table 6.

Table 6: Reference group and control group parameter assignment table.

	G	I	π_1	π_2	π_3	π_4	t	C_1	γ	C_2	F	S	X
Reference group	10	20	8	5	3	-5	0.8	4	5	6	23	3	15
Control group 1	10	20	8	5	3	-5	0.1	4	5	6	23	3	15
Control group 2	10	50	8	5	3	-5	0.8	4	5	6	55	3	35
Control group 3	50	20	8	5	3	-5	0.8	4	5	6	23	3	15

The main purpose of the parameter design of the reference group is to illustrate the evolution process of the three-party game. The parameter requirements that need to be met are: The profit of the enterprise declared not to be bankrupt should be $\pi_4<0$. The enterprise income tax rate meets $0<t<1$. Losses after banks provide loans to subsequent bankrupt enterprises $\gamma>0$. The principal and interest that the enterprise needs to pay to the bank $F>I$. The evolutionary game process of the control group is shown in Figure 4 (a).

The parameter design of the control group 1 mainly adjusts t， That is to observe the impact of corporate income tax rate on the game evolution process, and its evolution process is shown in Figure 4 (b). It is not difficult to find that due to the decline of t, enterprises can earn more profits, and the game is less likely to evolve to bankruptcy.

The parameter design of the control group 2 mainly adjusts I, that is, to observe the influence of the loan amount of the bank as a zombie enterprise on the game evolution process, and its evolution process is shown in Figure 4 (c). It is not difficult to find that due to the increase of I, banks are more willing to lend to enterprises, and the game evolution is dominated by banks.

The parameter design of the control group 3 mainly adjusts G, that is, to observe the influence of the government 's subsidy to zombie firms on the game evolution process. The evolution process is shown in Figure 4 (d). It is not difficult to find that due to the increase of G, the government is more willing to subsidize enterprises, and the game evolution is dominated by the government.

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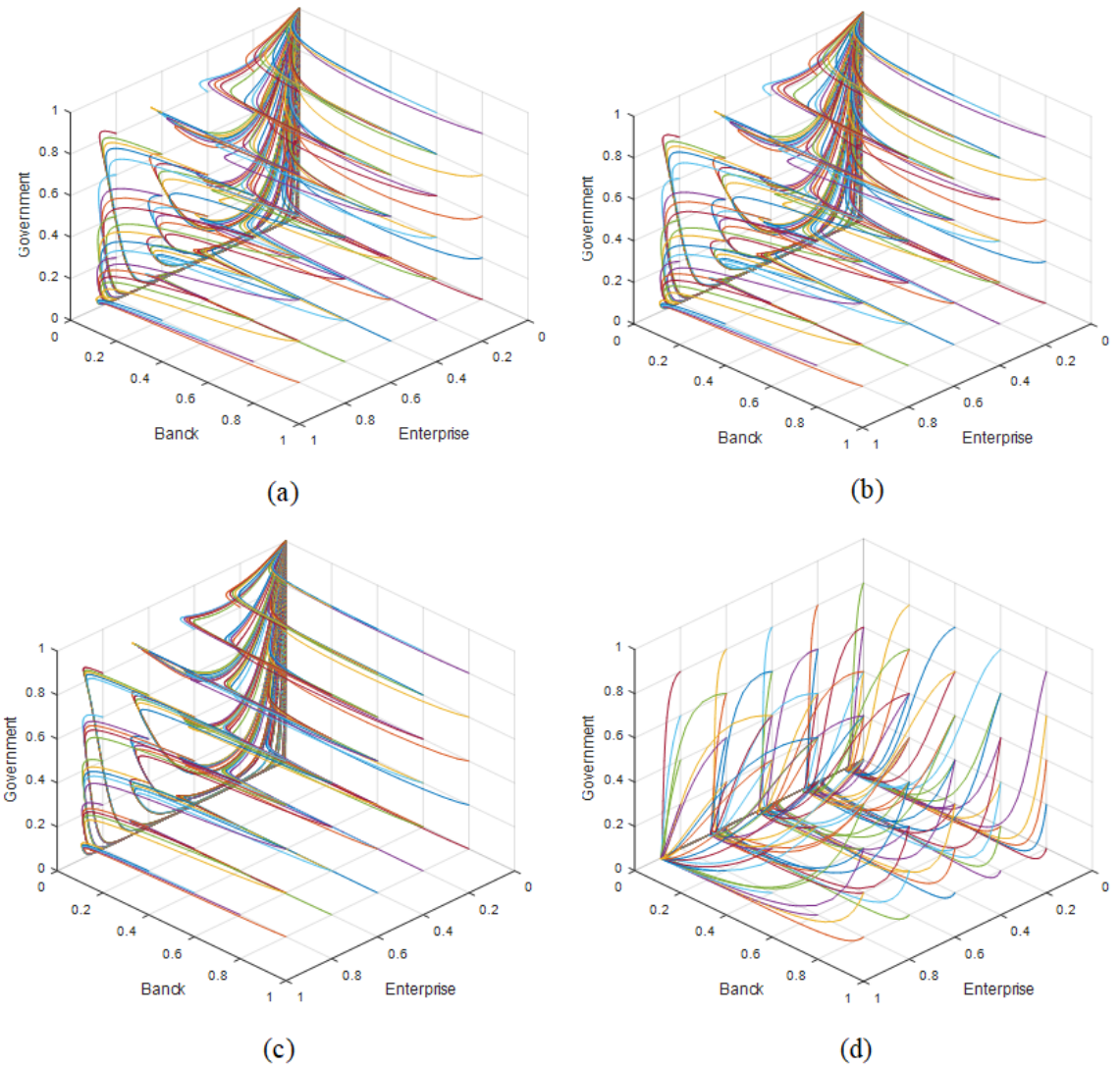

Figure 4: The schematic diagram of the game evolution process under different parameter designs : (a) reference group, (b) control group 1, (c) control group 2, (d) control group 3

On the basis of the assignment analysis of the game process, the enterprise tax rate t and the profit π_1 obtained by the zombie enterprise after not declaring bankruptcy and obtaining government subsidies and bank loans are selected as typical parameters for parameter sensitivity analysis. The results are shown in Figure 5. It is not difficult to find that the game evolution process is more sensitive to the corporate tax rate, and different initial values of the parameters will lead to completely different evolution results. However, it is less sensitive to the profit π_1 that zombie enterprises do not declare bankruptcy and obtain government subsidies and bank loans. Changing the value of parameter π_1 has little effect on the result of game evolution.

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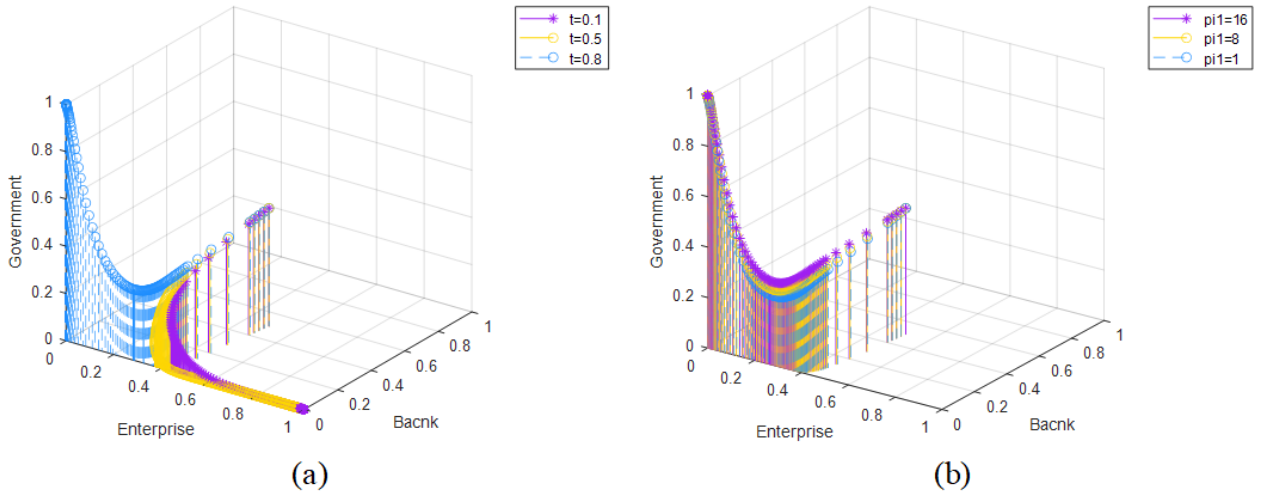

Figure 5: The sensitivity analysis results of the parameters of the game model are illustrated as follows : (a) sensitivity analysis of tax rate t, (b) sensitivity analysis of parameter π_1

4. Conclusion

This study examines the influence of banking decisions and governmental decisions on the choices made by zombie businesses under various conditions, drawing on pertinent domestic and international literature. Additionally, creating a three-part evolutionary game model with enterprises, banks and governments to analyse the issue.

(1) The cost of zombie enterprises announcing their choice to continue to operate and the cost of withdrawing from bankruptcy have an important impact on the choice of enterprises. When the expense of introducing a zombie firm is high and the cost of reforming is low, enterprises will still continue to operate without the intervention of banks and governments.

(2) Corporate income tax rates can influence the choice of government and zombie companies. When the enterprise income tax rate is higher, the tax revenue that zombie enterprises can bring about by continuing to operate is larger, and there will be an increase in government readiness to subsidize; On the contrary, for zombie companies, their tax burden increases, and their willingness to declare bankruptcy increases.

(3) The implicit benefits that zombie enterprises can bring about by continuing to operate, that is, the risks to society after enterprise bankruptcy, affect the government's decision-making. When the bankruptcy of zombie enterprises will have a greater impact on local employment, GDP and other indicators, seriously affecting local stability, the willingness of government subsidies will increase.

(4) The interest on bank loans and the expected return on using the loan for other purposes affect the bank's choice. When banks have a higher expected return on putting the same loan amount into financial markets for other purposes, they are less willing to choose loans.

The following policy recommendations are made in this article based on the aforementioned findings:

(1) Simplify bankruptcy procedures and reduce the exit costs of zombie enterprises. The current high exit costs have left many zombie enterprises that should have gone bankrupt frozen in the market. In order to reduce the procedural costs of zombie enterprise, clarifying the bankruptcy steps and simplifying the bankruptcy procedures is necessary. At the meanwhile, bankruptcy assistance should be taken and relevant laws should be improved to promote zombie enterprises to voluntarily withdraw from the market at a low cost.

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(2) Identify different zombie enterprises and encourage conditional enterprise reform and reorganization. The government should do a good job of distinguishing. When zombie enterprises can get rid of their difficulties through restructuring and innovation, the government can reduce their reform costs through special incentives to encourage the upgrade and transformation of conditional zombie businesses.

(3) Undertake the "stability maintenance" preparation and follow-up work of zombie enterprise bankruptcy. The bankruptcy of large state-owned zombie enterprises will inevitably have an adverse effect on the stability of local economy and other aspects. Therefore, the government should take the responsibility of risk identification, considering the possible unemployed workers and economic recession in advance and making countermeasures.

(4) Reduce improper intervention in banks and help the financial markets' healthy growth. The government should reduce excessive intervention in commercial banks. According to the market mechanism, when the zombie loans of banks decrease and the financial market prospers, commercial banks are more willing to invest funds in more efficient places. Furthermore, it can not only encourage the withdrawal of zombie enterprises but also decrease the generation of zombie loans, which promotes the virtuous circle of financial markets to a certain extent.

Authors Contribution

All the authors contributed equally and their names were listed in alphabetical order.

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