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Evolutionary Game Analysis of Financing Enterprise Behavior Decision in the Unified Credit Inventory Pledge Model

——Based on the perspective of prospect theory

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Abstract: This study examines the game behavior of credit pledge financing between logistics enterprises and financing enterprises from the perspective of prospect theory, and analyzes the influencing factors and constraints that can prevent credit risk accidents. The research uses evolutionary game rounds to establish a non-linear model of the evolutionary game between two enterprises and analyzes its stability. The study finds that various factors like cost of effort, fraudulent returns, loan interest, and loss cost of financing enterprises can all affect their behavioral decisions. Additionally, it shows that the perceived cost value of logistics enterprise supervision is lower than the perceived value of punishment for non-supervision, and the sum of the perceived cost value of financing enterprise integrity and the perceived value of obtaining additional benefits through deception is lower than the perceived value of punishment for breach of contract. Under certain conditions, credit rating incentive policies for financial institutions can reduce the occurrence of dishonest events in financing enterprises, but relying solely on credit rating incentive policies can also increase fraudulent events. Therefore, logistics enterprises, based on credit rating incentive policies of financial institutions, need to strengthen the supervision level of the repayment process of financing enterprises, increase the punishment for dishonest behavior of financing enterprises, and ensure the stable implementation of supply chain finance under the credit financing model.

Keywords: prospect theory; Evolutionary game; Inventory pledge; Financing enterprise.

I. Introduction

Small and medium-sized enterprises (SMEs) are fundamental to China's economy, but face difficulties in obtaining financing. The credit financing model of supply chain finance has emerged to alleviate this problem. However, this model involves risk perceptions and behavior choices that can lead to loan defaults and losses. Analyzing credit pledge financing from the perspective of prospect theory, this study examines the behavior decisions and risk countermeasures of financing and logistics enterprises in different situations. Using evolutionary game rounds, a non-linear evolutionary game model is established and analyzed for stability. The results show that the cost of effort, fraudulent returns, loan interest, and loss cost of financing enterprises can affect their behavioral decisions. Moreover, logistics enterprise supervision is less valuable than punishment for non-supervision, while the perceived value of obtaining additional benefits through deception and financing enterprise integrity is less valuable than punishment for breach of contract. Credit rating incentive policies for financial institutions can reduce dishonest events in financing enterprises, but relying only on credit rating incentives can increase fraudulent events. Therefore, logistics enterprises should strengthen supervision and punishment for dishonesty in financing enterprises, ensure the stable implementation of supply chain finance, and increase credit awareness among financing enterprises.

At present, there is a relatively mature body of research on game theory in the context of supply chain finance in China. Yan Guangle (2011) [1] developed a game model using information economics to explore the interaction between small to medium-sized businesses, banks, and third-party logistics providers in the supply chain financial system. Zhang Lu (2019) [2] analyzed the supply chain financial service model and blockchain incentive mechanism through a game theory lens, offering targeted solutions and countermeasures for the development of blockchain-driven supply chain finance innovations. Zhu Chen and Zhang Jixiang (2021) [3] constructed an evolutionary game model with and without government participation and found that the system can evolve to a cooperative outcome more quickly with government participation. Wu Xiaoping et al. (2022) [4] developed a tripartite evolutionary game model involving the government, third-party verification agencies, and logistics providers to analyze decision-making behavior related to carbon verification and carbon emission data reporting, as well as the effects of concealment, verification volume, effort level, and carbon price on evolutionary equilibrium strategy.However, most of the research on supply chain finance has focused on risk identification [5,6], risk assessment [7], risk management [8], and the management of credit and collateral risks by banks in inventory pledge models [9]. Despite these accomplishments, more work is needed to explore the dynamics of supply chain finance in China, particularly in regards to emerging financial technologies and global market developments.Despite the limited research on credit financing models in supply chain finance, there are several notable studies in China. Li Xiangqian et al. (2010) [10] examined the signal game problem between banks and logistics enterprises in the unified credit inventory pledge model. They found that higher quality logistics enterprises generated greater profits for banks, allowing them to choose the most desirable partners. Zhang Jing et al. (2011) [11] analyzed the game behavior of logistics enterprises and loan enterprises in credit pledge financing. The study demonstrated that when banks reasonably adjust credit ratings, the enthusiasm of both parties in the game is significantly affected, thereby strengthening financing supervision. Tao Zhengxu and Zhou Gengui (2016) [12] used evolutionary game theory to establish a game model of credit risk between logistics enterprises and financing enterprises. Their research found that factors influencing credit risk of financing enterprises include fines for contract breach by logistics enterprises, pledge rate, price risk of pledge, and reputation value among others.In conclusion, game theory is an important tool for studying the dynamics of supply chain finance in China, and there are already many notable studies on various aspects, such as financing models, government participation, and the role of emerging financial technologies. However, further research is required to explore and evaluate existing models, identify potential risks, and offer effective solutions to enhance supply chain finance development.

In summary, most domestic and foreign literature on supply chain finance models focus on game processes based on the assumption of complete rationality. However, in reality, credit financing is a complex system where the understanding of all players is limited by bounded rationality. Although existing research has made progress, there are still some shortcomings. For instance, most studies are based on expected utility theory, which ignores the psychological perception and bounded rationality characteristics of individuals. Additionally, the existence and role of financial institutions are not always addressed. Moreover, few studies use quantitative analysis to understand the behavioral patterns between supply chain financial entities. Finally, most research ignores the perspective of the logistics enterprises and the role they play in credit risk accidents.To overcome these shortcomings, this paper proposes to use prospect theory to build a behavioral game model of financing enterprises from the perspective of logistics enterprises. This approach takes bounded rationality into account and introduces parameters such as loan interest rates and punishments from financial institutions. This model aims to identify the factors and constraints that prevent credit risk accidents and study the impact of the game players' value perception and risk preferences on the system's evolution and stability.In conclusion, the proposed approach using prospect theory is a promising way to address the shortcomings of existing research in supply chain finance models. By considering bounded rationality and the behavior of all players in the game, this approach may provide helpful insights into a complex system and ultimately improve supply chain finance development.Furthermore, given the importance and role of financial institutions in credit financing supply chain finance, this paper also intends to investigate how financing enterprises will behave under credit rating incentive policies from financial institutions. By exploring the behavioral decisions taken by financing enterprises, this study can provide solutions and recommendations to enhance credit risk management and improve the stability of the system.

II. Establishing an Evolutionary Game Model Based on Prospect Theory

2.1 Model Assumptions

Without considering the external environment and other market entities, the occurrence of credit risk accidents in supply chain finance under the credit financing model can be seen as the result of a game between logistics enterprises and financing enterprises, and the game itself can be seen as a risk decision-making behavior. Based on the game relationship between logistics enterprises and financing enterprises, this article proposes the following assumptions:

Assumption 1: The strategy sets for the game between logistics enterprises and financing enterprises are (regulated, non-regulated) and (integrity, deception), respectively. It is believed that only when logistics enterprises are not regulated and financing enterprises deceive, the environment for credit pledge financing will be damaged. The probability of its occurrence is uncertain.

Assumption 2: The game process only involves logistics enterprises and financing enterprises, and both parties exhibit bounded rationality. Considering the uniqueness of supply chain finance in the credit financing model of financial institutions, financial institutions will participate in the game process between logistics enterprises and financing enterprises as influencing factors. In the future, this article will focus on exploring the decision-making of financing enterprises under the credit rating improvement policy given by financial institutions.

Assumption 3: After a credit financing accident occurs, both parties will bear a certain amount of risk cost responsibility. If the risk cost borne by the financing enterprise is $D2$, the risk cost borne by the logistics enterprise is $\delta D2$, where δ is the risk transmission coefficient. The value of δ is within the range of (0,1).

Assumption 4: For the convenience of calculation, this article sets the amount of credit granted by financial institutions to logistics enterprises to be equal to the amount of loans granted by logistics enterprises to financing enterprises, but the loan interest is not the same.

Assumption 5: Both decision makers are bounded rationality, and their choice of strategies is based on their own psychological feelings about the value of strategic gains and losses, rather than the actual benefits of the strategy. Here, the psychological perception of the game subject towards the strategic profit and loss value is defined as the prospect value V, which is composed of a value function and a weight function. The formula is:

$$V = \sum_{i=1}^{n} \pi(p_i) v(\Delta x_i) \tag{1}$$

$$v(\Delta x_i) = \begin{cases} (\Delta x_i)^{\alpha} & \Delta x_i \geq 0 \\ -\lambda(-\Delta x_i)^{\beta} & \Delta x_i < 0 \end{cases} \tag{2}$$

$$\pi(p_i) = \frac{(p_i)^{\sigma}}{\left[(p_i)^{\sigma} + (1-p_i)^{\sigma}\right]^{1/\sigma}} \tag{3}$$

Among ΔXi is the decision value, representing the profit difference between the two parties in the game before and after the decision; α and β Represent the marginal degree of decline in the perceived value of "gains" and "losses" by decision-makers, respectively. The larger the value, the greater the marginal degree of decline; It is the loss aversion coefficient. The larger the value, the higher the sensitivity of the decision-maker to the loss.

Assumption 6: For the difference between the profit and loss values of logistics enterprises under supervision and those without supervision, the value under the condition of financing enterprise deception is greater than that under the condition of integrity; The difference between the profit and loss value of financing enterprises' integrity and the profit and loss value of deception is greater under the non regulatory conditions of logistics enterprises than under the regulatory conditions. This setting is in line with the actual situation.

2.2 Model construction

Based on the above six assumptions, establish a revenue perception matrix for the game between logistics enterprises and financing enterprises, as shown in Table 1:

Table 1

Revenue Perception Matrix of the Game between Logistics Enterprises and Financing Enterprises

Logistics enterprises	Financing enterprise	
	good faith（y）	deception（1-y）
supervise（x）	$(\theta Er_2+D_1-C_1-\theta Er_3,\theta Er_1-D_1-D_4-\theta Er_2)$	$(\theta Er_2+D_3-C_1-\theta Er_3,\theta Er_1+H-D_3-D_4-\theta Er_2)$
Unregulated（1-x）	$(\theta Er_2+D_1-C_2-\theta Er_3,\theta Er_1-D_1-\theta Er_2)$	$(E-\theta Er_3-C_2-\delta D_2-\theta E,\theta Er_1+\theta E+H-D_2-E)$

The meanings of each parameter in Table 1 are as follows:

C1: Perceived value of labor and capital costs incurred by logistics enterprises in supervising financing enterprises and financing warehouse collateral, $C1 \in (0,+\infty)$;

C2: The perceived value of logistics enterprises not supervising financing enterprises and being warned or punished by financial institutions, $C2 \in (0,+\infty)$;

D1: Perceived value of collateral management fees paid by financing enterprises to maintain integrity of logistics enterprises, $D1 \in (0,+\infty)$;

D2: The risk cost of credit risk accidents borne by financing enterprises, i.e. the perceived value of social reputation loss and legal sanctions borne by financing enterprises after credit risk accidents occur, $D2 \in (0,+\infty)$;

D3: Perceived value of contract breach fines provided by financing enterprises to logistics enterprises, $D3 \in (0,+\infty)$;

D4: The cost of financing enterprises accepting logistics enterprise supervision;

E: The assessed value of the pledged property, $E \in (0,+\infty)$;

H: The perceived value of the additional deception benefits obtained by financing enterprises by choosing deception strategies, $H \in (0,+\infty)$;

R1: The rate of return of financing enterprises on the use of loan funds, $r1 \in (0,1)$;

R2: The loan interest rate of logistics enterprises to financing enterprises, $r2 \in (0,1)$;

R3: The loan interest rate of loans from financial institutions to logistics enterprises, $r3 \in (0,1)$;

θ: Pledge rate (ratio of loan amount to assessed value of pledged property), $\theta \in (0,1)$;

δ: The responsibility transfer coefficient of the loss cost after a credit risk accident occurs, $\delta \in (0,1)$。

Based on the above statements, corresponding explanations are made for the profit and loss of the four strategies in Table 1:

(1) When logistics enterprises and financing enterprises respectively adopt (regulatory, integrity) strategies, the income of logistics enterprises is the loan interest obtained $\theta Er2$ and the collateral management fees D1 paid by financing enterprises to logistics enterprises; The cost is interest on loans to financial institutions $\theta Er3$ and the labor and capital costs incurred in reviewing the financing enterprise C1. The income of the financing enterprise is the income from using the loan amount $\theta Er1$； The cost is paid to the logistics enterprise for the management fees of the pledged property, D1, and the loan interest to the logistics enterprise $\theta Er2$。 The profit and loss values of both parties are: $\theta Er2+D1-C1-\theta Er3$、 $\theta Er1-D1-D4-\theta Er2$。

(2) When logistics enterprises and financing enterprises adopt (non supervision, cheating) strategies respectively, the income of logistics enterprises is the market value E of the pledge; The cost is interest on loans to financial institutions $\theta Er3$. Cost paid by financial institutions for punishment C2 and loan amount to financing enterprises θE。 The income of the financing enterprise is the income from using the loan amount $\theta Er1$. The amount of the loan borrowed θE and the additional fraudulent gains obtained H; The cost is the perceived value D2 of social reputation loss and legal sanction and the market value E of the pledge. In addition, logistics enterprises will also bear the transmission cost of losing the social reputation of financing enterprises $\delta D2$。 Based on the above, it can be seen that the profit and loss values of both parties are: $E-\theta Er3-C2-\delta D2-\theta E$、 $\theta Er1+\theta E+H-D2-E$。

(3) When logistics enterprises and financing enterprises respectively adopt (regulatory, deceptive) strategies, the income of logistics enterprises is the loan interest obtained $\theta Er2$ and the penalty for breach of contract D3 collected; The cost is interest on loans to financial institutions $\theta Er3$ and the labor and capital costs incurred in reviewing the financing

enterprise C1. The income of the financing enterprise is the income from using the loan amount θ Er1 and the additional fraudulent gains obtained H; The cost is the penalty D3 for contract breach provided to the logistics enterprise and the loan interest provided to the logistics enterprise θ Er2。 The profit and loss values of both parties are: θ Er2+D3-C1- θ Er3、 θ Er1+H-D3-D4- θ Er2。

(4) When logistics enterprises and financing enterprises adopt (non regulatory, honest) strategies respectively, the income of logistics enterprises is the loan interest obtained θ Er2 and the collateral management fees D1 paid by financing enterprises to logistics enterprises; The cost is interest on loans to financial institutions θ Er3 and the cost C2 paid for being punished by financial institutions. The income of the financing enterprise is: the income from using the loan amount θ Er1； The cost is to pay the collateral management fee D1 to the logistics enterprise and the loan interest to the logistics enterprise θ Er2。 The profit and loss values of both parties are: θ Er2+D1-C2- θ Er3、 θ Er1-D1- θ Er2。

The proportions of logistics companies choosing regulatory and non regulatory strategies in Table 1 are x and 1-x, respectively, while the proportions of financing companies choosing integrity and deception are y and 1-y, respectively. Based on the evolutionary game theory method, the expected prospect value UY1, UY2 and the average expected prospect value of logistics enterprises when they choose regulatory and non regulatory strategies can be obtained as follows:

$$\begin{cases} U_{Y1} = (\theta Er_2 + D_1 - C_1 - \theta Er_3)y + (\theta Er_2 + D_3 - C_1 - \theta Er_3)(1-y) \\ \quad = \theta Er_2 + D_3 - C_1 - \theta Er_3 + (D_1 - D_3)y \\ U_{Y2} = (\theta Er_2 + D_1 - C_2 - \theta Er_3)y + (E - \theta Er_3 - C_2 - \delta D_2 - \theta E)(1-y) \\ = E - \theta Er_3 - C_2 - \delta D_2 - \theta E + (\theta Er_2 + D_1 - E + \delta D_2 + \theta E)y \\ \overline{U_Y} = xU_{Y1} + (1-x)U_{Y2} \end{cases} \tag{4}$$

Similarly, the expected future values UN1, UN2, and average expected future values of financing enterprises when choosing integrity and deception strategies can be obtained as follows:

$$\begin{cases} U_{N1} = (\theta Er_1 - D_1 - D_4 - \theta Er_2)x + (\theta Er_1 - D_1 - \theta Er_2)(1-x) \\ \quad = \theta Er_1 - D_1 - \theta Er_2 - D_4 x \\ U_{N2} = (\theta Er_1 + H - D_3 - D_4 - \theta Er_2)x + (\theta Er_1 + \theta E + H - D_2 - E)(1-x) \\ = \theta Er_1 + \theta E + H - D_2 - E + (-D_3 - D_4 - \theta Er_2 - \theta E + D_2 + E)x \\ \overline{U_N} = yU_{N1} + (1-y)U_{N2} \end{cases} \tag{5}$$

Combining equations (4) and (5), the replication dynamic equations for logistics enterprise supervision and financing enterprise integrity are obtained as follows:

$$F(x) = \frac{\mathrm{dx}}{\mathrm{dt}} = x(U_{Y1} - \overline{U}_Y) = x(1-x)(U_{Y1} - U_{Y2})$$

$$= x(1-x)[\theta Er_2 + D_3 - C_1 - E + C_2 + \delta D_2 + \theta E - (D_3 + \theta Er_2 - E + \delta D_2 + \theta E)y] \tag{6}$$

$$G(y) = \frac{\mathrm{dy}}{\mathrm{dt}} = y(U_{N1} - \overline{U}_N) = y(1-y)(U_{N1} - U_{N2})$$

$$= y(1-y)[-D_1 - \theta Er_2 - \theta E - H + D_2 + E - (-D_3 - \theta Er_2 - \theta E + D_2 + E)x] \tag{7}$$

2.3 Stability analysis of equilibrium points

According to equation (6), when x=0, 1, or y *= $\frac{D_3+\theta Er_2-E+\delta D_2+\theta E}{\theta Er_2+D_3-C_1-E+C_2+\delta D_2+\theta E}$,logistics enterprises can achieve local stability when choosing regulatory strategies.

According to equation (7), when y=0, 1, or x *= $\frac{-D_3-\theta Er_2-\theta E+D_2+E}{-D_1-\theta Er_2-\theta E-H+D_2+E}$,the financing enterprise can achieve local stability when choosing an integrity strategy.

Therefore, the five equilibrium points of the system are (0,1), (1,0), (1,1), (0,0), and (x *, y *), respectively.

According to the calculation method of the system evolution stability strategy, it can be inferred that the system evolution stability strategy can be obtained from the local stability of the Jacobian matrix of the system. The Jacobian matrix of the system can be obtained through equations (6) and (7) as follows:

$$J=\begin{bmatrix}\frac{\partial F(x)}{\partial x} & \frac{\partial F(x)}{\partial y}\\ \frac{\partial G(y)}{\partial x} & \frac{\partial G(y)}{\partial y}\end{bmatrix}=\begin{bmatrix}J_1 & J_2\\ J_3 & J_4\end{bmatrix}$$

$J_1=(1-2x)[\theta Er_2+D_3-C_1-E+C_2+\delta D_2+\theta E-(D_3+\theta Er_2-E+\delta D_2+\theta E)y]$

$J_2=x(1-x)(-C_1+C_2)$

$J_3=y(1-y)(-D_1-H+D_3)$

$J_4=(1-2y)[-D_1-\theta Er_2-\theta E-H+D_2+E-(-D_3-\theta Er_2-\theta E+D_2+E)x]$

According to the Jacobian matrix, its determinant and trace are:

$Det(J)=J_1\times J_4-J_2\times J_3=(1-2x)(1-2y)[\theta Er_2+D_3-C_1-E+C_2+\delta D_2+\theta E-(D_3+\theta Er_2-E+\delta D_2+\theta E)y][-D_1-\theta Er_2-\theta E-H+D_2+E-(-D_3-\theta Er_2-\theta E+D_2+E)x]-x(1-x)y(1-y)(-C_1+C_2)(-D_1-H+D_3)$

$Tr(J)=J_1+J_4=(1-2x)[\theta Er_2+D_3-C_1-E+C_2+\delta D_2+\theta E-(D_3+\theta Er_2-E+\delta D_2+\theta E)y]+(1-2y)[-D_1-\theta Er_2-\theta E-H+D_2+E-(-D_3-\theta Er_2-\theta E+D_2+E)x]$

Then, under the condition of equilibrium point (0,0), the determinant and trace values of the Jacobian matrix are:

$Det(J)=(\theta Er2+D3-C1-E+C2+\delta D2+\theta E)(-D1-\theta Er2-\theta E-H+D2+E)$

$Tr(J)=\theta Er2+D3-C1-E+C2+\delta D2+\theta E-D1-\theta Er2-\theta E-H+D2+E$

Under the condition of equilibrium point (0,1), the determinant and trace values of the Jacobian matrix are:

$Det(J)=-(-C1+C2)(-D1-\theta Er2-\theta E-H+D2+E)$

$Tr(J)=-C1+C2-(-D1-\theta Er2-\theta E-H+D2+E)$

Under the condition of equilibrium point (1,0), the determinant and trace values of the Jacobian matrix are:

$Det(J)=-(\theta Er2+D3-C1-E+C2+\delta D2+\theta E)(-D1-H+D3)$

$Tr(J)=-(\theta Er2+D3-C1-E+C2+\delta D2+\theta E)+(-D1-H+D3)$

Under the condition of equilibrium point (1,1), the determinant and trace values of the Jacobian matrix are:

$Det(J)=(-C1+C2)(-D1-H+D3)$

$Tr(J)=-(-C1+C2)-(-D1-H+D3)$

Under the condition of equilibrium points (x *, y *), the determinant and trace values of the Jacobian matrix are:

$Det(J)=-x^*(1-x^*)y^*(1-y^*)(-C_1+C_2)(-D_1-H+D_3)$

$Tr(J)=0$

Based on the above statement, the determinant Det (J) and trace Tr (J) of the five equilibrium points are obtained, as shown in Table 2:

Table 2

Parameter Expressions for Determinants Det (J) and Trace Tr (J) of Equilibrium Points

均衡点	$Det(J)$	$Tr(J)$
(0,0)	$(\theta Er_2+D_3-C_1-E+C_2+\delta D_2+\theta E)(-D_1-\theta Er_2-\theta E-H+D_2+E)$	$\theta Er_2+D_3-C_1-E+C_2+\delta D_2+\theta E-D_1-\theta Er_2-\theta E-H+D_2+E$
(0,1)	$-(-C_1+C_2)(-D_1-\theta Er_2-\theta E-H+D_2+E)$	$-C_1+C_2-(-D_1-\theta Er_2-\theta E-H+D_2+E)$
(1,0)	$-(\theta Er_2+D_3-C_1-E+C_2+\delta D_2+\theta E)(-D_1-H+D_3)$	$-(\theta Er_2+D_3-C_1-E+C_2+\delta D_2+\theta E)+(-D_1-H+D_3)$
(1,1)	$(-C_1+C_2)(-D_1-H+D_3)$	$-(-C_1+C_2)-(-D_1-H+D_3)$
(x^*,y^*)	$-x^*(1-x^*)y^*(1-y^*)(-C_1+C_2)(-D_1-H+D_3)$	0

According to the knowledge of nonlinear dynamics, when an equilibrium point satisfies the condition that the determinant of the Jacobian matrix is greater than 0 and the trace is less than 0, it is the evolutionary stable point of the system; When an equilibrium point satisfies the condition that the determinant of the Jacobian matrix is greater than 0 and the trace is greater than 0, it is the unstable fixed point of the system; When an equilibrium point satisfies the condition that the determinant of the Jacobian matrix is less than 0, it is the saddle point of the system. Based on Table 2, the following conclusions can be drawn:

(1) When C1> θ Er2+D3-E+C2+ δ D2+ θ E. Simultaneously D1>- θ Er2- θ When E-H+D2+E, (0,0) is the evolutionary stable point of the system.

(2) When C1>C2, while D1<- θ Er2- θ When E-H+D2+E, (0,1) is the evolutionary stable point of the system.

(3) When C1< θ Er2+D3 -E+C2+ δ D2+ θ E. When D1>- H+D3, (1,0) is the evolutionary stable point of the system.

(4) When C1<C2 and D1<- H+D3, (1,1) is the evolutionary stable point of the system.

2.4 Stability Analysis of Evolutionary Systems

From Hypothesis 6, it can be concluded that C2< θ Er2+D3-E+C2+ δ D2+ θ E；- H+D3<- θ Er2- θ E-H+D2+E。Based on the above four conclusions, it can be found that there are three inequalities in the system, from large to small, based on the cost of logistics enterprise supervision C1 and the cost of financing enterprise integrity D1, expressed as follows:

$$\begin{cases} C_1 > \theta Er_2 + D_3 - E + C_2 + \delta D_2 + \theta E \\ C_2 < C_1 < \theta Er_2 + D_3 - E + C_2 + \delta D_2 + \theta E \\ C_1 < C_2 \end{cases} \tag{8}$$

$$\begin{cases} D_1 > -\theta Er_2 - \theta E - H + D_2 + E \\ -H + D_3 < D_1 < -\theta Er_2 - \theta E - H + D_2 + E \\ D_1 < -H + D_3 \end{cases} \tag{9}$$

Based on equations (8) and (9), further analyze the stability of the system under different conditions based on the different value ranges of C1 and D1. The analysis is as follows:

Scenario 1: When C1> θ Er2+D3-E+C2+ δ D2+ θ The stability analysis of the evolutionary equilibrium points of three inequalities for D1, from large to small, is shown in Table 3:

Table 3

C1> θ Er2+D3-E+C2+ δ D2+ θ system steady-state analysis

D1 Value	equilibrium				
	(0,0)	(0,1)	(1,0)	(1,1)	(x*,y*)
D1>-θEr2-θE-H+D2+E	Det(J)>0; Tr(J)<0	Det(J)<0; Tr(J) indeterminacy	Det(J)<0; Tr(J) indeterminacy	Det(J)>0; Tr(J)>0	-
	ESS	saddle point	saddle point	Instability point	-
-H+D3<D1<-θEr2-θE-H+D2+E	Det(J)<0; Tr(J) indeterminacy	Det(J)>0; Tr(J)<0	Det(J)<0; Tr(J) indeterminacy	Det(J)>0; Tr(J)>0	-
	saddle point	ESS	saddle point	Instability point	-
D1<-H+D3	Det(J)<0; Tr(J) indeterminacy	Det(J)>0; Tr(J)<0	Det(J)>0; Tr(J)>0	Det(J)<0; Tr(J) indeterminacy	-
	saddle point	ESS	Instability point	saddle point	-

From Table 3, it can be seen that the cost of supervision in logistics enterprises C1> θ Er2+D3-E+C2+ δ D2+ θ Under the condition of E, regardless of the financing strategy adopted by the financing enterprise, logistics enterprises will adopt an unregulated strategy.

Scenario 2: When C2<C1< θ Er2+D3-E+C2+ δ D2+ θ the stability analysis of equilibrium points for three inequalities of D1, from large to small, at E is shown in Table 4:

Table 4

C2<C1<θEtr2+D3-E+C2+δD2+θEsystem steady-state analysis

D_1 Value	equilibrium				
	(0,0)	(0,1)	(1,0)	(1,1)	(x^*,y^*)
$D_1>-\theta Er_2-\theta E-H+D_2+E$	$Det(J)<0$; $Tr(J)$ indeterminacy	$Det(J)<0$; $Tr(J)$ indeterminacy	$Det(J)>0$; $Tr(J)<0$	$Det(J)>0$; $Tr(J)>0$	-
	saddle point	saddle point	*ESS*	Instability point	-
$-H+D_3<D_1<-\theta Er_2-\theta E-H+D_2+E$	$Det(J)>0$; $Tr(J)>0$	$Det(J)>0$; $Tr(J)<0$	$Det(J)>0$; $Tr(J)<0$	$Det(J)>0$; $Tr(J)>0$	$Det(J)<0$; $Tr(J)=0$

	Instability point	*ESS*	*ESS*	Instability point	saddle point
D_1<-H+D_3	$Det(J)$>0; $Tr(J)$>0	$Det(J)$>0; $Tr(J)$<0	$Det(J)$<0; $Tr(J)$ indeterminacy	$Det(J)$<0; $Tr(J)$ indeterminacy	-
	Instability point	*ESS*	saddle point	saddle point	-

From Table 4, it can be seen that the cost of supervision in logistics enterprises, C1, is valued at (C2, θ Er2+D3-E+C2+ δ D2+ θ E) Under certain conditions:

(1) When financing companies pay the cost of integrity D1>- θ Er2- θ When E-H+D2+E, the evolutionary stability point of the system is (1,0). At this point, logistics companies will choose regulatory strategies, while financing companies will choose deceptive strategies.

(2) When financing enterprises pay the cost of integrity D1 (- H+D3- θ Er2- θ When E-H+D2+E), (0,1) and (1,0) are both evolutionary stable points of the system. In such cases, if the financing enterprise chooses a deceptive strategy, the logistics enterprise will tend to choose to supervise the financing enterprise because the losses caused by the other party's deceptive strategy outweigh the benefits; If financing companies choose an honest strategy, logistics companies will choose not to supervise financing companies due to unnecessary costs.

(3) When the cost of integrity paid by the financing enterprise D1<- H+D3, the evolutionary stability point of the system is (0,1). At this point, logistics companies will choose an unregulated strategy, while financing companies will choose an honest strategy.

Scenario 3: When C1<C2, the stability analysis of the equilibrium points of three inequalities for D1 is taken from large to small, as shown in Table 5:

Table 5

C_1<C_2system steady-state analysis

D_1 Value	equilibrium				
	(0,0)	(0,1)	(1,0)	(1,1)	(x^*,y^*)
D_1>-θEr_2-θE-H+D_2+E	$Det(J)$<0; $Tr(J)$ indeterminacy	$Det(J)$>0; $Tr(J)$>0	$Det(J)$>0; $Tr(J)$<0	$Det(J)$<0; $Tr(J)$ indeterminacy	-
	saddle point	Instability point	*ESS*	saddle point	-
-H+D_3<D_1<-θEr_2-θE-H+ D_2+E	$Det(J)$>0; $Tr(J)$>0	$Det(J)$<0; $Tr(J)$ indeterminacy	$Det(J)$>0; $Tr(J)$<0	$Det(J)$<0; $Tr(J)$ indeterminacy	-
	Instability point	saddle point	*ESS*	saddle point	-
D_1<-H+D_3	$Det(J)$>0;	$Det(J)$<0;	$Det(J)$<0;	$Det(J)$>0;	-

	$Tr(J)>0$	$Tr(J)$ indeterminacy	$Tr(J)$ indeterminacy	$Tr(J)<0$	
	Instability point	saddle point	saddle point	*ESS*	-

From Table 5, it can be seen that under the condition that the cost of supervision for logistics enterprises is C1<C2, regardless of the strategy adopted by the financing enterprise, logistics enterprises will adopt a regulatory strategy.

2.5 Discussion of Results

Based on the analysis of scenario 1, scenario 2, and scenario 3, it can be concluded that:

(1) When the cost of logistics enterprise supervision is C1<C2; When the cost of paying for the integrity of financing enterprises D1<- H+D3, the system converges to the optimal evolutionary equilibrium point (regulatory, integrity).

(2) The system meets C1< θ Er2+D3-E+C2+ δ D2+ θ E; D1<- θ Er2- θ E-H+D2+E。

Based on the above discussion, when the following four conditions are met, logistics enterprises and financing enterprises will respectively tend to implement regulatory and integrity strategies, with the lowest probability of credit risk accidents occurring.

$$\begin{cases} C_1 < C_2 \\ C_1 < \theta Er_2 + D_3 - E + C_2 + \delta D_2 + \theta E \\ D_1 < -H + D_3 \\ D_1 < -\theta Er_2 - \theta E - H + D_2 + E \end{cases} \tag{10}$$

For local equilibrium points (x *, y *), conventional Jacobian matrix analysis methods are ineffective and require differential analysis to analyze them. By taking the derivatives of y and x using equations (6) and (7), the specific coordinates of point (x *, y *) can be obtained. Combining the above four conditions, it can be concluded that point (x *, y *) is an unstable fixed point. From this, the dynamic evolution phase diagram of the system can be obtained as shown in Figure 1.

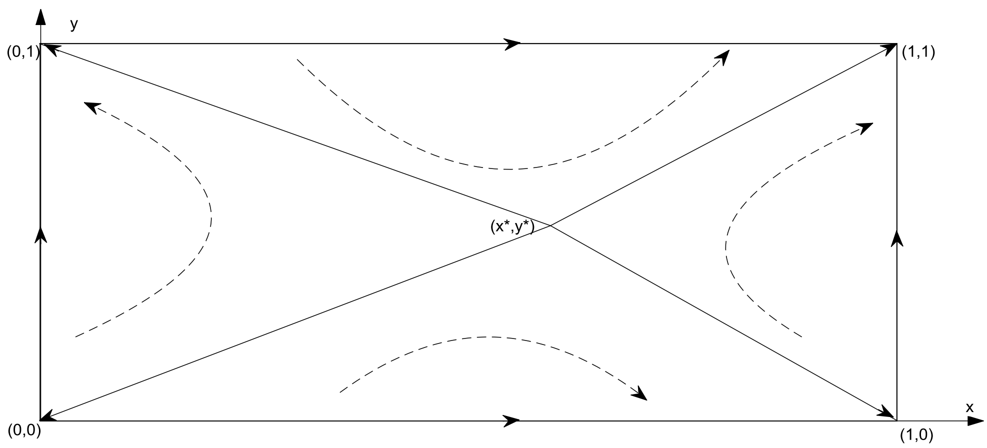


Fig. 1.Dynamic evolution phase diagram of equilibrium point system

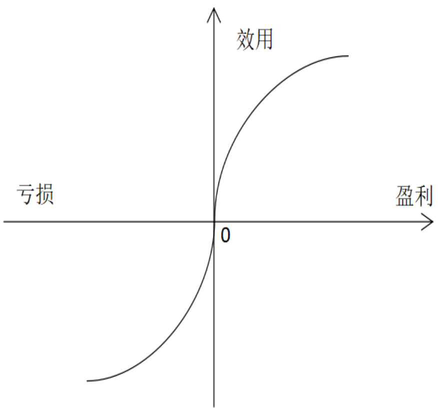
However, according to prospect theory, decision-makers do not rely solely on the relative profitand loss value of the strategy when making decisions. The specific analysis is as follows:

(1) According to the experimental analysis of cognitive psychology, when an actor's information processing ability is limited, their judgment and decision-making will deviate. Due to the fact that logistics enterprises and financing enterprises belong to two separate industries and lack clear policies, there is information asymmetry, which makes it easy for logistics enterprises and financing enterprises to have cognitive biases towards each other, causing decision-makers to overestimate the cost of carrying out their own actions, and the actual cost paid is less than the perceived cost paid, i.e. v (c1) c1; v(d1) d1。 When logistics enterprises or financing enterprises respectively choose regulatory and integrity strategies, the probability p1 of logistics enterprise regulation and the probability p2 of financing enterprise integrity are both equal to 1, that is, p1=p2=1. According to equation (1), it can be concluded that:

$$C_1=\pi(p_1)v(c_1)+\pi(1-p_1)v(0)=\pi(1)v(c_1)+\pi(0)v(0)=v(c_1)\geq c_1$$

$$D_1=\pi(p_2)v(d_1)+\pi(1-p_2)v(0)=\pi(1)v(d_1)+\pi(0)v(0)=v(d_1)\geq d_1$$

(2) Logistics and financing companies are prone to optimistic biases when judging the value of strategic choices. Optimistic prejudice is manifested as an unrealistic optimism. People think that they are less likely to encounter negative events than ordinary people, and tend to develop towards good results. Generally speaking, optimistic bias reduces people's level of risk perception and their willingness to avoid risks. The optimistic biases of logistics and financing companies make both parties hope that losses and risk accidents will not occur even though they are aware that unregulated and deceptive behavior may bring risks and losses to themselves. In addition, graphical analysis was conducted on the foreground theoretical value function represented by Equation (2) and the foreground theoretical weight function represented by Equation (3), as shown in Figures 2 and 3:



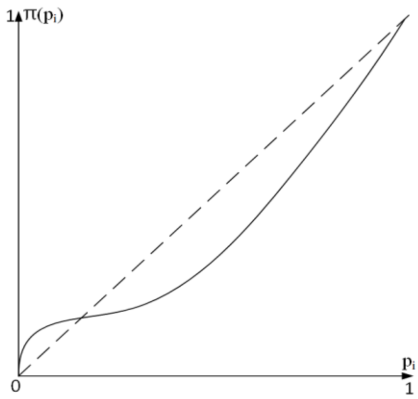


Fig. 2.Prospect Theory Value Function Image. Fig. 3.Foreground Theory Weight Function

From Figure 2 and Figure 3, it can be seen that the weight function, except for extremely small probability events, usually; At that time, the value function has the characteristics of convex function, that is, it can be concluded that:

$\pi(p_3)\leq p_3$; $\pi(p_4)\leq p_4$; $\pi(p_5)\leq p_5$; $v(d_2)\leq d_2$; $v(d_3)\leq d_3$; $v(c_2)\leq c_2$

Among the above parameters, p3 represents the objective probability of credit risk accidents occurring; P4 and P5 are the probabilities of punishment for logistics enterprises and financing enterprises that adopt unregulated and deceptive strategies, respectively; D2 represents the actual risk losses borne by the financing enterprise after a credit risk accident occurs; C2 and d3 are the actual penalty costs incurred by logistics enterprises and financing enterprises, respectively. From this, it can be concluded that:

$$D_2=\pi(p_3)v(d_2)+\pi(1-p_3)v(0)=\pi(p_3)v(d_2)\leq p_3d_2;$$

$$C_2=\pi(p_4)v(c_2)+\pi(1-p_4)v(0)=\pi(p_4)v(c_2)\leq p_4c_2;$$

$$D_3=\pi(p_5)v(d_3)+\pi(1-p_5)v(0)=\pi(p_5)v(d_3)\leq p_5d_3;$$

The combined effect of the above situations can easily lead to higher values for C1 and D1, and lower values for D2, D3, and C2. This means that the cost of logistics and financing enterprises is overestimated, while the risk loss cost and penalty cost are underestimated. Moreover, both parties in the game have a risk preference under the temptation of relative interests, which makes it difficult to meet the four conditions for the system to converge to the evolutionary equilibrium point (1,1).

In summary, both logistics and financing enterprises may tend to choose risk preference strategies under the premise of sufficient benefits, which is highly likely to lead to credit risk accidents. Therefore, this article will introduce the variables related to the cost of paying for the integrity of financing enterprises D1 and the risk loss cost of financing enterprises D2- the return L brought by financial institutions raising the credit rating of financing enterprises, and based on this, construct a financing enterprise behavior decision-making model with improved credit rating, analyze the behavior decision-making of financing enterprises in different situations, and further propose suggestions that are conducive to the system achieving the optimal decision based on the analysis results.

III. Analysis of the Impact of Credit Rating Incentives on Financing Enterprise Behavior Decision

3.1 Behavioral Decision Model of Financing Enterprises after Introducing Credit Rating Incentives

Financial institutions are established to incentivize financing enterprises to implement integrity strategies in the credit financing model, and to provide favorable policies for improving the credit rating of financing enterprises that maintain integrity. When implementing deception strategies, the income of a financing enterprise is K, its own income is L after improving its credit rating, and the actual income at the reference point is L0; The probability of being caught by logistics companies when financing companies implement deception strategies is q; If a financing enterprise is investigated and punished, the punishment cost is ξ K， ξ The punishment cost includes the cost of credit rating reduction, loss of corporate social reputation, and compensation for breach of contract damages, which is the penalty coefficient. Based on prospect theory, establish a financing enterprise behavior decision-making model that introduces credit rating improvement, as shown below:

$$Max\,V(K)=\pi(1-q)v(K+L-L_0)+\pi(q)v(L-\xi K-L_0) \quad (11)$$

$$s.t.\begin{cases} V(K)\geq 0 \\ K\geq 0 \end{cases}$$

In the above formula, it is assumed that the gains and losses of financing enterprises when implementing corresponding strategies in the process of credit pledge financing can be measured in currency and determined relative to the reference point, so the value function can be divided into gains and losses. The decision makers of financing enterprises prefer risk aversion when making decisions on gains and risk preference when making decisions on losses. According to this, decision makers can be divided into three categories: risk aversion, risk neutral and risk preference.

3.2 Analysis of the Impact of Credit Rating Incentives on the Behavioral Decisions of Financing Enterprises

The behavioral decision-making model of financing enterprises represented by equation (11) can indicate that the implementation of deception strategies by financing enterprises will directly affect the income of financing enterprises, thereby affecting their psychological perception of future value. Therefore, the above model is further analyzed to consider the behavior decisions of financing enterprises based on the criteria of risk appetite and risk aversion. The specific analysis is as follows:

Based on the assumptions mentioned earlier, let's assume that the income of a financing enterprise that implements deception strategies but has not been investigated is: F1=K+L-L0; The income of the financing enterprise being investigated for implementing fraudulent strategies is: F2=L- ξ K-L0, and satisfying F1>F2, it can be obtained that:

$$V(L)=\pi(1-q)v(F_1)+\pi(q)v(F_2) \qquad (12)$$

In order to obtain the optimal value of equation (12), the equation (12) can be calculated by taking full differentiation on both sides. By taking full differentiation and simplifying it, it can be obtained:

$$\frac{dF_1}{dF_2}=\frac{\pi(q)v'(F_2)}{\pi(1-q)v'(F_1)} \quad (13)$$

SetF_1-F_2=(1+ξ)K=b, there are:

$$\frac{dF_1}{dF_2}=\frac{\pi(q)v'(F_2)}{\pi(1-q)v'(F_2+b)} \qquad (14)$$

$S=\frac{dF_1}{dF_2}=\frac{\pi(q)v'(F_2)}{\pi(1-q)v'(F_2+b)}$,by simplifying and taking the derivative of F2 for S, we can obtain:

$$\frac{dS}{dF_2}=-\frac{\pi(q)}{\pi(1-q)}\times\frac{v'(F_2+b)v''(F_2)-v''(F_2+b)v'(F_2)}{\left[v'(F_2+b)\right]^2}=\frac{\pi(q)}{\pi(1-q)}\times\frac{v''(F_1)v'(F_2)-v'(F_1)v''(F_2)}{\left[v'(F_1)\right]^2}$$

$$=\frac{\pi(q)}{\pi(1-q)}\times\frac{v'(F_2)}{v'(F_1)}\times\left[\frac{v''(F_1)}{v'(F_1)}-\frac{v''(F_2)}{v'(F_2)}\right] \quad (15)$$

This article adopts the approach of scholar Li Yu et al. (2019) [13] to determine the absolute risk avoidance coefficient of financing enterprises at an income level of F. And in most cases, the greater the absolute risk aversion coefficient, the more financing enterprises tend to risk aversion. Based on equation (15), it can be concluded that:

$$\frac{dS}{dF_2}=\frac{\pi(q)}{\pi(1-q)}\times\frac{v'(F_2)}{v'(F_1)}\times\left[Z(F_2)-Z(F_1)\right] \quad (16)$$

According to equations (2) and (3), $\frac{\pi(q)}{\pi(1-q)}\times\frac{v'(F_2)}{v'(F_1)}>0$, $\frac{dS}{dF_2}$, the positive and negative values will be jointly determined by Z (F1) and Z (F2).

In the case of a given F1>F2, as the credit rating of the financing enterprise increases and the income L brought about by itself continues to increase, the behavioral decisions of the financing enterprise can be expressed in the following three situations: case 4, case 5, and case 6:

Case 4: When the absolute risk aversion coefficient decreases, it indicates that the financing enterprise is a risk averse. With the continuous improvement of credit ratings given by financial institutions to financing enterprises, financing enterprises may use the benefits of credit rating improvement to adopt fraudulent strategies for greater benefits. In this case, the increase in credit rating does not motivate financing enterprises to actively implement integrity strategies, but rather increases the lucky mentality of financing enterprises in the credit financing process.

Case 5: When the absolute risk avoidance coefficient remains unchanged, it indicates that the financing enterprise is a risk neutral entity. With the continuous improvement of credit rating given by financial institutions to financing enterprises, their decision-making choices have not changed. In this situation, the improvement of credit rating cannot motivate financing enterprises to implement integrity strategies.

Case 6: When the absolute risk aversion coefficient increases, it indicates that the financing enterprise is risk aversion. As financial institutions continue to increase the credit rating given to financing enterprises, they may choose to continue to adhere to integrity strategies for longer-term benefits. In this case, an increase in credit rating will motivate financing enterprises to actively implement integrity strategies.

According to equation (2), it can be concluded that:

$$Z(F_2)-Z(F_1)=(1-\alpha)(\frac{1}{F_2}-\frac{1}{F_1})=\frac{(1-\alpha)(1+\xi)L}{(K+L-K_0)(K-\xi L-K_0)} \tag{17}$$

In the case of a given F1>F2, the behavioral decision of the financing enterprise can be further expressed as the following three case: case 7, case 8, and case 9:

Case 7: $F_2=K-\xi L-K_0>0$,When the difference between the income and penalty cost of the financing enterprise when it is investigated and punished for implementing fraudulent strategies is greater than the reference point income, $Z(F_1)<Z(F_2)$,according to Scenario 4, it can be inferred that the financing enterprise is a risk preference. Due to the insufficient punishment imposed by logistics enterprises on financing enterprises to offset the benefits of implementing fraudulent strategies, financing enterprises are more willing to take the risk of being investigated by logistics enterprises and adopt fraudulent strategies. In this situation, the improvement of credit rating does not motivate financing enterprises to actively implement honest strategies, but rather promotes the occurrence of dishonest behavior in the credit financing process.

Case 8: $F_1=K+L-K_0<0$,When the sum of the income from the implementation of fraudulent strategies by the financing enterprise and the income from the improvement of credit rating is less than the reference point income, $Z(F_1)<Z(F_2)$,according to Scenario 4, it can be concluded that the financing enterprise is a risk averse. Due to the fact that the benefits brought by the improvement of the credit rating of financing enterprises cannot meet their own expectations for profits, financing enterprises are more likely to choose to implement fraudulent strategies to obtain greater benefits. In this case, the improvement of credit rating does not motivate financing enterprises to actively implement honest strategies, but instead promotes the occurrence of dishonest behavior in the credit financing process.

Case 9: 当 $F_1>0$ 且 $F_2<0$,When and, that is, the sum of the income of the financing enterprise when implementing the fraud strategy and the income brought by the credit rating improvement is greater than the reference point income, and the difference between the income of the financing enterprise when implementing the fraud strategy and the penalty cost is less than the reference point income, $Z(F_1)>Z(F_2)$， according to case 6, the financing enterprise is risk aversion. In this situation, financing companies will choose to implement integrity strategies due to the benefits brought by the increase in credit rating, which serves as an incentive.

To sum up, $F_1>0$ and $F_2<0$ under the condition that the punishment intensity is fixed, the higher the financial institutions improve the credit rating of financing enterprises, the greater the possibility that financing enterprises tend to risk aversion. At this time, the perceived value of financing enterprises' losses due to fraud strategies will also increase, and financing enterprises will more tend to choose honest strategies.

3.3 decision analysis of financing enterprises' behavior when credit rating incentive is invalid

When situation 7 occurs, that is, the punishment of logistics enterprises on financing enterprises is insufficient; And when scenario 8 occurs, where the improvement of the credit rating of the financing enterprise cannot meet its own expectations, the financing enterprise will become a risk averse and tend to choose to implement deception strategies, thereby obtaining greater benefits. Therefore, the following will discuss how logistics enterprises can adopt regulatory strategies to make financing enterprises more inclined to implement integrity strategies when the credit rating improvement of financing enterprises is ineffective. The analysis is as follows:

Assuming that the financing enterprise moderately engages in fraudulent behavior without being investigated by the logistics enterprise, that is, there is a phenomenon of default in repayment to maximize its own interests, the income obtained from the financing enterprise's fraudulent behavior during this process is a. From equation (12), it can be inferred that:

$$\frac{\partial V}{\partial a} = \pi(1-q)v'(F_1) - \xi\pi(q)v'(F_2) \tag{18}$$

Then $\frac{\partial V}{\partial a} = 0$, $\xi = \frac{\pi(1-q)v'(F_1)}{\pi(q)v'(F_2)}$,the optimal penalty coefficient is obtained.

According to Figure 1 above, it can be seen that the more the horizontal axis value of the function develops towards both ends, the more the function tends to flatten out. Under the condition of situation 7, $F_1 > F_2 > 0$, $v'(F_2) > v'(F_1) > 0$,immediately, $\xi = \frac{\pi(1-q)v'(F_1)}{\pi(q)v'(F_2)} < \frac{\pi(1-q)}{\pi(q)}$,can be obtained; Similarly, under the condition of scenario 8, $0 > F_1 > F_2$, $v'(F_1) > v'(F_2) > 0$, immediately, $\xi = \frac{\pi(1-q)v'(F_1)}{\pi(q)v'(F_2)} > \frac{\pi(1-q)}{\pi(q)}$,can be obtained.

In summary, in order for financing companies to still tend to implement integrity strategies when credit rating incentive policies are ineffective, logistics companies can set the penalty coefficient to, $\xi = \frac{\pi(1-q)}{\pi(q)}$,indicating that logistics companies can adopt the following two strategies:

(1) When the probability of being caught by logistics companies when financing companies implement deception strategies is fixed, increase the penalty coefficient ξ。 Regarding the above, when the probability x of logistics enterprises implementing supervision is certain, increasing the punishment for fraudulent behavior of financing enterprises D3 can effectively reduce the occurrence of dishonest behavior. As shown in Figure 4, the impact of different penalty risk perceptions on the behavioral decisions of financing enterprises. From the evolution chart, it can be seen that with the continuous improvement of punishment level D3 for logistics enterprises, the probability of financing enterprises implementing integrity behavior gradually converges from 0 to 1. There exists a critical value of D3 near 40, and when D3 is less than the critical value, y converges to 0; When D3 is greater than the critical value, y converges to 1, and the larger the D3 value, the faster the convergence speed. Therefore, improving the punishment risk perception of financing enterprises can indeed affect their strategic behavior and promote their compliance.

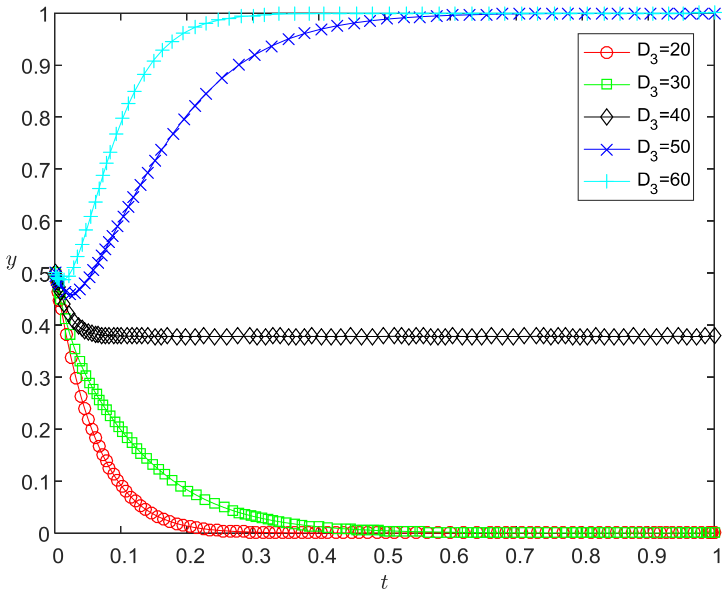


Fig. 4.Evolution of Decision Behavior of Financing Enterprises under Different Penalty Risk Conditions

（r2=0.08;E=800;θ=0.95;C1=30;C2=40;D1=15;D2=20;H=25;δ=0.7）

(2) When the penalty coefficient ξ At certain times, increase the probability of financing companies being caught by logistics companies when implementing fraudulent strategies. Referring to the previous text, when the punishment level D3 of logistics enterprises for fraudulent behavior of financing enterprises is fixed, increasing the probability of logistics enterprises implementing supervision x can effectively reduce the occurrence of dishonest behavior. As shown in Figure 5, the impact of different regulatory probabilities x of logistics enterprises on the behavioral decisions of financing enterprises. From the evolution chart, it can be seen that from a short-term perspective, the lower the regulatory probability x of logistics enterprises, the greater the probability of financing enterprises engaging in fraudulent behavior; Based on a long-term perspective, as the probability x of logistics enterprise supervision continues to increase, the faster the probability y of financing enterprises implementing integrity behavior converges to 1. Therefore, increasing the probability of logistics enterprise supervision can indeed affect the strategic behavior of financing enterprises and promote their compliance.

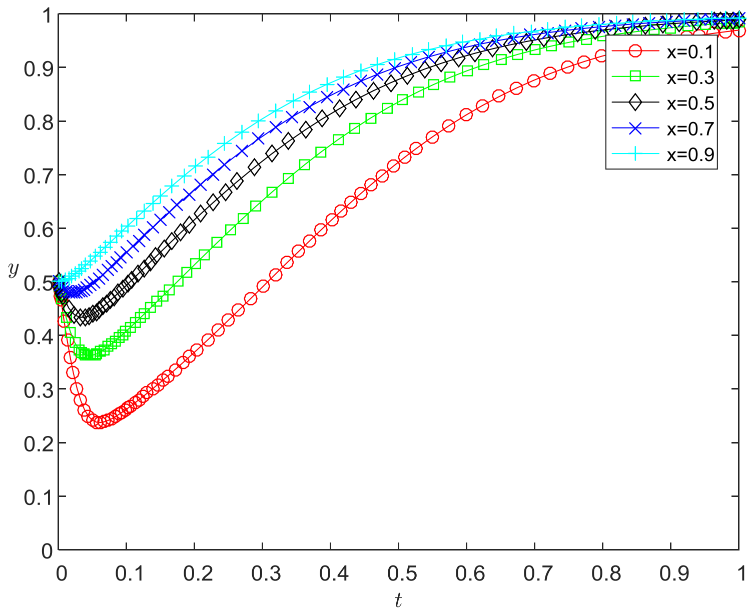


Fig. 4.Evolution of Decision Behavior of Financing Enterprises under Different Regulatory Probability Conditions

（r2=0.08;E=800;θ=0.95;C1=30;C2=40;D1=15;D2=20;D3=45;H=25;δ=0.7）

IV. Conclusion

The credit financing model, as a core model in supply chain finance, is worth studying for its risk management issues in order to promote its development and protect the interests of all participants. Therefore, this article first introduces prospect theory into the evolutionary game between logistics enterprises and financing enterprises, constructs an evolutionary game model of credit risk between financing enterprises and logistics enterprises, conducts stability analysis and numerical analysis on the model, and obtains the influencing factors and constraints of financing enterprises implementing integrity strategies under different parameter values from the perspective of logistics enterprises. Secondly, analyze the strategic choices of financing enterprises under different conditions by introducing changes in the credit rating of financing enterprises by financial institutions. Finally, through the analysis of the entire text, this article draws the following conclusions on the supply chain finance of credit financing models:

(1) The indicators such as the cost of payment, deceptive benefits, loan interest, and loss cost of loan enterprises can all affect the decision-making choices of loan enterprises. Any changes in the above indicators may cause loan companies to adjust their strategies, but the benefits of maintaining integrity by loan companies have no impact on the evolutionary stability strategy. This indicates that logistics companies should focus on monitoring the fraudulent benefits obtained by loan companies when implementing fraudulent strategies. Therefore, logistics enterprises should increase their punishment for lending enterprises, strengthen the promotion of strict resistance to dishonest behavior in the industry, and make lending enterprises realize that the benefits obtained from implementing fraudulent strategies are not enough to offset the penalty or loss costs brought by the strategies, so as to promote lending enterprises to maintain integrity.

(2) Logistics enterprises need to strengthen credit risk prevention and control for loan enterprises. When selecting loan enterprises that need financing, logistics enterprises should comprehensively consider the qualifications of the loan enterprises, investigate the historical situation of the loan enterprises in repaying debts, analyze the performance ability

of the loan enterprises in past loan transactions, select loan enterprises with strong sense of responsibility and business ability, and carry out regular supervision and dynamic management to avoid the occurrence of dishonest events.

(3) A reasonable increase in credit rating can effectively motivate loan companies to implement integrity strategies. When implementing deception strategies in loan enterprises, if the undisclosed income is greater than 0 and the detected income is less than 0, the improvement of credit rating can effectively encourage loan enterprises to adopt honest behavior. In other cases, an increase in credit rating will actually increase the probability of dishonest events occurring. Therefore, financial institutions need to judge the market environment in which lending enterprises are located with a rigorous attitude, and provide favorable policies for improving the credit rating of lending enterprises under reasonable conditions.

(4) Logistics enterprises need to reasonably regulate and strengthen the level of supervision and punishment of loan enterprises. If the regulatory level and punishment level of logistics enterprises towards loan enterprises cannot meet the corresponding standards, loan enterprises are likely to engage in fraudulent behavior due to their relative interests. Logistics enterprises need to recognize the importance of regulatory level and punishment intensity, ensuring that when one factor is at a certain level, the other factor can meet the corresponding requirements. Improve the degree of information sharing in the process of credit financing, implement a risk monitoring and early warning system, and refine punishment measures for dishonest behavior of loan enterprises.

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