Evolutionary Game Analysis of Digital Warehouse Receipt Pledges Considering Blockchain Under B2B Platforms

Juntian Ren

673886297@qq.com

Institute of Logistics Science and Engineering, Shanghai Maritime University, Shanghai201306, China

Abstract: The technological advantages of third-party B2B supply chain bill service platforms, such as online docking, real-time information and big data, provide banks with the possibility to realize the supervision of digital warehouse receipt pledge financing. This paper considers the existence of collusion in warehouse receipt pledge financing, and constructs a three-party evolutionary game model of enterprises, banks and platforms of B2B bills under the consideration of whether banks apply blockchain regulation, explores the relationship between the influence of each element on the strategic choices of the three parties, and further analyses the stability of equilibrium points in the three-party game system. The results show that: 1) the setting of the bank's warehouse receipt pledge rate is very important, too high will lead to collusive tendency of B2B platforms, too low will lead to default of enterprises, when it is set to a moderate value banks can reduce their own regulatory costs. 2) the increase of the enterprise's normal production margin will help it tend to comply with the strategy choice, high production costs will make enterprises tend to default strategy choice. 3) the government should strengthen incentives for the application of blockchain distributed ledgers, encourage the application of blockchain technology in warehouse receipt pledges, and reduce the cost of using blockchain. Finally, Matlab 2019a is used for simulation analysis to propose countermeasures and suggestions for banks' risk control.

Keywords: Digital Warehouse Receipt Pledge; Blockchain; Three-party Evolutionary Game; Collusive Loan Fraud

1 Introduction

As an important part of supply chain financing, warehouse receipt pledge is based on the actual operating conditions of SMEs, optimising the flow of funds and alleviating the financial difficulties of SMEs through the early realisation of warehouse goods[1]. However, repeated cases of fraudulent warehouse receipt pledge financing, such as the Shanghai Steel Trade case in 2013 and the Qingdao Port fraud case in 2014[2], have fully exposed the risk control problems arising from information asymmetry in traditional warehouse receipt pledge financing activities, prompting banks to raise the financing threshold[3]. Problems such as opaque information, worrying data quality and confusing payment delivery in the whole warehouse receipt pledge activities further increase the investment risks of financial institutions and cause financing difficulties[4]. To strengthen regulation, the "2022 China Supply Chain Finance Ecological Development White Paper" stresses that banks should strengthen cooperation with B2B supply

ICBBEM 2023, May 19-21, Hangzhou, People's Republic of China

DOI 10.4108/eai.19-5-2023.2334394

chain bill of exchange service providers and establish a digital warehouse receipt platform to build a real-time cargo supervision system and reduce banks' credit collection costs. Although banks are currently cooperating with B2B supply chain invoice service providers, there is still no way to avoid the possibility of joint fraudulent lending between enterprises and B2B invoice service platforms[5]. And the current warehouse receipt financing pledged goods are basically bulk commodities, generally of high value, and the profits gained from fraudulent warehouse receipt pledge are huge[6]. Given the limited regulatory constraints on banks, there is a tendency for companies to collude with B2B invoice service providers to engage in collusive lending. There is also a risk of collusion by B2B bill providers for profit.

The openness, decentralisation, disintermediation, traceability, authenticity and tamper-resistance of blockchain technology can be very helpful in solving trust issues[7]. Some academics have already studied blockchain design and provided detailed guidance on the development of blockchain application systems[8,9]. By building a new type of supply chain finance platform[10], the entire financing process of supply chain finance will be managed using blockchain technology, which will improve the efficiency of financing and complete the supervision of the most important financing aspects of supply chain finance[11]. In this paper, the characteristics of blockchain technology are translated into mathematical parameters and applied to an evolutionary game model for the risk control of electronic warehouse receipt financing with the participation of a B2B invoice platform.

In summary, this paper differs from previous scholars' research in the following three main aspects: first, this paper considers the introduction of a financing model under digital warehouse receipts under a B2B bill platform, the establishment of a three-party evolutionary game model for B2B bill institutions, financial institutions (banks), and financing application enterprises, and analyses the strategy stability of each game party and the relationship between the influence of each element on strategy choice. Second, the study focuses on the human moral hazard, especially considering the collusion between the third-party bill institution and the enterprise. Finally, the technical characteristics of the blockchain are translated into mathematical parameters and applied to the evolutionary game model for risk control of digital warehouse receipt pledge financing to analyze the effect of the blockchain on the control of artificial moral risk in digital warehouse receipt pledge platforms.

2 Modelling the three-party evolutionary game of warehouse receipt pledges

To effectively carry out the game evolution study, assumptions are made and parameters are set for the game evolution model involving B2B platforms, financial institutions, companies applying for financing.

Assumption 1: In supply chain finance, the financing applicant is participant 1, the B2B bill platform is participant 2, and the financial institution (bank) is participant 3. All three participants are considered to be finitely rational, and their strategy choices evolve over time towards an optimal and stable strategy.

Assumption 2: Financing companies in supply chain finance face two strategic choices including intentional default or rejection of default; B2B bill platforms face two strategic choices including intentional collusion or rejection of collusion; financial institutions (banks) include access the blockchain or not accessing the blockchain.

Assumption 3: The behavioral strategy choice space for financing firms in supply chain finance is $\varphi = (\varphi_1, \varphi_2) = (\text{default, refusal to default})$ and chooses α_1 with probability x and α_2 with probability $(1-x)$, x∈[0,1]; the behavioral strategy choice space for B2B bill platforms is $\beta = (\beta_1, \beta_2) = $ (refusal to collude, intention to collude), where the probability of choosing β_1 is y and the probability of choosing β_2 is $(1-y)$, $y \in [0,1]$; the behavioral strategy choice space of the financial institution (bank) is $\gamma = (\gamma_1, \gamma_2) = $ (uplink regulation, non-uplink regulation), where the probability of choosing γ_1 with probability z and the probability of choosing γ_2 with probability $(1-z)$, $z \in [0,1]$.

Assumption 4: The total value of goods to be pledged by the financing enterprise in the warehouse receipt pledge financing activity is(a). The rate of return for the enterprise to use the money for normal production is (b) and the cost of production is (f). The rate of return for the enterprise to use the money for speculation is (c) and the rate of return for normal production is $(b) >$ the rate of return for speculation (c). When the enterprise chooses the behavioral strategy of default, the speculative cost of fraud is (d). Companies may conspire to provide bribes to third-party B2B note platforms in order to secure regular access to finance when they adopt a behavioural strategy of compliance

Assumption 5: The B2B bill platform in supply chain finance provides digital warehouse receipt construction and verification services after receiving goods, and the verification cost rate charged to enterprises is (g). In carrying out the financing activity of pledging digital warehouse receipts, it has the obligation to confirm the authenticity of digital warehouse receipts and provide verification services, and the verification service rate charged to banks is (h). The B2B bill platform's own operating cost is(j). In its intention to adopt collusion behavioural strategy, it also incurs overheads such as falsifying digital warehouse receipts and false entry records, and let its speculative cost at the time of collusion be $(k)$and the bribe it charges to the firm be (e) and the bribe (e)> the speculative cost (k).

Assumption 6: The bank's warehouse receipt pledge rate in supply chain finance is set to (m). The bank engages in credit activities at a lending rate of (n). It can earn revenue from credit operations after it has not declined to participate in the financing. The bank assesses a cost of (i) to the B2B bill platform when it adopts a not accessing the blockchain strategy, and incurs an accessing the blockchain cost (q) and an incentive (p) from the government when the bank adopts an access strategy. the compensation that the B2B bill platform will give to the bank when its intention to collude is detected by the bank is l, and the penalty (l) > uplinking cost (q). the bank gives an incentive to the B2B note platforms are given an incentive (v) when they refuse to collude.

Based on the above model assumptions, the payoff game matrix of the financing applicant company, the third-party B2B bill platform and the financial institution (bank) is derived, as shown in Table 1.

Table 1. The payoff matrix

		B2B Billing Platform			
		Collusion(y)		Non-Collusion ($1-y$)	
		Financial institutions		Financial institutions	
		Access(z)	Refuse($1-z$)	Access(z)	Refuse($1-z$)
Company	Default (x)	$-d-e-ag$ $ah+ag-j-k-l+e$ $amn+l-ah+p-q$	$am+amc-d-e-ag$ $ag+ah-j-k+e$ $-i-am-amn-ah$	$-d-ag$ $ag+ah-j+v$ $-v+amn+p-q-ah$	$d-ag$ $ag+ah-j+a$ $amn-i$
	Trustworthy($1-x$)	$am(b+1)-f-a-ag$ $ag+ah-j-k-l$ $l-ah+(1-m)a-amn+p-q$	$am(b+1)-f-a-ag-e$ $ag+ah-j-k+e$ $-ah+(1-m)a-amn$	$am(b+1)-f-a-ag$ $ag+ah+v-j$ $-v-ah+(1-m)a-amn+p-q$	$am(b+1)-f-a-ag$ $ag+ah-j$ $-ah+(1-m)a-i-amn$

3 Evolutionary game analysis

3.1 Analysis of replication dynamics

From Table 1., we can obtain the expected returns E_{11}, E_{12} and the average expected return $\bar{E}_1$ for a firm applying for financing in supply chain finance that chooses to keep or default on its contract are:

$$E_{11} = (-d-e-ag)yz + (am+amc-d-e-ag)y(1-z) + (-d-ag)(1-y)z + (-d-ag)(1-y)(1-z) \quad (1)$$

$$E_{12} = (am(b+1)-f-a-ag)yz + (am(b+1)-f-ag-e)y(1-z) + (am(b+1)-f-a-ag)(1-y)z + (1-y)(1-z)(am(b+1)-f-a-ag) \quad (2)$$

$$\bar{E}_1 = x * E_{11} + (1-x) * E_{12} \quad (3)$$

Based on the above equation, we then calculate the replicated dynamic equation for the company as:

$$F_{(X)} = \frac{d_x}{d_t} = x\left(E_{(x)} - \bar{E}_x\right) = x(x-1)(d-a-f+am+ay+abm-amy-ayz+eyz-acmy+amyz+acmyz) \quad (4)$$

Let formula 4 = 0, which gives $x_1^* = 0, x_2^* = 1, y^* = \frac{a-d+f-am-abm}{-am-az+ez-acm+amz+acmz+a}$ is the equilibrium solution to the company replicated dynamic equation.

Using the same method, we can obtain the replication dynamic equation and equilibrium solution for B2B platform:

$$F(y) = y(y-1)(k - e + ez + lz + vz - exz) \quad (5)$$

Let formula 5 = 0, which gives $x_1^* = 0, x_2^* = 1, z^* = \frac{e-k}{e+l+v+ex}$ is the equilibrium solution to the company replicated dynamic equation.

We can also obtain the replication dynamics equation and equilibrium solution for financial institutions:

$$F(z) = -z(z-1)(i + p - q - v + ly + vy - ahx + ahxy + amxy + 2amnxy) \quad (6)$$

Let formula 6 = 0, which gives $z_1^* = 0, z_2^* = 1, y^* = \frac{-ahx-q-v+i+p}{-l-v-ahx-amx-2amnx}$ is the equilibrium solution to the company replicated dynamic equation.

Through replicated dynamic equations for Company, B2B Billing Platform and Financial institutions, we can obtain nine equilibria which are $E_1(0,0,0), E_2(1,0,0), E_3(0,1,0), E_4(0,0,1) E_5(1,1,0), E_6(1,0,1), E_7(0,1,1), E_8(1,1,1), (x_0, y_0, z_0)$ .The set (x_0, y_0, z_0) represents the possible strategy solutions, including pure and mixed strategy solutions.

3.2 Evolutionary equilibrium point analysis

The local stability analysis of the Jacobi matrix leads to the evolutionary stability strategy(ESS), so we take partial derivatives of the replicated dynamic equations for three main subjects respectively, and obtain the Jacobi matrix as

$$J = \begin{bmatrix} \partial F(x)/\partial x & \partial F(x)/\partial y & \partial F(x)/\partial z \\ \partial F(y)/\partial x & \partial F(y)/\partial y & \partial F(y)/\partial z \\ \partial F(z)/\partial x & \partial F(z)/\partial y & \partial F(z)/\partial z \end{bmatrix} = \begin{bmatrix} j_{11} & j_{12} & j_{13} \\ j_{21} & j_{22} & j_{23} \\ j_{31} & j_{32} & j_{33} \end{bmatrix} \quad (7)$$

After calculation, we get

$$j_{11} = (2x-1)(d - a - f + am + -amy - ayz + eyz - acmy + amy + acmyz) \quad (8)$$

$$j_{12} = x(x-1)(a - am - az + ez - acm + amz + acmz) \quad (9)$$

$$j_{13} = x(x-1)(ey - ay + amy + acmy) \quad (10)$$

$$j_{21} = -eyz(y-1) \quad (11)$$

$$j_{22} = (2y-1)(k - e + ez + lz + vz - exz) \quad (12)$$

$$j_{23} = y(y-1)(e + l + v - ex) \quad (13)$$

$$j_{31} = -z(z-1)(ahy - ah + amy + 2amny) \quad (14)$$

$$j_{32} = -z(z-1)(l + v + ahx + amx + 2amnx) \quad (15)$$

$$j_{33} = -(2z-1)(i + p - q - v + ly + vy - ahx + ahxy + amxy + 2amnxy) \quad (16)$$

Substituting the points $E_1, E_2, E_3, E_4, E_5, E_6, E_7, E_8$ into the above equation to calculate the determinant respectively, and the final calculation results are shown in Table 2.

Table 2. Stability analysis of equilibrium points in the evolution of receivables financing

Balancing point	Jacobian matrix eigenvalues	Stability
$E_1 = (0,0,0)$	$\lambda_1 = a - d + f - am - abm$ $\lambda_2 = e - k > 0$ $\lambda_3 = i + p - q - v$	Unstable point
$E_2 = (1,0,0)$	$\lambda_1 = d - a - f + am + abm$ $\lambda_2 = e - k > 0$ $\lambda_3 = i + p - q - v - ah$	Unstable point
$E_3 = (0,1,0)$	$\lambda_1 = f - d - abm + acm$ $\lambda_2 = k - e < 0$ $\lambda_3 = i + l + p - q$	$\lambda_1 = f - d - abm + acm < 0, \lambda_3 = i + l + p - q < 0$, ESS if the case holds
$E_4 = (0,0,1)$	$\lambda_1 = a - d + f - am - abm$ $\lambda_2 = -k - l - v$ $\lambda_3 = q + p - i + v$	$\lambda_1 = a - d + f - am - abm < 0$，$\lambda_2 = -k - l - v < 0$，$\lambda_3 = q - p - i + v < 0$, ESS if the case holds
$E_5 = (1,1,0)$	$\lambda_1 = d - f + abm - acm$ $\lambda_2 = k - e$ $\lambda_3 = i + l + p - q + am + 2am > 0$	Unstable point
$E_6 = (1,0,1)$	$\lambda_1 = d - a - f + am + abm$ $\lambda_2 = e - k - l - v$ $\lambda_3 = q - p - i + v + ah$	$\lambda_1 = d - a - f + am + abm < 0$，$\lambda_2 = e - k - l - v < 0, \lambda_3 = q - p - i + v + ah < 0$, ESS if the case holds
$E_7 = (0,1,1)$	$\lambda_1 = a - d - e + f - am - abm$ $\lambda_2 = k + l + v > 0$ $\lambda_3 = q - p - l - i$	Unstable point
$E_8 = (1,1,1)$	$\lambda_1 = d - a + e - f + am + abm$ $\lambda_2 = k - e + l + v$ $\lambda_3 = q - p - l - i - am - 2amn$	$\lambda_1 = d - a + e - f + am + abm < 0$，$\lambda_2 = k - e + l + v < 0, \lambda_3 = q - p - l - i - am - 2amn < 0$ ESS if the case holds

Based on Table 2. There are four evolutionary stability points, $E_3(0，1，0)$，$E_4(0，0，1)$，$E_6(1，0，1)$，$E_8(1，1，1)$, respectively, under certain circumstances. Strategy $E_3(0，1，0)$ is the evolutionary stability point when $i + l + p - q < 0$, i.e. when the cost of assessing reliability and the government incentive to go on the chain and the compensation given to the bank when collusion is detected is less than the bank's cost to go on the chain. In reality, the amount of penalty compensation for B2B platforms when collusion is detected is greater than the cost of regulatory speculation spent by banks, so the case where the amount of penalty compensation for collusion detected is less than the cost of up-linking is relatively rare. Therefore, there are only three stable points, $E_4(0，0，1)$，$E_6(1，0，1)$，$E_8(1，1，1)$.

For reasons of space, we only perform numerical simulations for point $E_8(1,\ 1,\ 1)$.

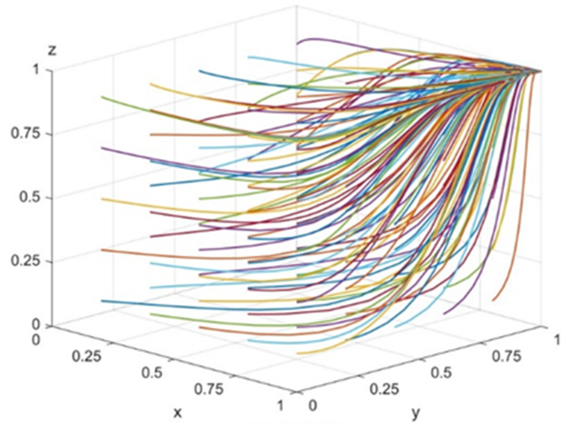


Fig.1. Simulation of a three-way evolutionary game model

We can see from Fig.1 that the strategy choices of all three subjects of the warehouse receipt pledge eventually converge to point $(1,\ 1,\ 1)$, so we can confirm the correctness of the model in this paper. Next, we will perform a sensitivity analysis of the specific parameters in the model.

4 Numerical simulation analysis

To describe the evolution of both sides of the game in the process of receivables financing in supply chain finance more concrete and intuitive way, and to verify the conclusion that blockchain can enable receivables financing for SMEs derived from the above derivation, this paper uses $Matlab2019a$. Before conducting the analysis, we need to assign values to the parameters and satisfy the assumptions in Chapter 2, and the default values of the specific parameters are as follows: $a = 400$, $b = 0.3$, $c = 0.02$, $d = 2$, $e = 50$, $f = 80$, $g = 0.02$, $h = 0.02$, $k = 5$, $l = 10$, $v = 5$, $m = 0.8$, $n = 0.04$, $i = 8$, $p = 0.5$, $q = 1$.Analysis of evolutionary stability conditions satisfying $E_8(1,\ 1,\ 1)$ on the basis of the array for (a), (m), (b), (q), (f), (p) on the process and outcome of the evolutionary game.

First, in order to analyze the impact of the change of (a) on the process and result of the evolutionary game, $(a) = 400,500,600$, respectively, and the simulation results of the dynamic equation system with 50 changes in time are shown in Fig. ; in order to analyze the impact of the change of (m) on the process and result of the evolutionary game, $m = 0.75,0.775,0.8$, respectively, and the simulation results of the dynamic equation system with 50 changes in time are shown in Fig. 3.

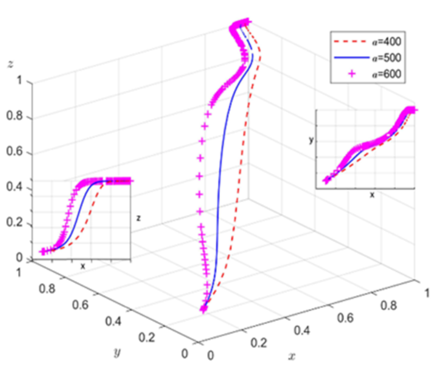


Fig. 2. Impact of the amount pledged by the business

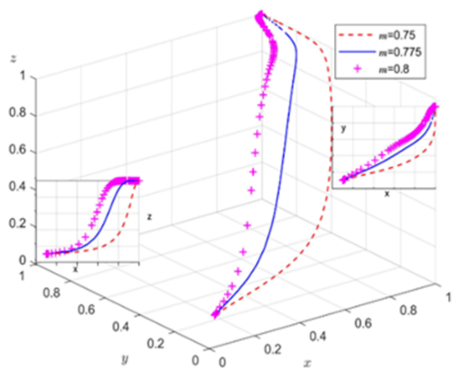


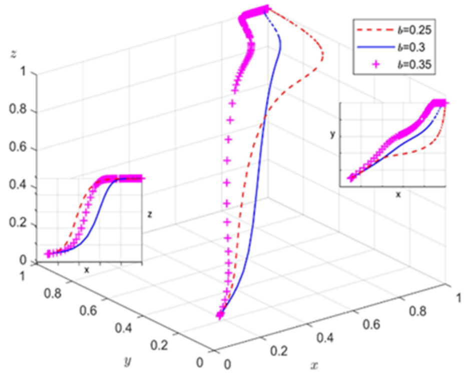
Fig. 3. Impact of pledge rates on bank receipts

From Fig. 2, it can be seen that during the evolution of the system to a stable point, the rising amount of corporate pledges can enhance the probability of banks to choose the uplink strategy, in addition to the B2B platforms are more inclined to collude in the strategy choice. Therefore, banks must not let their guard down when dealing with large warehouse receipts pledge financing business as they may face collusion risk from B2B platforms. In addition, as the amount of finance obtained increases, companies will tend to choose a stable strategy of compliance to meet their own profitability needs, so the larger the amount of warehouse receipt pledge finance, the better for the company's own normal production and the more effective the amount of finance can be used for normal production activities.

As can be seen in Fig. 3. ,as the pledge rate of warehouse receipts increases, banks tend to move up the chain and the change in strategy choice is very pronounced, and at $m = 0.075$ the change in banks' willingness to move up the chain is not as pronounced as when the pledge rate is less than m. At this point, it can be seen that when the pledge ratio of warehouse receipt financing reaches a fixed value, the banks' willingness to move up the chain is very strong in order to reduce their own losses in case of collusion or default. While companies tend to choose the strategy of default when the pledge rate of warehouse receipt financing is low, B2B platforms tend to reject the strategy of collusion when the pledge rate of warehouse receipt financing is low. When the pledge rate for bank warehouse receipt financing is high, banks can reduce the occurrence of collusion by strengthening supervision and increasing the penalties for B2B platforms.

Next, the simulation results are shown in Fig. 4 for $b = 0.25, 0.3, 0.35$and in Fig. 5 for $f = 80, 100, 120$.

As can be seen from Fig. 4 the trend of strategy choice for banks choosing to go up the chain gradually decreases as the firm's normal production yield increases, but there is another increase in the trend of strategy choice for banks choosing to go up the chain when the firm's normal production yield is higher than a fixed value. As normal production yields increase, firms also tend to choose a strategy of compliance, and B2B platforms tend to choose a strategy of intentional collusion. This is because firms must bribe in order to maintain their ability to produce normally in order to obtain normal financing. It can be seen that banks in warehouse receipts pledge financing, when facing the normal production yield of enterprises to do a good investigation, there is a suitable normal production yield banks will tend not to chain the regulatory strategy to reduce the cost of chain supervision on the chain. However, in the face of low or high normal production yields, banks still need to adopt an on-chain strategy to prevent corporate defaults or collusive behaviour by B2B platforms..



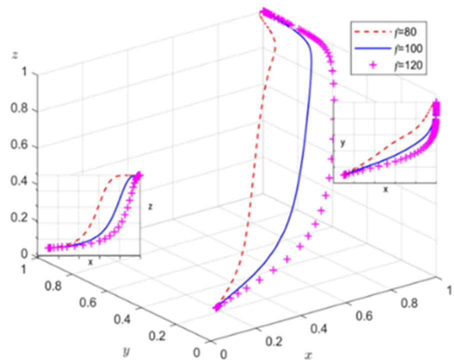
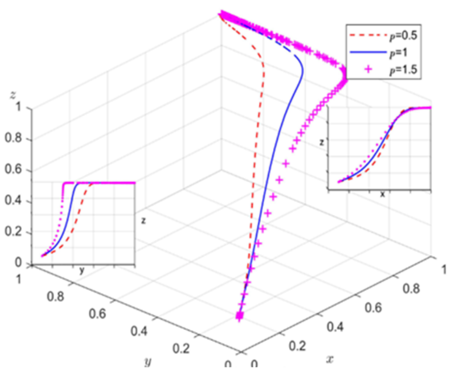


Fig. 4. Business's normal rate of return on production **Fig. 5.** Impact of normal business production costs

As can be seen in Fig. 5, the trend in the evolutionary process of the bank's strategic choice to opt out of collusion gradually decreases as the firm's normal cost of production increases, and the higher the cost, the faster its tendency to opt out of collusion. On the other hand, the increase in the firm's normal cost of production will also cause the firm to tend towards the strategic choice of default and B2B platform will tend to reject the strategic choice of collusion in the face of high production costs and the trend will change very quickly. Therefore, in daily warehouse receipt pledge activities, in the face of high normal production costs of enterprises, B2B platform can play its supervisory role as an intermediary, and banks can choose not to go on the chain to reduce their supervision costs.

Furthermore, the results of 50 simulations with $p = 0.5, 1, 1.5; q = 1, 1.5, 2$ replicating the dynamic equations over time are shown in Fig.6 and Fig.7 respectively.



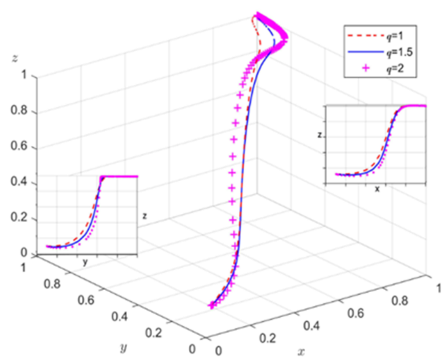


Fig.6. The impact of government incentives **Fig.7.** Impact of bank uplink costs

Fig.6 and Fig.7 show that as banks' blockchain onboarding incentives increase; their own onboarding costs decrease, banks will tend towards the strategy choice of onboarding, and when banks' blockchain onboarding incentives increase firms will tend towards the strategy choice of compliance, and third party B2B platforms will tend towards the strategy choice of refusing to collude. When the banks' own costs of up-chaining increase, the third-party B2B platforms will tend to choose the strategy of intentional collusion, and the enterprises will tend to choose the strategy of default. It can be seen that the government should strengthen the incentives for the application of blockchain distributed ledgers and encourage the application of blockchain technology in warehouse receipt pledges.

5 Conclusions

Considering the possibility of collusion between B2B platforms and enterprises in warehouse receipt pledge financing activities, this paper analyzes the stability of each party's strategy choice, the stability of the equilibrium strategy combination of the game system and the influence of the change of each parameter in the model on each party's strategy choice by constructing a tripartite evolutionary game model among the enterprises applying for financing, B2B platforms and financial institutions (banks), and verifies the validity of the conclusions through numerical simulation analysis. The validity of the conclusions is verified through numerical simulations, with particular emphasis on the strategy choice models of enterprise default, B2B platform collusion and bank upstream, and relevant countermeasures and suggestions are put forward for the control of warehouse receipt pledge risk based on the influence relationship and stability conditions of each factor on the case.

The main conclusions include: the increase in the amount of the enterprise pledge can motivate the enterprise to carry out normal production activities, and the bank itself will tend to wind up the strategic choice to deal with the collusion of the B2B platform; the setting of the bank warehouse receipt pledge rate is very important, too high will lead to the collusion of the B2B platform, too low will lead to the default of the enterprise, when it is set to a moderate value the bank can reduce their own supervision costs In addition, B2B platforms can play a supervisory role as intermediaries in daily warehouse receipt pledging activities in the face of high normal production costs. The government's incentive for blockchain use and the reduction of banks' own use costs help enterprises and B2B platforms to produce normally and reject collusion, which has a catalytic effect on the normal development of warehouse receipt financing.

This paper only considers the risk control problems of the three parties involved in warehouse receipt pledge financing activities from the perspective of asymmetric information and limited rationality, and does not consider the influence of market conditions with time windows, the probability of monetary inflation and deflation, policies and other factors on the choice of strategy, nor the influence of the order of the game. Therefore, the introduction of influencing factors such as government and third-party note institution regulation, the construction of a dynamic and replicative game model under the participation of third-party regulation, and the study of market conditions, the probability of inflation deflation on the impact mechanism of warehouse receipt pledge financing are the shortcomings of this paper.

Reference

[1]Chai Zhengmeng, Duan Li Li. Evolutionary game analysis of logistics enterprises and banks based on warehouse receipt pledge financing[J]. Operations Research and Management,2018,27(05):31-39.

[2]Wang Xiaoguang,Zhou Qiang. Evolutionary game analysis of warehouse receipt pledge banking enterprises under blockchain[J]. Computer Engineering and Applications,2022,58(08):307-316.

[3]Jiang Chen. Research on the decision of warehouse receipt pledge financing from the perspective of banks [D]. Donghua University,2018.

[4]Sun Rui, He Dayi, Su Huiling. Research on the application of blockchain technology in supply chain finance based on evolutionary game [J/OL]. China Management Science:1-18 [2022-12-15].DOI:10.16381/j.cnki.issn1003-207x.2021.1538.

[5]Si Fanfan. Research on the evolutionary game of electronic warehouse receipt pledge financing [D]. Sichuan Academy of Social Sciences, 2020.

[6]Li Zhihua, Shi Jinzhao. Risk identification and control of supply chain finance-a comparison based on online and offline models[J]. Business Economics Research,2015(08):99-101.

[7]Zhou, L. Q., Li, Z. H.. Application of blockchain in supply chain finance [J]. Information Systems Engineering,2016(07):49-51.

[8]Cai W.D., Yu L., Wang R., Liu N., Deng E.Y.. Research on blockchain-based application system development methods[J]. Journal of Software,2017,28(06):1474-1487.

[9]Chod Jiri, Trichakis Nikolaos ,Tsoukalas Gerry. On the Financing Benefits of Supply Chain Transparency and Blockchain Adoption [J].Management Science201966(10):4378-4396.

[10]Du Mingxiao, Chen Qijun, Ma Xiaofeng. Supply chain finance innovationusing block chain[J].IEEE Transactionon engineering management 202067(4):1045-1058.

[11]Zhang Xiaheng. Optimization of blockchain-based supply chain management model [J]. China circulation economy,2018,32(08):42-50