

Research Article

Study on Enterprise Financial Risk Prevention and Early Warning System Based on Blockchain Technology

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To address the challenges of financing SMEs, breaking the limitations of traditional financing models, a blockchain-based financial risk prevention and early warning system for businesses has been proposed and an in-depth study of the system has been undertaken. As a scientific and technological means to strengthen the disclosure and sharing of information such as credit records and risk early warning, The key to getting financial institutions to lend to SMEs is to avoid financial credit risk in the value chain. Considering SMEs located in supply chains as an object of study, using the logical relationships between block chains and financial credit risk management chains, three principles of supply chain management are proposed by analyzing the logical relationships between supply chains and financial credit control chains. Chain using blockchain technology, namely: the principle of recognizing the trust of major enterprises, the principle of sharing information about the financing process and the principle of general cooperation for successful financing. Based on this principle, an evolutionary game model is used to analyze the evolutionary path of endorsement fiduciary relationships between major enterprises and SMEs, the influencers of evolutionary equilibrium, the evolutionary path of cooperation between commercial banks and SMEs in financing, the evolutionary path under the control of third-party institutions, and influencers. The research shows that the financing activities of commercial banks and small and medium-sized enterprises are based on the trust endorsement of core enterprises in the supply chain, and the intervention of third-party regulators will help to promote the consistent cooperation and information sharing of all participants in the supply chain, so as to promote the smooth completion of supply chain financing.

1. Introduction

In traditional financial business, banks often need to comprehensively consider the borrower's financial status, mortgage and pledge assets, so as to determine whether its repayment source is sufficient and evaluate its overall risk. Because upstream SMEs are usually separate economic entities, risk tolerance, low credibility and inadequacy are weak, unreliable and inadequate. Therefore, banks are less willing to lend to small and medium-sized enterprises. At the same time, banks create cumbersome approval processes to hedge against risks, and financial services are ineffective and do not match the economic contribution of SMEs. Worse, the financing channels of small and medium-sized enterprises are much less than those of large group companies. When formal financial institutions are bound by higher financial obligations, only private loans with a high cost of capital

can be shifted, resulting in the loss of a large number of clients and the high cost of financing SMEs. The emergence of supply chain finance has improved the above problems to a certain extent. It takes the core enterprises with high credit level in the industrial chain as the node, carries out financing business through credit transmission, and realizes multi-party win-win [1]. Different from the simple one-time creditor's right and debt relationship between traditional banks and enterprises, the borrower and the borrower have built a long-term cooperative relationship. Value chain finance business processes focus on the quality of information flow, logistics and capital flows, are efficient and inexpensive, and improve the efficiency of value chains. But, as a way of history is also shortly financed, finance is established to deploy the supply chain during the financial services process, risk, credit risk, operation, liquidity risk, rights, many risks await in a technologically advanced

context, and the corresponding risk has an important theoretic and practical meaning. Blockchain application scenes currently exist: retail, financial industry, supply chain management, smart manufacturing, impartiality, record keeping, archive management such as retail consumer goods traceability, security, segregated logistics knowledge, real-time logistics tracking, registration digital assets of the civil service, identity card, etc [2]. Figures 1 show the financial risk warning system of enterprises in the field of block chain.

2. Literature Review

Gupta, Y. B. and others said that value chain finance as a service of financial innovation to address the challenges of SME finance, breaking through the constraints of traditional SME finance models, attempts to spur SME development under the influence of national policies and emerging technologies [3]. Avgouleas, E. and others believe that as the models of SME finance change, the concepts and models of value chain finance must also change. How to mitigate the credit risk of value chain finance is fundamental not only to address urgently needed challenges in the development of value chain finance, but also to facilitate the smooth implementation of SME finance [4]. Wang, K. and others said that as a scientific and technological means to strengthen the disclosure and sharing of information such as credit records and risk early warning, The key to getting financial institutions to lend to SMEs is avoiding financial credit risk in the value chain [5]. Liu, G. F. and others took small and medium-sized enterprises with financing needs in the supply chain as the research object. By analyzing the logical relationship between blockchains and the financial credit risk control of the supply chain, three principles for controlling the financial credit risk of the supply chain using blockchain technology are proposed, namely the principle of sharing information about the financing process, the basic principle of recognizing enterprise trust and the principle of general cooperation for successful financing [6]. Yan and others said that supply chain finance provides new financing channels for core enterprises and upstream and downstream enterprises in supply chain members. At the same time, it makes the management of supply chain financial credit risk face new challenges [7]. F Ying and others said that due to historical reasons such as the industrial revolution, the research on supply chain finance is earlier than that in China, has formed a relatively perfect theoretical system, and the research is relatively mature and in-depth, with a variety of perspectives. In contrast, China's research in this field started late, but its practical development should be ahead of academic research [8]. Qu, M. and others said that the research on China's supply chain finance is still in its infancy both in practice and theory. In addition, China's supply chain finance has its own characteristics. Chinese scholars should carry out localized supply chain finance research based on this situation to improve the local applicability of the research results [9]. Secondly, Ding, Q. and others said that the credit risk evaluation model applied by tradi-

tional credit is difficult to be fully applicable to supply chain finance. Supply chain finance takes transaction as the background, requires that loan funds and goods operate in closed loop, and the repayment funds must be self-owned funds, and introduce the information reference of core enterprise credit in the supply chain system. Therefore, for the credit risk control of supply chain finance, it is necessary to build a new risk evaluation system to scientifically predict the probability of credit risk [10]. Finally, Zeng, H. and others said that the conjecture and research of blockchain technology breaking through the bottleneck of supply chain financial development are emerging one after another. How to apply it to supply chain financial credit risk control is also the research trend. Therefore, based on this technical perspective, it is necessary to explore the mechanism of supply chain financial credit risk control and improve supply chain financial credit risk control [11]. Wang, Z. and others said that the research on financial credit risk control of the whole supply chain from the perspective of blockchain, from the perspective of commercial banks, can help commercial banks comprehensively evaluate the credit status of other upstream and downstream enterprises with the help of other participants in the supply chain, such as the credit status of core enterprises and the supervision of logistics enterprises [12]. Li, J. and others believe that from the perspective of core enterprises, it can reduce the impairment risk of collateral in the financing process and disperse the default risk of losses caused by the default of small and medium-sized enterprises. From the perspective of logistics enterprises, it can effectively improve the traceability of products and their ability to respond to emergencies [13]. From the perspective of the whole supply chain, it can make data interaction more convenient and reduce the rise of transaction costs caused by information asymmetry. Therefore, Kurt and others believe that the key to the success of supply chain finance is how to combine risk sources to strengthen risk management and effectively control risks in the whole financing process [14].

3. Method

Value chain actors such as major businesses and SMEs are important elements of the value chain financial system, and SME finance can be smooth and depend on different actors throughout the value chain in addition to that financial institutions fulfill the important role of lending. In fact, the trust endorsement of core enterprises is the beginning of whether supply chain finance can implement financing services. Because core enterprises grasp the core value of the whole supply chain and play a key role in integrating supply chain logistics, information flow and capital flow, the operation status of core enterprises also determines the transaction quality of upstream and downstream enterprises. Thus, the main enterprise's own business and the possibility of real financial credit collateral for SMEs are the key points of control of the financial credit risk of the value chain based on a cooperative endorsement relationship between the main enterprise

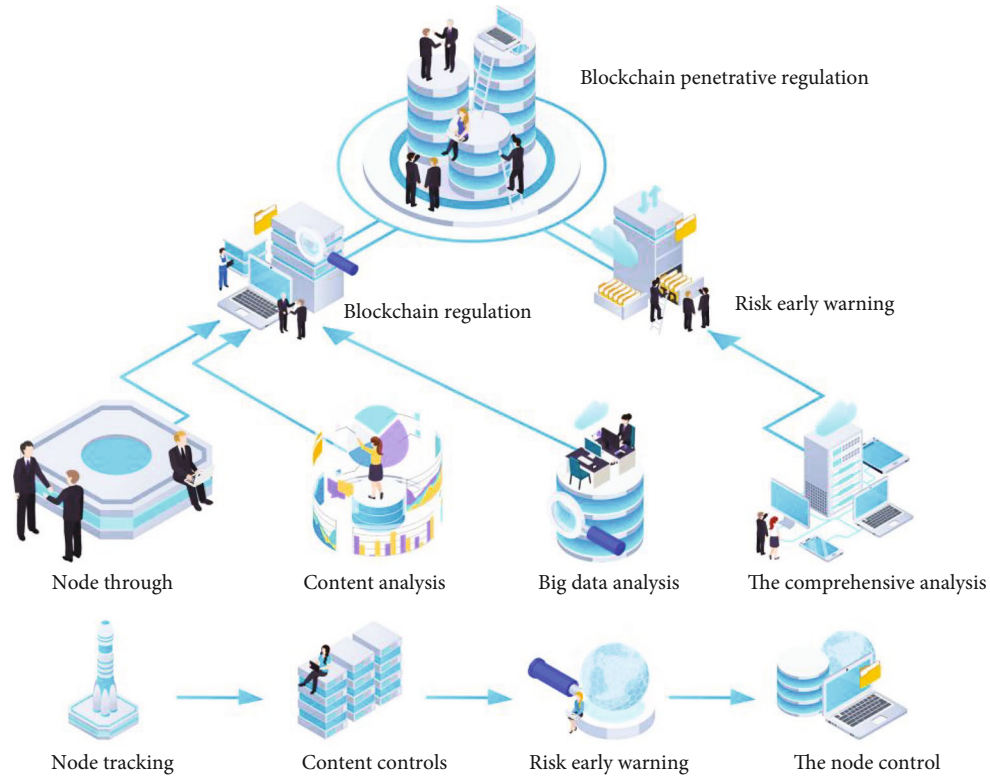


FIGURE 1: Enterprise financial risk prevention and early warning system based on blockchain technology.

and the SME, the principle of trust endorsement of the main enterprise in the blockchain from a technical point of view vision promotes fiduciary endorsement in the value chain [15–16]. So, a good start to the financing process is that the main enterprises act as loan guarantees for SMEs, and at the same time the asymmetry of information between the main enterprises and SMEs does not allow them to determine which solution can provide the maximum benefits. Thus, using the accounts receivable finance model as an example, major businesses as buyers in the value chain, SMEs as sellers, both parties are upstream and downstream of the value chain to establish fiduciary endorsements. Open up access to value chain finance for commercial banks, major enterprises provide SMEs, SMEs receive finance from value chain financial services, businesses have no incentive to provide SMEs, and SMEs face difficulties in obtaining finance from value chain financial services. Businesses are reluctant to provide guarantees to SMEs that face difficulties in obtaining finance from value chain financial services. This article analyzes the factors that influence the trust recognition of SMEs by major businesses through the following evolutionary games [17–18].

(1) Game subject

The financial financing of the value chain requires many multiple fiduciary games with multiple actors involved.

(2) Strategy selection

The strategy set of both parties is divided into core enterprise C (guaranteed, non-guaranteed) and small and medium-sized enterprise S (financing, non-financing)

(3) Income matrix

As shown in Table 1, when the core enterprises and small and medium-sized enterprises do not establish a trust endorsement relationship, the two sides maintain the status quo, which is difficult to promote the implementation of supply chain financial financing services. When both major businesses and SMEs adopt the Guarantee Funding strategy, both parties benefit from, for example, long-term partnerships with banks. In the accounts receivable financing mode, S_c is the income from the stable supply of raw materials for core enterprises, and S_s is the income from the financing of small and medium-sized enterprises through supply chain finance, so as to alleviate the capital pressure caused by credit sales and quickly recover the payment for goods for the next production. C_1 is the cost of adopting guarantee strategy for core enterprises, provide guarantees for small and medium enterprises on behalf of the parent enterprise at the same time as the costs of third-party Unicom logistics enterprises to supervise and manage small and medium enterprises. C_2 is the cost when SMEs adopt financing strategies, which represents the cost when SMEs cooperate with core enterprises to ensure the smooth information flow of logistics, information flow and capital flow, and the cooperation income obtained by core enterprises, $S_c > C_1$, $S_s > C_2$.

TABLE 1: Evolutionary game benefits matrix of core enterprises and small and medium-sized enterprises.

Game subjects		Probability	Small and medium-sized enterprise S	
			Financing y	Non-financing $1 - y$
Core enterprise C	Guaranteed	x	$S_c - C_1, S_s - C_2$	$-C_1 - C_c, 0$
	Non-guaranteed	$1 - x$	$0, -C_2 - C_s$	$0, 0$

That is, the benefits of both parties actively seeking cooperation are greater than the costs of this process. When the main business guarantees SMEs, but SMEs refuse to finance, the core enterprise bears the loss C_c . Representatives acting as the main guarantor enterprises need to take on the lack of trust in banks. When major enterprises do not guarantee SMEs, but they are still actively involved in financing, SMEs suffer losses C_s . Representing SMEs are unable to alleviate working capital shortages while having narrower funding channels [19]. It is assumed that in the early stage of the game, the probability of core enterprises adopting guarantee and non-guarantee is x and $1 - x$, respectively, The probability of SMEs choosing financing and not financing is y and $1 - y$.

3.1. Evolutionary Game Benefits of Core Enterprises and Small and Medium-Sized Enterprises

3.1.1. Earnings Analysis of Core Enterprises. It is known from the model hypothesis and the payoff matrix that when major businesses are willing to provide collateral to finance SMEs, the expected benefits of major businesses are:

$$U_{c1} = y(S_c - C_1) + (1 - y)(-C_1 - C_c) \quad (1)$$

When the main enterprise is unwilling to provide SMEs, the expected income of the main enterprise is:

$$U_{c2} = 0 \quad (2)$$

Then the expected return of hybrid strategy of core enterprise choosing the mixed strategy of guarantee and non-guarantee is:

$$U_c = xU_{c1} + (1 - x)U_{c2} = xU_{c1} \quad (3)$$

Analyze the dynamic replication equation from which funding is derived for the selection of the main enterprise C [20]:

$$F(x) = \frac{dx}{dt} = x(U_{c1} - U_c) = x(1 - x)(yS_c + yC_c - C_1 - C_c) \quad (4)$$

3.1.2. Analysis of Income of Small and Medium Enterprises.

Similarly, the expected return functions of SMEs seeking financing U_{s1} and non-financing U_{s2} and the expected return functions of mixed strategies of SMEs U_s are, respectively:

$$\begin{aligned} U_{s1} &= x(S_s - C_2) + (1 - x)(-C_2 - C_s) \\ U_{s2} &= 0 \\ U_s &= yU_{s1} + (1 - y)U_{s2} = yU_{s1} \end{aligned} \quad (5)$$

Dynamic copying equation to analyze the thus obtained financing choice S for SMEs:

$$F(y) = \frac{dy}{dt} = y(U_{s1} - U_s) = y(1 - y)(xS_s + xC_s - C_2 - C_s) \quad (6)$$

3.1.3. Analysis of the Stability of the Equilibrium Point of the Model. The combination of the dynamic replication equations of SMEs with major enterprises form equations to satisfy:

$$\begin{cases} F(x) = \frac{dx}{dt} = 0 \\ F(y) = \frac{dy}{dt} = 0 \end{cases} \quad (7)$$

The solution is as follows:

$$\begin{aligned} x_1 = 0, x_2 = 1, x^* &= \frac{C_2 + C_s}{S_s + C_s} \\ y_1 = 0, y_2 = 1, y^* &= \frac{C_1 + C_c}{S_c + C_c} \end{aligned} \quad (8)$$

Thus, we get 5 local points of equilibrium of game behavior between SMEs and main enterprises, respectively $0(0, 0), A(0, 1), B(1, 0), C(1, 1), D((C_2 + C_s/S_s + C_s), (C_1 + C_c/S_c + C_c))$ [21]. To verify whether these five local equilibrium points are the evolutionary stability strategy (ESS) of the whole system, it can be obtained according to the stability judgment method of Jacobian matrix. The partial derivatives of x and y of dx/dt and dy/dt are obtained, respectively, and the Jacobian matrix J of the system is:

$$J = \begin{bmatrix} (1 - 2x)(yS_c + yC_c - C_1 - C_c) & x(1 - x)(S_c + C_c) \\ y(1 - y)(S_s + C_s) & (1 - 2y)(xS_s + xC_s - C_2 - C_s) \end{bmatrix} \quad (9)$$

The equilibrium point $0(0, 0), A(0, 1), B(1, 0), C(1, 1), D((C_2 + C_s/S_s + C_s), (C_1 + C_c/S_c + C_c))$ is substituted into the Jacobian matrix J obtained in the above formula, the trace of the matrix $tr(J)$ and the value of the determinant $\det(J)$ are obtained, and then the analysis results of five local equilibrium points are obtained. Through the stability analysis of Jacobian matrix, it is obtained that two of the five local equilibrium points are stable, that is, both parties adopt (guarantee, financing) or (non-guarantee, non-financing) strategies, and there are another two unstable points and one saddle point in the evolutionary system [22]. The system finally tends to point $(1, 1)$, that is, the enterprises of both sides adopt the cooperative mode of guaranteed financing. Or it finally tends to point $(0, 0)$, that is, the enterprises of both parties adopt the way of no guarantee and no financing.

3.2. Evolutionary Gaming Benefits of Commercial Banks and SMEs in Supply Chain Finance

3.2.1. Income Analysis of Commercial Banks. When commercial banks choose loans, their income is:

$$U_{A1} = \beta(S_A + \pi_A - C_{0A}) + (1 - \beta)(\pi_A - C_{0A} - C_A) \quad (10)$$

When a commercial bank chooses not to lend, its income is:

$$U_{A2} = \beta\pi_A + (1 - \beta)\pi_A \quad (11)$$

Thus, commercial banks choose between borrowing and non-borrowing a mixed strategy that expects to make a profit:

$$U_A = \alpha U_{A1} + (1 - \alpha)U_{A2} \quad (12)$$

Thus, it is possible to obtain a dynamic copying equation chosen by a commercial bank A:

$$F(X) = \frac{dx}{dt} = \alpha(U_{A1} - U_A) = \alpha(1 - \alpha)(\beta S_A + \beta C_A - C_{0A} - C_A) \quad (13)$$

3.2.2. Income Analysis of Commercial Banks. Similarly, the expected return function U_{B1} and U_{B2} of small and medium-sized enterprises' trustworthiness and default and the expected return function U_B of their hybrid strategy are as follows:

$$\begin{aligned} U_{B1} &= \alpha(S_B + \pi_B - C_{0B}) + (1 - \alpha)(\pi_B - C_{0B}) \\ U_{B2} &= \alpha(\pi_B - C_{0B} - C_B) + (1 - \alpha)\pi_B \\ U_B &= \beta U_{B1} + (1 - \beta)U_{B2} \end{aligned} \quad (14)$$

So SMBs choose a robust dynamic replication equation:

$$F(y) = \frac{dy}{dt} = \beta(U_{B1} - U_B) = \beta(1 - \beta)[\alpha(S_B + C_B + C_{0B}) - C_{0B}] \quad (15)$$

3.2.3. Analysis of the Stability of the Equilibrium Point of the Model. Combine the dynamic replication equations of commercial banks with SMEs into equations to match:

$$\begin{cases} F(\alpha) = \frac{d\alpha}{dt} = 0 \\ F(\beta) = \frac{d\beta}{dt} = 0 \end{cases} \quad (16)$$

The solution is as follows:

$$\begin{aligned} \alpha_1 = 0, \alpha_2 = 1, \alpha^* &= \frac{C_{0B}}{S_B + C_B + C_{0B}} \\ \beta_1 = 0, \beta_2 = 1, \beta^* &= \frac{C_{0A} + C_A}{S_A + C_A} \end{aligned} \quad (17)$$

Thus, obtain 5 points of local equilibrium of the gaming behavior of commercial banks with SMEs, which are $0(0, 0), A(0, 1), B(1, 0), C(1, 1), D((C_{0B}/S_B + C_B + C_{0B}), (C_{0A} + C_A/S_A + C_A))$. To verify whether these five local equilibrium points are the evolutionary stability strategy (ESS) of the whole system, it can be obtained according to the stability judgment method of Jacobian matrix. The partial derivatives of x and y of dx/dt and dy/dt are obtained, respectively, and the Jacobian matrix J of the system is:

$$J = \begin{bmatrix} (1 - 2\alpha)(\beta S_A + \beta C_A - C_{0A} - C_A) & \alpha(1 - \alpha)(S_A + C_A) \\ \beta(-\beta)(S_B + C_B + C_{0B}) & (1 - 2\beta)[\alpha(S_B + C_B + C_{0B}) - C_{0B}] \end{bmatrix} \quad (18)$$

The equilibrium points $0(0, 0), A(0, 1), B(1, 0), C(1, 1), D((C_{0B}/S_B + C_B + C_{0B}), (C_{0A} + C_A/S_A + C_A))$ are substituted into the Jacobian matrix obtained in the above formula, the trace of the matrix $tr(J)$ and the value of the determinant $\det(J)$ are obtained, and then the analysis results of five local equilibrium points are obtained. It can be seen that there are two possible trends in the evolution process of the system. One is to evolve to $0(0, 0)$, It does not cooperate with each other on behalf of commercial banks and SMEs, that is, commercial banks do not take loans and SMEs violate their obligations; The second is to evolve to $C(1, 1)$, It represents a win-win financing on behalf of commercial banks and small and medium enterprises, i.e. loans from commercial banks, small and medium enterprises. As for which direction the saddle point evolves, it is jointly affected by the initial state of the system, the initial cost investment in the financing process, the benefits brought by smooth financing, and the losses to be borne by financing failure.

4. Results and Analysis

4.1. Numerical Modeling and Analysis of Factors Affecting the Stability of the Evolution of Major Enterprises and Small and Medium Enterprises

4.1.1. Influence of the Initial State of the System on the Evolution of the System. For major enterprises and SMEs,

the evolutionary path of the trajectory of their selection strategy (provision, financing) can be modeled using the following values. Given that $C_1 = C_2 = 2$, $S_c = S_s = 5$, $C_c = C_s = 3$, Likelihood of establishing major businesses and SMEs for the selection of provisioning and financing strategies (x, y) is $(0.1, 0.9)$, $(0.2, 0.9)$, $(0.3, 0.9)$, $(0.5, 0.9)$, $(0.7, 0.9)$, and the time period is $[0, 2]$, that is, when $y=0.9$. The readiness of the SME to finance is extremely high, and the impact of the likelihood of adoption of the provisioning strategy by the main enterprises on the evolutionary results is shown in Figure 2. This shows that with a greater likelihood of actively seeking funding for SMEs, the system will eventually evolve to an optimal state of collateral and financing, when the probability of acceptance of collateral by the main enterprise is greater than a certain threshold level, and the faster it tends to be stable as the probability increases [23].

The probability of the creation of the main enterprises and the choice of the provision and financing strategy by SMEs (x, y) is taken separately $(0.1, 0.1)$, $(0.1, 0.2)$, $(0.1, 0.3)$, $(0.1, 0.7)$, $(0.1, 0.9)$, respectively, and the time period is $[0, 2]$. That is, when $x=0.1$, the financing willingness of core enterprises is very low, the impact of the likelihood of SMEs adopting a financing strategy on evolutionary outcomes is illustrated in Figure 3, which shows that when the probability of accepting guarantees by major enterprises is lower, systems continue to evolve to a state of insecurity and underfunding, despite the increasing likelihood of SME financing choices.

It can be concluded that the initial state of the cooperative system between core enterprises and small and medium-sized enterprises will affect the direction and speed of system evolution. In reality, SMEs are overwhelmingly proactive about financing, and when SMEs choose a financing strategy, the key to opening up value chain financial financing services is whether major businesses are ready for fiduciary endorsements. When the probability of the guarantee of the main enterprise is greater than a certain value, the system as a whole will tend to a stable state of guarantee and financing of both parties. And when major businesses are reluctant to provide collateral, even if this makes the willingness of SMEs to seek funding extremely high, the system as a whole is still difficult to open up collateral and funding opportunities. Thus, collaboration between major enterprises and SMEs in value chain financial financing is based on the fact that both parties are in the same value chain, that SMEs have a demand for financing and that value chain financial services chains will only be released when the main businesses are ready for a fiduciary endorsement to SMEs [24].

4.1.2. The Benefits S_c and S_s of Bilateral Cooperation and Its Impact on System Evolution. S_c and S_s the income distribution obtained by core enterprises and small and medium-sized enterprises in supply chain financial financing. Given the initial value of the system $(0.5, 0.5)$, that is, the probability of core enterprises and small and medium-sized enterprises choosing guarantee and financing strategies is 0.5. Set $C_1 = C_2 = 2$, $C_c = C_s = 3$, time period as $[0, 2]$.

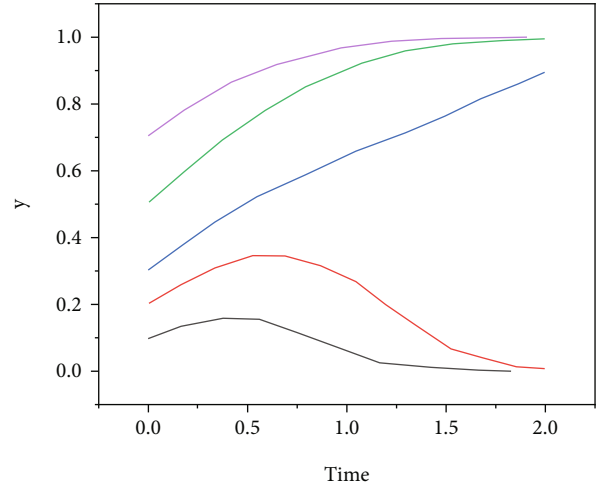


FIGURE 2: Influence of probability of core enterprises adopting guarantee strategy on evolution results in initial state.

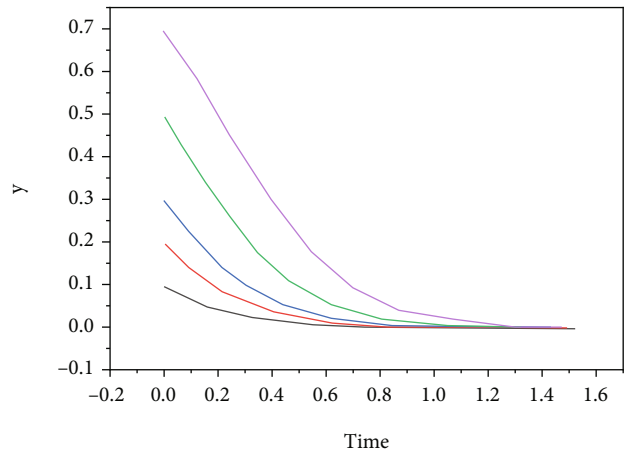


FIGURE 3: Influence of probability of SMEs adopting guarantee strategy on evolution results in initial state.

When $S_s = 5$, taking into account the impact of the change of S_c on the system evolution. When $S_c = 6$, $S_c = 11$, $S_s = 18$, respectively, the evolution trend of the system over time is shown in Figure 4. It can be seen that when the income value obtained by the core enterprise from the guarantee increases, the core enterprise will be more inclined to adopt the guarantee strategy. Similarly, when $S_s = 5$, taking into account the impact of the change of S_s on the system evolution. When $S_s = 6$, $S_s = 11$, $S_s = 18$, respectively, considering the impact of the change on the system evolution at that time, the evolution trend of the system over time is shown in Figure 5. From this it can be concluded that, for mainstream enterprises and SMEs, if they benefit more from guarantees and financing, then mainstream enterprises actively provide guarantees to SMEs in the financial services value chain, reducing the difficulty of financing SMEs and thereby stimulating development of enterprises throughout the value chain, creating a beneficial cycle of value chain financing, creating a win-win situation between major enterprises and SMEs.

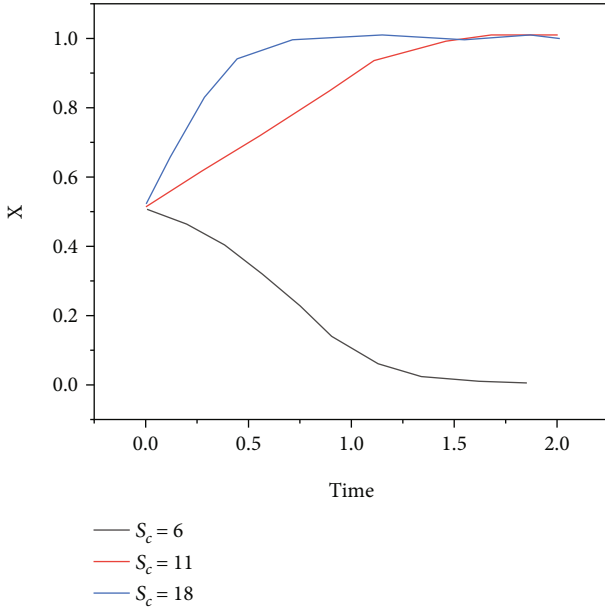


FIGURE 4: Evolution Trend of system with time under S_c change.

4.1.3. *The Cost C_1 and C_2 of Cooperation between the Two Sides and Its Impact on System Evolution.* C_1 and C_2 is costs required in accepting guarantees and financing by major businesses and SMEs, such as sorting out bill information, transaction information sharing, etc. Given the initial value of the system (0.5, 0.5), set $S_c = S_s = 5$, $C_c = C_s = 3$, time period as [0, 2]. When $C_2 = 2$, taking into account the impact of the change of C_1 on the system evolution. When $C_2 = 2$, $C_2 = 4$, $C_2 = 6$, respectively, the evolution trend of the system over time is shown in Figure 6. It can be seen that when the cooperation cost of the core enterprise increases in the guarantee process, the core enterprise will be more inclined to adopt the strategy of non-guarantee. Similarly, when $C_1 = 2$, considering the impact of the change of C_2 on the system evolution, when $C_2 = 2$, $C_2 = 4$, $C_2 = 6$, respectively, the evolution trend of the system over time is shown in Figure 7. It follows that when SMEs increase the cost of cooperation in the financing process, this makes SMEs more inclined to pursue a non-financing strategy. From this it can be concluded that, for both mainstream enterprises and SMEs, the higher the costs required for this provisioning process, and the more SMEs engage in seeking financial services along the value chain, the more they do not have. Incentives to seek guarantees and cooperation in financing.

4.1.4. *The Impact of Loss of C_c and C_s on System Evolution.* C_c is the losses suffered by small and medium-sized enterprises when they choose not to finance, and C_s is the losses suffered by small and medium-sized enterprises when they seek banks to provide supply chain financial financing services, while the core enterprises do not provide credit guarantee for small and medium-sized enterprises. Given the initial value of the system (0.5, 0.5), set $S_c = S_s = 5$, $C_1 = C_2 = 2$, time period as [0, 2]. When $C_s = 3$, considering the impact of the change of C_c on the system evolution, take $C_c = 2$, $C_c = 4$, $C_c = 6$, respectively, the evolution trend of

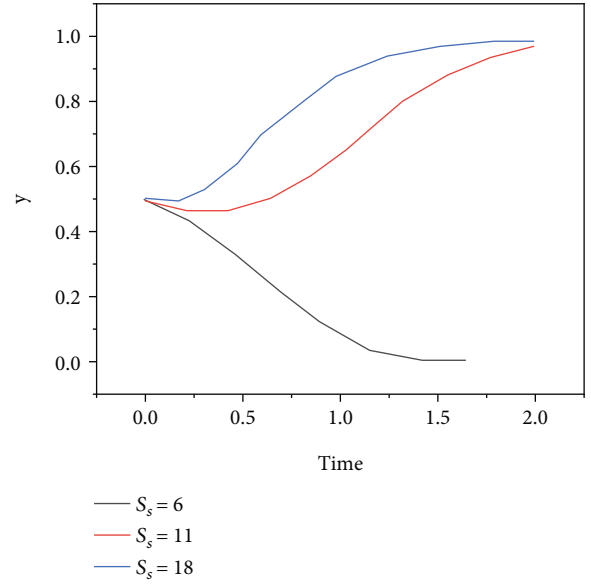


FIGURE 5: Evolution trend of system with time under S_s changes.

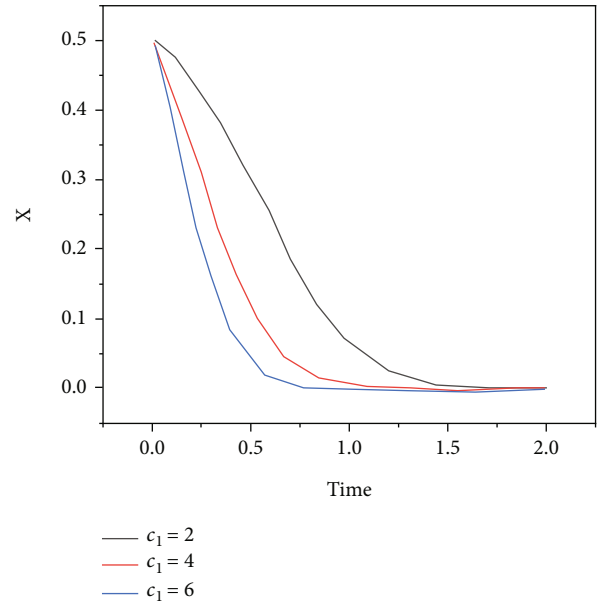


FIGURE 6: Evolution trend of system with time under C_1 changes.

the system over time is shown in Figure 8. It can be seen that the higher the loss C_s suffered by the core enterprise, the lower the probability of the core enterprise choosing guarantee, so that the system is in an unsecured state. Similarly, when $C_c = 3$, considering the impact of the change of C_s on the system evolution and taking $C_s = 2$, $C_s = 4$, $C_s = 6$, respectively, the evolution trend of the system over time is shown in Figure 9. It can be seen that the higher the loss C_s suffered by small and medium-sized enterprises, the lower the probability of small and medium-sized enterprises choosing financing, so that the system is in a non-financing state. It can be concluded that for core enterprises

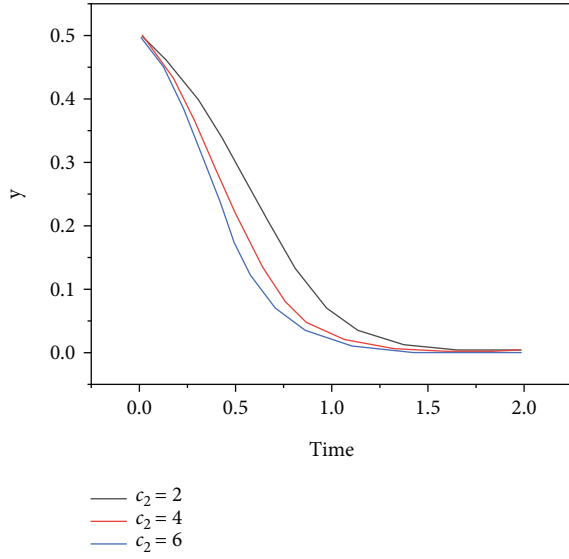


FIGURE 7: Evolution trend of the system with time under C_2 changes.

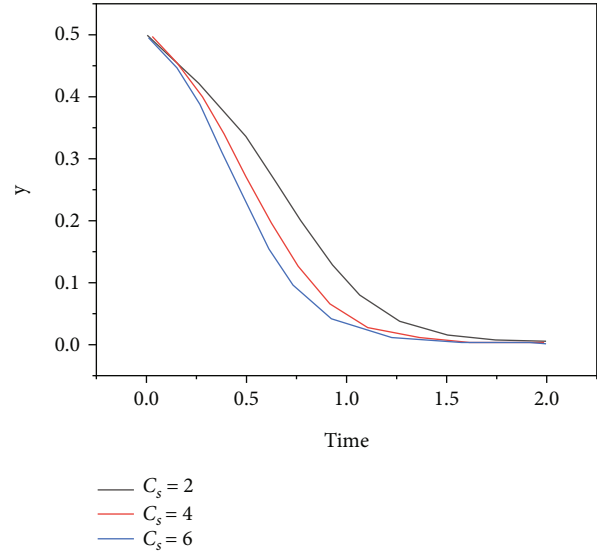


FIGURE 9: Evolution trend of the system with time under the change of loss of C_s .

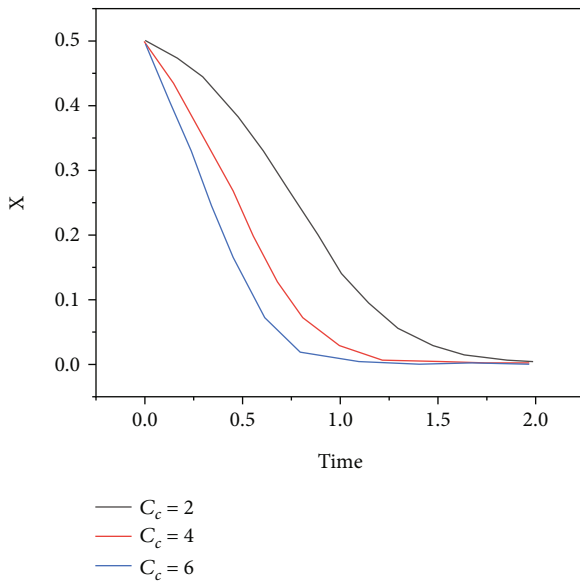


FIGURE 8: Evolution trend of the system with time under the change of loss of C_c .

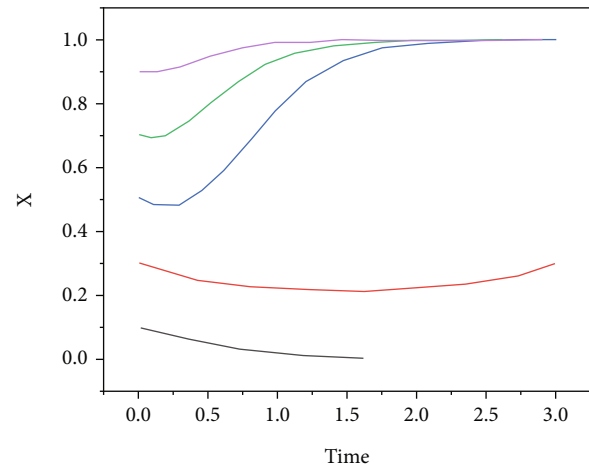


FIGURE 10: The impact of the probability of commercial banks taking loans in the initial state on the evolution results.

and small and medium-sized enterprises, if they seek guarantee and financing cooperation in order to carry out supply chain financial services, because the higher the loss suffered by the other party to give up cooperation, the more difficult it is for both parties to form cooperation, which will directly lead them to choose to give up guarantee and financing cooperation.

4.2. Numerical Modeling and Analysis of Factors Affecting the Sustainability of Financing Development between Commercial Banks and SMEs

4.2.1. Influence of the Initial State of the System on the Evolution of the System. For commercial banks and small

and medium-sized enterprises, the evolution path of their selection (loan, trustworthiness) strategy can be simulated and analyzed through the following numerical values. Given $S_A = S_B = 5$, $C_{OA} = C_{OB} = 2$, $C_A = C_B = 3$, let the initial values be $(0.1, 0.5)$, $(0.3, 0.5)$, $(0.5, 0.5)$, $(0.7, 0.5)$, $(0.9, 0.5)$, that is, when $y=0.5$, the likelihood that small and medium-sized enterprises will commit themselves remains unchanged. The impact of the probability of commercial banks taking loans on the evolution results is shown in Figure 10. It can be seen that when the probability of commercial banks taking loans is greater than a certain threshold, the system will eventually evolve to the optimal state of loans and compliance, both parties can smoothly carry out supply chain financial financing. And with the increase of this probability, the faster the system tends to a stable state.

Let the initial values be $(0.5, 0.1)$, $(0.5, 0.3)$, $(0.5, 0.5)$, $(0.5, 0.7)$, $(0.5, 0.9)$, respectively, that is, when $x=0.5$, the probability of acceptance of loans by commercial banks does

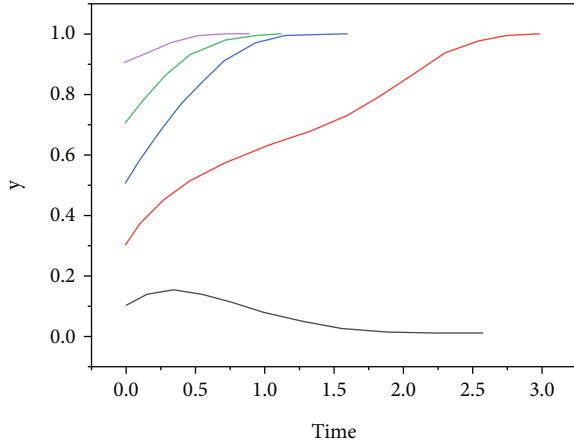


FIGURE 11: The impact of the probability of small and medium-sized enterprises adopting compliance in the initial state on the evolution results.

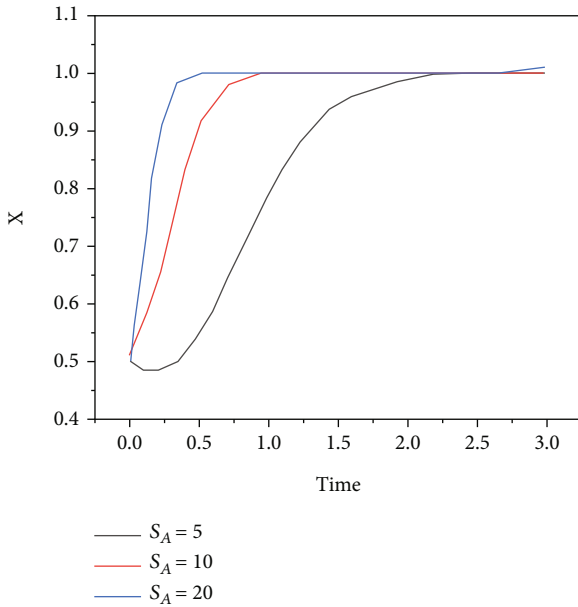


FIGURE 12: Evolution of commercial banks and SMEs in different conditions under different S_A .

not change, the influence of the probability of acceptance by small and medium-sized enterprises of Non-Violations on evolutionary results is shown in Figure 11, from which it can be seen that with the probability of acceptance by small and medium-sized enterprises, Non-violations are greater than a certain threshold. The system will eventually evolve to the optimal state of loan and compliance, and both parties will smoothly carry out supply chain financial financing. With the increase of this probability, the faster the system tends to a stable state [25].

From this it can be concluded that the initial state in which commercial banks and systems of cooperation between SMEs are located will affect the direction and pace of evolution of the system.

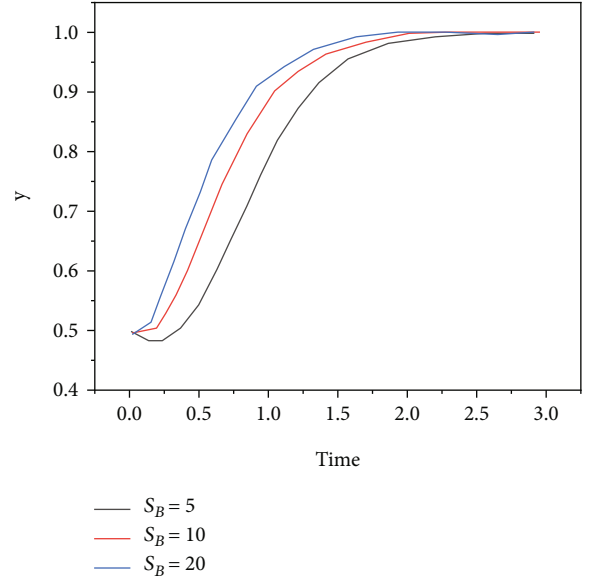


FIGURE 13: Evolution of commercial banks and SMEs in different conditions under different S_B .

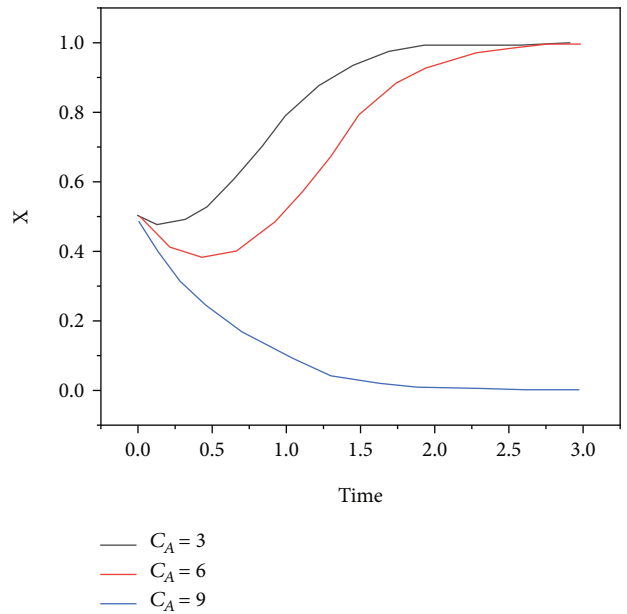


FIGURE 14: Evolution track of commercial banks and small and medium-sized enterprises under different C_A .

4.2.2. *The Impact of Income S_A and S_B on System Evolution when Financing Is Smooth.* S_A and S_B are the income distribution obtained by commercial banks and small and medium-sized enterprises after successful completion of supply chain financial financing. Given the initial value of the system (0.5, 0.5), that is, the probability of commercial banks and small and medium-sized enterprises choosing cooperation strategy is 0.5. Set $C_{OA} = C_{OB} = 2$, $C_A = C_B = 3$, when $S_B = 5$, taking into account the impact of the change of S_A on the system evolution. Take $S_A = 5$, $S_A = 10$, $S_A = 20$, respectively, results are shown in Figure 12 below. It

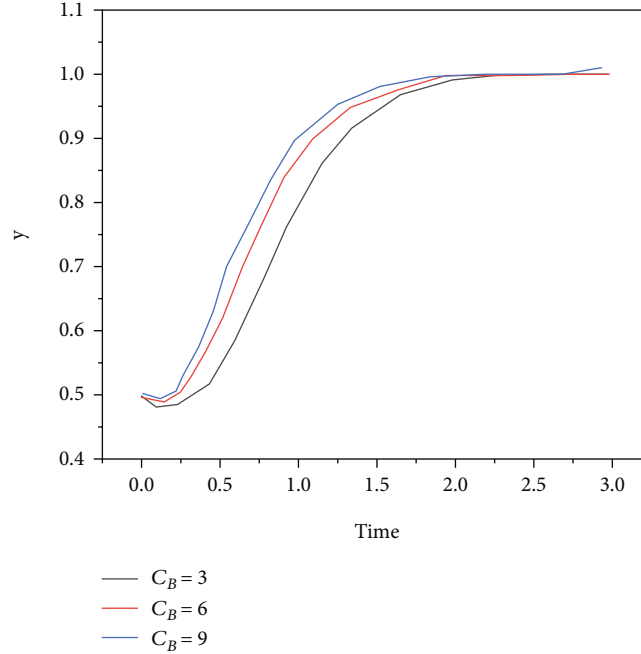


FIGURE 15: Evolution track of commercial banks and small and medium-sized enterprises under different C_B .

can be seen that when the excess return obtained by commercial banks from financing increases, commercial banks tend to adopt the loan strategy. Similarly, when $S_A = 5$, considering the impact of the change of S_B on the system evolution. Take $S_B = 5, S_B = 10, S_B = 20$, respectively, results are shown in Figure 13 below. It can be seen from this that with an increase in the excess profits received by small and medium enterprises from financing, this makes small and medium enterprises prone to non-disruptive tactics. This suggests a conclusion: the greater the surplus of funding revenues, the more they prefer a cooperation strategy, that is, the more commercial banks prefer loans, the more SMEs prefer Non-Breaker. Therefore, in the process of cooperation, we should try our best to keep the information of both parties unobstructed, and the greater the amount of information obtained, so as to ensure that both parties can obtain as much income as possible from supply chain financial financing.

4.2.3. The Impact of Loss Factors C_A and C_B on System Evolution. C_A and C_B are the losses suffered by commercial banks and small and medium-sized enterprises in financing cooperation due to the default of the other party. Given the initial value of the system (0.5, 0.5), that is, the probability of commercial banks and small and medium-sized enterprises choosing cooperation strategy is 0.5. Given $S_A = S_B = 5, C_{OA} = C_{OB} = 2$, when $C_B = 3$, considering the impact of C_A on the system evolution. Take $C_A = 3, C_A = 6, C_A = 9$, respectively, and get the results as shown in Figure 14. It can be seen that when the losses suffered by commercial banks due to the default of small and medium-sized enterprises increase, commercial banks tend to adopt the strategy of no loan, making the system stable in the state of no loan. When $C_A = 3$, considering the impact of C_B on system

evolution. Take $C_B = 3, C_B = 6, C_B = 9$, respectively, and get the results as shown in Figure 15. It can be seen from this that with an increase in losses incurred by small and medium-sized enterprises due to the fact that commercial banks did not take loans, this, rather, will make them more active in applying the Non-Disruption strategy, and the greater the losses, the faster SMEs will be inclined to Non-violation. From this it can be concluded that in the process of financing the value chain, the greater the losses incurred by commercial banks due to the default of SMEs, the more difficult it is for commercial banks to lend to SMEs, and, conversely, SMEs themselves finance commercial banks through the financial services of the supply chain. Chains, and SMEs will actively push to reduce the risk losses of commercial banks and, therefore, receive financing.

5. Conclusion

On the basis of supply chain financial services, this paper mainly takes small and medium-sized enterprises in supply chain financial services as the study object to clarify the logical relationship between supply chain finance, supply chain financial credit risk control and block chain theory. Start with a painful solution to the problem of financial development of the supply chain within the framework of blockchain technology, i.e. from the three principles that the trust of the main enterprises, the exchange of information on the financing process, and the successful co-financing in general, is possible with the analysis of the control of blockchain technology over financial credit risks in the supply chain. Therefore, thinking that the credit risk during the finance process of financed supply chain control will not only consider small and medium enterprises this single financed object, but participating in supply chain

transactions, in turn creating the main enterprise and small and medium enterprises JSV evolution of the games model, without third party institute under economic bank and small and medium enterprise financed evolution of games model, third party institute under economic bank and small and medium enterprise financed evolution of games model, analysis in finance supply chain process financed by commercial bank, intercore enterprise, small and medium enterprise and the third parties established in relation to the evolution, came to the parties in the finance supply chain process financed credit risk influencing each other factor, and this establishment of the finance supply chain credit risk assessment is measured. Credit risk analysis created a credit risk assessment model to predict credit risk measurements to determine the supply chain, to create a more rational credit risk assessment system for the financial supply chain, Applied Logistic reverse analysis method using the second classification Logistic created a credit risk assessment model to predict the credit risk situation for financing the financial chain supply chain and effectively identify SME credit risks by creating rational split points.

Data Availability

No data were used to support this study.

Conflicts of Interest

The author declare that they have no competing interests.

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