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Evolutionary Strategies of Supply Chain Finance From the Perspective of a Return Policy

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ABSTRACT Return policy and supply chain finance are significant measures for banks and enterprises to improve the overall competitiveness of their supply chain. Supervision and guidance by banks are prerequisites to the smooth implementation of return policy and supply chain finance. This study analyzes the evolutionary stable strategy of three parties, namely, one bank, one supplier and one retailer, by establishing an asymmetric evolutionary game model. The model assumes that banks apply a reward and punishment policy for suppliers and retailers. Results show that regardless of the strategy the bank chooses, one party will always choose non-implementation of the return policy or non-adoption of the supply chain finance. From a short-term perspective, regardless of the strategy the bank chooses, suppliers and retailers will select the strategy of non-implementation and non-adoption, respectively. From the long-term perspective, suppliers and retailers will actively choose implementation and adoption whether or not there is bank supervision.

INDEX TERMS Evolutionary game theory, return policy, supply chain coordination, supply chain finance.

I. INTRODUCTION

It is well known that supply chain integration has become an inevitable choice for the sustainable development of China's economy [1]–[5]. However, traditional supply chain researches focus on logistics and information flow, neglecting capital flow in supply chain operation [6]–[11]. This paper focuses on the study of small and medium-sized enterprises (SMEs), hoping to provide an optimized path for retailers' channel finance. In the traditional supply chain system, retailers often have difficulty accessing financing from banks, due to their lack of collateral and credit history [12], [13]. Given their payment costs, suppliers often push the pressure of generating funds to weak retailers in the supply chain system through credit sales. On the one hand, retailers have various products that require financial support for purchasing. On the other hand, the effective injection of funds can promote long-term strategic synergy between suppliers and retailers to enhance the competitiveness of the supply chain.

Return policy fits in the seasonable market such as clothing, fruit and newspapers, due to it is easy to operate. The core of buyback policy design is how to formulate proper buyback mechanism to realize win-win between supplier and retailer. The supplier often adopted return policy to encourage the retailer to order more products. If the retailer fails to repay the bank debt in time, the supplier will buy back the product from the retailer and return the money to the bank for repayment of the bank debt of the retailer [14]–[16]. Here, we mainly pay attention to how to design return policy in a supply chain including one bank, one supplier and one retailer.

The introduction of return policy brings to the several research questions: How return policy has an impact on the finance channel of retailers? How do the return policy parameters affect the integration of supply chain? What are the implications of return policy for supply chain efficiency and the profitability of each party in the chain?

To answer these questions, we study a supply chain which is composed of one bank, one supplier and one retailer. In this model, the bank supervises the supplier to implement a return policy and the retailer to implement supply chain finance, carrying out certain incentives and penalties. The supplier implements the return policy and provides credit guarantees to the retailer involving supply chain finance. The retailer who is supervised by the bank is a participant in supply chain finance. This paper attempts to find out the evolutionary strategy for the bank, supplier and retailer under a return policy.

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Banks and retailers maximize the benefits to both parties by suppliers. Suppliers not only obtain the corresponding benefits but also use their credit advantages to reduce the financial burden on retailers.

Our work contributes to the literature in three ways. First, we derive the evolutionary equilibrium of the supplier selling to the budget-constrained retailer with the use of return policy. Return policy optimized on both parameters, bank default and subsidy coefficient, are analyzed for the first time in the literature. Second, our results show that under return policy, the retailer offers a level of involvement in supply chain finance more than that in traditional supply chain contract. Third, the supplier with a higher initial implementation of the return policy would exhibit substantial chain effect to coordinate the chain. We indicate that, under the return policy, the supplier plays dual roles as a guarantor and a producer.

The rest of the paper is organized as follows. In Section 2 we review the relevant literature. In Section 3 we describe the conditions and problem assumptions of the model. In Section 4 we build a game model and derive the evolution of banks, suppliers, and retailers. In Section 5 we consider the range of initial ratios of bank default and subsidy which affect the three parties' evolutionary results. Finally, we summarize and present the shortcomings and outlook in Section 6.

II. LITERATURE REVIEW

Our work fits in the broad area of supply chain finance. An early influential work by Koch analyzes inventory loans and receivable financing [17]. In the actual operation, financing decision factors and capital constraints may affect the operation of the supply chain [18], [19]. Buzacott and Zhang firstly incorporated asset-based financing into production decisions and showed the necessity of considering production and financing decisions jointly [20]. Li *et al.* considered the dynamic control problem and used the control policy to compute the optimal strategy of the retailer periodically [21]. Ding *et al.* proved that a firm's financial hedging strategies have qualitative and quantitative impacts on firm's production capacity and financial optimal decision [22]. we are particularly interested in the decision-making of supply chain participants under financial constraints. Until the last few years, most of the researches on supply chain finance have focused on finding optimal financing strategy, but have ignored the influence of the relationship between the participants on the whole strategy. Our work provides a supply chain theory-based rationale for the impact of the relationship of the participating entities on the supply chain by explicitly modeling the operational interactions of the bank, supplier and retailer.

Scholars have proposed different opinions on the relationship among banks, suppliers and retailers in a supply chain. Zhou *et al.* proved that retailers can obtain more benefits under a flexible two-part trade credit than under the original inventory model [23]. Kouvelis and Zhao use the Stackelberg game with the supplier as the leader to analyze all decisions from the supplier's perspective [24]. Chen studied the distribution of single-source suppliers and manufacturers through numerical analysis to illustrate the impact of product costs, internal capital, and demand changes on market equilibrium under banks and trade credits [25]. On the basis of the model established by Bing, Chen studied a similar problem and demonstrated that banks can improve the efficiency of the supply chain by financing suppliers and retailers [26]. However, the above model focuses on suppliers and retailers in the supply chain. The above literature mentioned does not consider the indispensable role of capital flow in overall supply chain. This paper focuses on the bank as a player which enriches the existing theory of supply chain and more fits the reality of supply chain operations, especially for undeveloped supply chain.

Return policy in the supply chain build a good relationship among banks, suppliers and retailers. Padmanabhan and Ivan believed that various return policies exist in reality because retailers aim to mitigate their capital risks and suppliers fear the cost of overproduction [27]. For example, Hengda Steel, as one of the leading steel distribution companies in China, has more than 20 s-level distributors ((Jin Bank Training Center 2010). The initial capital of one of second-level dealers is only $3 million Yuan, but it takes 10 million Yuan to purchase steel. The dealer first signed a tripartite BGF agreement with Hengda Steel and bank. The BGF Agreement requires retailers to deposit no less than 30% of the purchase funds as guarantee money. Hengda Steel promises to provide retailers with repurchase guarantee. Pasternack demonstrated that channel coordination can be achieved in a multi-retailer environment under the return policy provided by manufacturers and retailers [28]. Most scholars studied the optimal profit strategy between suppliers and retailers and compared the difference before and after implementation of return policy by quantitative methods [29]–[32]. But they did not consider the impact of incentives and penalties on the return policy in the supply chain. This paper considers the impact of bank incentives and penalties on the evolutionary stable strategy of three parties under initial conditions. Our study has certain practical significance for bank's reward and punishment measures.

III. PROBLEM DESCRIPTION

Our research is based on the model of Kouvelis and Zhao [24], assuming that there is one bank, one supplier and one retailer in the supply chain. The retailer purchases goods from the supplier at a wholesale price of w and gives the market a retail price of p. The product market and wholesale market are completely competitive. At the beginning of the sales period, the retailer must allow the bank to open the acceptance bill for the supplier as the payee, and the bank will accept the acceptance. The retailer is creditworthy and will repay its loan obligations (if any) to the extent possible. If the retailer's sales and the supplier's repurchase payment are insufficient to repay the bank's loan and the retailer does not go bankrupt, then the loss on the financial pledge will be covered by the supplier's other business funds. In the event

TABLE 1. Parameters and definitions.

Symbol	Definition
C_1	Bank's supervision cost of supplier's credit repayment ability
C_2	Bank's supervision cost of retailer's credit repayment ability
C_3	Cost of the supplier implementing a return policy
C_4	Cost of retailer adopting supply chain finance
C_5	Opportunity cost when retailer do not adopt supply chain finance
G_1	Bank's gains from retailer adopting supply chain finance under a return policy
G_2	Bank's gains from retailer adopting supply chain finance without a return policy
G_3	Bank's gains when retailer do not adopt supply chain finance under a return policy
G_4	Bank's gains when retailer do not adopt supply chain finance without a return policy
R_1	Revenue from retailer adopting supply chain finance under a return policy
R_2	Revenue from retailer adopting supply chain finance without return policy
R_3	Revenue from retailer not adopting supply chain finance under a return policy
R_4	Revenue from retailer not adopting supply chain finance without a return policy
d_1	Bank's subsidy factor to implement a return policy for supplier
d_2	Bank's subsidy factor for retailer adopting supply chain finance
M	Bank's default coefficient for retailer not adopting supply chain finance
S_1	Revenue from supplier under a return policy
S_2	Revenue from supplier without a return policy
p	Default coefficient of the bank's failure to implement the return policy for the supplier
q	Retailer's order quantity
w	Wholesale price of supplier to retailer

of a bankruptcy breach by the retailer, the bank will receive all sales and repurchase payments and bear the corresponding losses.

IV. EQUILIBRIUME ANALYSIS OF THE EVOULTIONARY GAME

A. ESTABLISHMENT OF THE EVOULTIONARY GAME

A list of notations is presented in Table 1. The effective implementation of supply chain finance can be seen as the result of the dynamic game among the three parties. The combinations of bank supervision and non-supervision, supplier implementation and non-implementation, and retailers' adoption and non-adoption strategies are based on the model assumptions. The income combination matrix of the three parties involved in the main body is shown in Table 2.

In addition, suppose the probability that a bank chooses supervision and non-supervision are x and $1-$ x, respectively. Similarly, the probability that a supplier chooses implementation and non-implementation are y and $1-$ y. A retailer choosing adoption and non-adoption are z and $1-$z respectively.

TABLE 2. Game matrix of banks, suppliers, and retailers.

retailer	Bank Supervision(x)		Bank Non-supervision(1-x)	
	Supplier implementation(y)	Supplier Non-Implementation(1-y)	Supplier implementation(y)	Supplier Non-Implementation(1-y)
Adoption (z)	(a_1, b_1, c_1)	(a_2, b_2, c_2)	(a_3, b_3, c_3)	(a_4, b_4, c_4)
Non-adoption(1-z)	(a_5, b_5, c_5)	(a_6, b_6, c_6)	(a_7, b_7, c_7)	(a_8, b_8, c_8)

TABLE 3. Game revenue value of banks, suppliers, and retailers.

Strategy	Bank	Supplier	Retailer
(a_1, b_1, c_1)	$G_1-C_1-C_2-d_1wq-d_2C_4$	$S_1+d_1wq-C_3$	$R_1-C_4+d_2C_4$
(a_2, b_2, c_2)	$G_2-C_1-C_2+pwq-d_2C_4$	$2S_2-S_1-pwq$	$R_2-C_4+d_2C_4$
(a_3, b_3, c_3)	G_1	S_1-C_3	R_1-C_4
(a_4, b_4, c_4)	G_2	$2S_2-S_1$	R_2-C_4
(a_5, b_5, c_5)	$G_3-C_1-C_2-d_1wq+M$	$S_1+d_1wq-C_3$	R_3-C_5-M
(a_6, b_6, c_6)	$G_4-C_1-C_2+pwq+M$	$2S_2-S_1-pwq$	R_4-C_5-M
(a_7, b_7, c_7)	G_3	S_1-C_3	R_3-C_5
(a_8, b_8, c_8)	G_4	$2S_2-S_1$	R_4-C_5

B. ESTABLISHMENT GAME ANALYSIS

1) ESTABLISHMENT GAME ANALYSIS ON BANK

(1) Bank equilibrium analysis

Suppose that the expected return of the bank's choice of supervision is U_{B1}, the expected return of supervision is U_{B2}, and the average expected return of the bank supervision and non-supervision is U_B.

$$U_{B1} = yza_1+(1-y)\,za_2+y\,(1-z)\,a_5+(1-y)\,(1-z)\,a_6$$
$$U_{B2} = yza_3+(1-y)\,za_4+y\,(1-z)\,a_7+(1-y)\,(1-z)\,a_8$$
$$U_B = xU_{B1}+(1-x)\,U_{B2}$$

(2) Analysis of replication dynamic equation of the bank's cooperative ratio

$$\begin{aligned} \mathrm{F}(\mathrm{x}) &= \frac{dx}{dt} \\ &= x\,(U_{B1}-U_B) = x\,(1-x)\times[(1-y)\,pqw \\ &\quad -zd_2C_4-yw_1I-C_1-C_2] \end{aligned}$$

If $z_0 = \frac{pqw-C_1+M-C_2-(d_1+pqw)y}{d_2C_4+M}$ and $\mathrm{z} = z_0$, then $\mathrm{F}(\mathrm{x}) \equiv 0$, which means F(x) is stable regardless of x's value. If $z_0 = \frac{pqw-C_1+M-C_2-(d_1+pqw)y}{d_2C_4+M}$ and $\mathrm{z} \neq z_0$, then x=0 and x=1 are two stable points.

Therefore, we have $\frac{dF(x)}{dx} = (1-2x)\,[(1-y)\,pqw + (1-z)\,M - yd_1I - zd_2C_4 - C_1 - C_2]$.

From $\frac{dF(x)}{dx} < 0$, the following conclusions are obtained:

Proposition 1: When $[pqw - C_1 + M - C_2] < 0$, $(1-y)\,pqw + (1-z)\,M - yd_1I - zd_2C_4 - C_1 - C_2] < 0$. Therefore, when $\mathrm{x} = 0$, $\frac{dF(x)}{dx} < 0$, and when $\mathrm{x} = 1$, $\frac{dF(x)}{dx} > 0$.x = 0 is an evolutionary stable strategy (ESS).

Proposition 2: When $[pqw - C_1 + M - C_2] > 0$

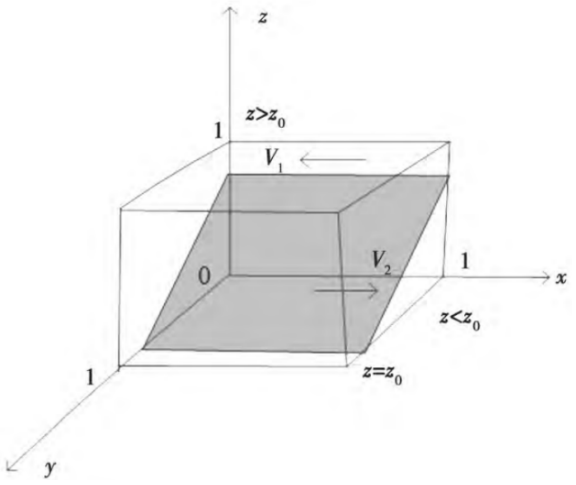

FIGURE 1. Dynamic trend diagram of the bank.

If z $<$ z_0, when $x = 0$, $\frac{dF(x)}{dx} < 0$, and when $x = 1$, $\frac{dF(x)}{dx} > 0$. x = 0 is an ESS. If $z > z_0$, when $x = 0$, $\frac{dF(x)}{dx} > 0$, and when $x = 1$, $\frac{dF(x)}{dx} < 0$. x = 1 is an ESS.

(1) When the initial state of the bank policy is V_1 and $pqw + M < C_1 + C_2$, x = 0 is the equilibrium point. At this point, the bank will adopt the non-supervision strategy. Therefore, when the cost of the bank's supervision is greater than the benefits obtained, the bank will choose the non-supervision strategy.

(2) When the initial state of the bank policy is V_2 and $pqw + M > C_1 + C_2$, x = 1 is the equilibrium point. At this point, the bank will adopt the supervision strategy. Therefore, when the cost of bank's supervision is less than the benefits obtained, the bank will choose the supervision strategy.

(3) Parameter analysis

Figure 1 shows that when other parameters are unchanged and p, q and w decrease, thus z_0 lowers. When z_0 lowers, the cross-section will move down to increase V_1, which means that when the bank imposes few penalties on the supplier's failure to implement a return policy or the retailer's order quantity and price is small, the bank tends to be unsupervised. When C_1 or C_2 increases, V_1 also increases. When the bank's credit repayment cost to supplier and retailer is greater, the bank is pressured by the costs, which makes it inclined to choose the non-supervision strategy.

(4) Analysis of the evolution of bank

The smaller the order quantity and price of the retailer, the smaller the losses caused by the breach of contract to the bank, which causes the bank to choose the unsupervised strategy. Therefore, if it is necessary to promote bank supervision, on the one hand, it can reduce the investment of banks in monitoring costs. On the other hand, it controls the sales revenue of a single transaction of a supplier and speeds up the transaction speed to seek a balance among the three parties.

2) ESTABLISHMENT GAME ANALYSIS ON SUPPLIER

(1) Supplier equilibrium analysis

Suppose that the expected return of the supplier's choice of implementation is U_{M1}, the expected return of non-implementation is U_{M2}, and the average expected return of the supplier implementation and non-implementation is U_M,

$$U_{M1} = xzb_1 + x(1-z)b_5 + z(1-x)b_3 + (1-x)(1-z)b_7$$
$$U_{M2} = xzb_2 + x(1-z)b_6 + z(1-x)b_4 + (1-x)(1-z)b_8$$
$$U_M = yU_{M1} + (1-y)U_{M2}$$

(2) Analysis of replication dynamic equation of supplier's cooperative ratio

$$\begin{aligned} \mathrm{F(y)} &= \frac{dy}{dt} = y(U_{M1} - U_M) \\ &= y(1-y) \times [2P_1 - 2P_2 - C_3 + pqwx] \end{aligned}$$

If $x_0 = \frac{C_3 - 2(P_1 - P_2)}{pqw}$ and x = x_0, then F(y) $\equiv$ 0, which means F(y) is stable regardless of y's value. If $x_0 = \frac{C_3 - 2(P_1 - P_2)}{pqw}$ and x $\neq$ x_0, then y = 0 and y = 1 are two stable points.

Therefore, we have $\frac{dF(y)}{dy} = (1-2y) \times [2P_1 - 2P_2 - C_3 + x(pqw + d_1qw)]$.

From $\frac{dF(y)}{dy} < 0$, we obtained the following conclusions:

Proposition 3: When $x_0 > 1$ and $C_3 - 2(P_1 - P_2) > pqw + d_1qw$, x $<$ x_0. Therefore, when x = 0, $\frac{dF(x)}{dx} < 0$, and x = 1, then $\frac{dF(x)}{dx} > 0$ and x = 0 is an ESS.

Proposition 4: When $x_0 < 1$, $C_3 - 2(P_1 - P_2) < pqw + d_1qw$.

If x $<$ x_0, when y = 0, $\frac{dF(y)}{dy} < 0$, and when y = 1, $\frac{dF(y)}{dy} > 0$. y = 0 is an ESS. If x $>$ x_0, when y = 0, $\frac{dF(y)}{dy} > 0$, and when y = 1, $\frac{dF(y)}{dy} < 0$. y=1 is an ESS.

(1) When the initial state of the supplier policy is at V_3, $x_0 > 1$, that is, $2P_2 - pqw > d_1pw + 2P_1 - C_3$, y = 0 is the equilibrium point, which causes the supplier to select the non-implementation strategy. When considering the bank's default for the supplier's failure to implement a return policy, the supplier will ultimately choose the non-implementation strategy when the supplier's implementation of the return policy yields less than the gain without the implementation.

(2) When the initial state of the supplier policy is at V_4, $2P_2 - pqw < d_1qw + 2P_1 - C_3$, y = 1 is the equilibrium point, which causes the supplier to select the implementation strategy. When considering the bank's default for the supplier's failure to implementation the return policy, the supplier will ultimately choose the implementation strategy when the supplier's implementation of the return policy yields more than the gain without the implementation.

(3) Parameter analysis

Figure 2 shows that the initial state space of the bank strategy is related to the size of V_3, V_4 and x_0. When p increases, x_0 decreases. In Figure 2, the shadow cross-section moves to the left, thus V_4 increases, indicating that the greater the default factor that the bank does not implement the return policy and the more willing the supplier to implement the return

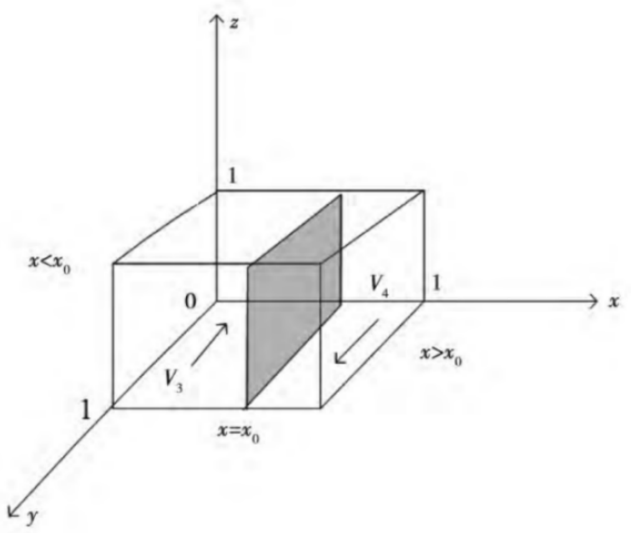

FIGURE 2. Dynamic trend diagram of the supplier.

policy. When C_3 increases, x_0 and V_3 increase, indicating that the greater the cost of supplier return policy the less reluctant the supplier to implement the return policy.

(4) Analysis of the evolution of supplier

The above analysis shows that the supplier will ultimately choose the strategy based on the net income. Therefore, for the essence of the profit-oriented operation of the supplier, the supplier should actively choose the implementation strategy. The parameters must be adjusted to make $2P_2 - pqw < d_1qw + 2P_1 - C_3$. Therefore, the bank should take measures to utilize its natural advantages and reduce the cost of the supplier's implementation of the return policy.

3) ESTABLISHMENT GAME ANALYSIS ON RETAILER

(1) Retailer equilibrium analysis

Suppose the retailer chosen expected return of adoption is U_{R1}, the expected return of non-adoption is U_{R2} and the average expected return of the retailer adoption and non-adoption is U_R,

$$\begin{aligned} U_{R1} &= xyc_1 + x(1-y)c_2 + y(1-x)c_3 + (1-x)(1-y)c_7 \\ U_{R2} &= xyc_2 + x(1-y)c_6 + y(1-x)c_4 + (1-x)(1-y)c_8 \\ U_R &= yU_{R1} + (1-y)U_{R2}. \end{aligned}$$

(2) Analysis of replication dynamic equation of retailer's cooperative ratio

$$\begin{aligned} \mathrm{F}(z) = \frac{dz}{dt} &= z(U_{R1} - U_{R2}) \\ &= z(1-z)[C_5 - C_4 + y(R_1 - R_3) + (1-y)(R_2 - R_4) \\ &\quad + x(d_2C_4 + M)] \end{aligned}$$

If $y_0 = \frac{C_4 - C_5 + R_4 - R_2 - x(d_2C_4 + pqw)}{R_1 + R_4 - R_2 - R_3}$ and $y = y_0$, then $\mathrm{F}(z) \equiv 0$, which means $\mathrm{F}(z)$ is stable regardless of z's value. If $y_0 = \frac{C_4 - C_5 + R_4 - R_2 - x(d_2C_4 + pqw)}{R_1 + R_4 - R_2 - R_3}$ and $y \neq y_0$, then $z = 0$ and $z = 1$ are two stable points.

Therefore, we have $\frac{\mathrm{dF}(z)}{dz} = (1-2z)[C_5 - C_4 + y(R_1 - R_3) + (1-y)(R_2 - R_4) + x(d_2C_4 + M)]$.

From $\frac{dF(z)}{dz} < 0$, the following conclusions are obtained:

Proposition 5: Given that $0 < x < 1, 0 < y < 1, 0 < z < 1$, it can be proved that $C_5 - C_4 + y(R_1 - R_3) + (1-y)(R_2 - R_4) + x(d_2C_4 + M) < 0$ When $R_3 - R_1 + C_4 - C_5 > d_2C_4 + M$. When $z = 0$, $\frac{dF(z)}{dz} < 0$, and when $z = 1$, $\frac{dF(z)}{dz} > 0$, $z = 0$ is an ESS.

Proposition 6: When $R_3 - R_1 + C_4 - C_5 < d_2C_4 + M$,

If $y < y_0$, when $z = 0$, $\frac{dF(z)}{dz} < 0$; when $z = 1$, $\frac{dF(z)}{dz} > 0$. $z = 0$ is an ESS. If $y > y_0$, when $z = 0$, $\frac{dF(z)}{dz} > 0$; when $z = 1$, $\frac{dF(z)}{dz} < 0$, $z = 1$ is an ESS.

(1) When the retailer's initial state is at V5, $R_4 - R_2 + C_4 - C_5 > d_2C_4 + M$, $z = 0$ is the equilibrium point at which the retailer will choose the non-adoption strategy. Therefore, in the case of banks implementing subsidies to retailers, the retailer will eventually choose the non-adoption strategy when the retailer's adoption net income is less than the non-adoption net income.

(2) When the retailer's initial state is at V6, when $R_4 - R_2 + C_4 - C_5 < d_2C_4 + M$, $z = 1$ is the equilibrium point, at which point the retailer will choose the non-adoption strategy. Therefore, in the case of bank implementing subsidies to retailer, the retailer will eventually choose the adoption strategy when the retailer's adoption net income is more than the non-adoption net income.

(3) Parameter analysis

Figure 3 shows that when d1 increases, V6 also increases, indicating that the greater the subsidy coefficient of the bank to the retailer, the more the retailer tends to choose to adopt supply chain finance. Similarly, when C4 is smaller, the larger C5, the smaller the cost of taking the supply chain finance when the retailer implements it and the higher the opportunity cost of the retailer not taking the supply chain finance. Therefore, the retailer tends to choose to adopt the supply chain finance.

(4) Analysis of the evolution of retailer

The above analysis shows that the retailer will ultimately choose which strategy is based on the net income. Therefore, the retailer, a profit-oriented operator, should actively choose the adoption strategy. The parameters must be adjusted to make $R_4 - R_2 + C_4 - C_5 < d_2C_4 + M$. Therefore, the bank should take measures to utilize its natural advantage to increase the adoption of the retailer's subsidy factor. Also, the retailer should minimize the cost of taking supply chain finance.

C. COMPREHENSIVE ANALYSIS OF EACH RTICIPATING ENTITY

Figures 1–3 respectively divide the dynamic trend graphs of the three parties into two parts and arrange the initial status of each participating entity. The equilibrium points of the three parties involved in each space are shown in Table 4.

Figures 1–3 shows that the above eight equilibrium states do not have robustness to small disturbances. The equilibrium

TABLE 4. Strategy choice of participants in each space.

Space	V_1		V_2	
	V_3	V_4	V_3	V_4
V_5	(0, 0, 1)	(0, 1, 0)	(1, 0, 0)	(1, 1, 0)
V_6	(0, 0, 1)	(0, 1, 1)	(1, 0, 1)	(1, 1, 1)

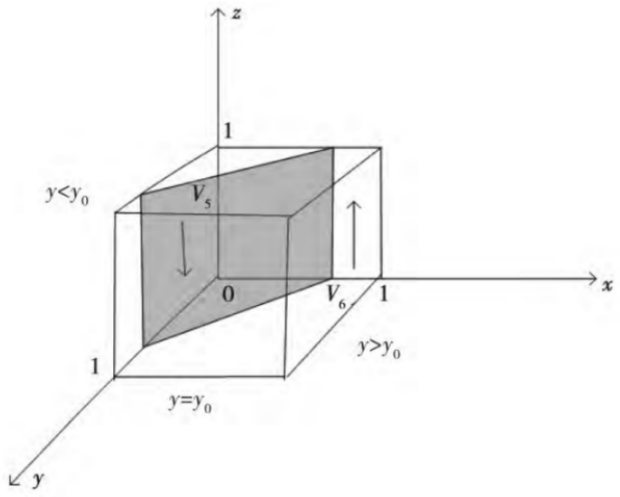

FIGURE 3. Dynamic trend diagram of the retailer.

states are short-lived and the choices of all participating subjects are mutually influential. Therefore, the three-party game is not an ESS.

When the initial state is in the space within the intersection of space V_2, V_3, and V_5, the strategic behavior of each participating subject will converge to (1, 0, 0). Therefore, from a short-term perspective, when the initial proportion of the retailer adopting supply chain finance and the supplier implementing the return policy is extremely low, the supplier and retailer do not see the long-term financial returns. If the bank takes appropriate supervision measures, then the supplier and retailer will eventually choose the non-implementation and non-adoption strategies. Therefore, banks should take strong incentives to develop the supply chain in the current situation. Under the equilibrium states of $x = 1$, $y = 1$, and $z = 1$ (supervision, implementation, and adoption, respectively) are in line with the current situation in China.

When the initial state is in the space within the intersection of spaces V_1, V_4, and V_6, the strategic behavior of each participating subject will converge to (0, 1, 1). From a long-term perspective, suppliers and retailers will eventually choose the implementation and adoption strategies without bank supervision, which are inevitable long-term goals of China's development of supply chain finance.

V. NUMBERICAL EXAMPLE AND COOPERATION STRATEGY

The following is a numerical value that reflects the initial proportion of the choice of strategy between banks, suppliers, and retailers, as well as the impact of changes in bank and supplier and retailer penalties and subsidies on the evolutionary results.

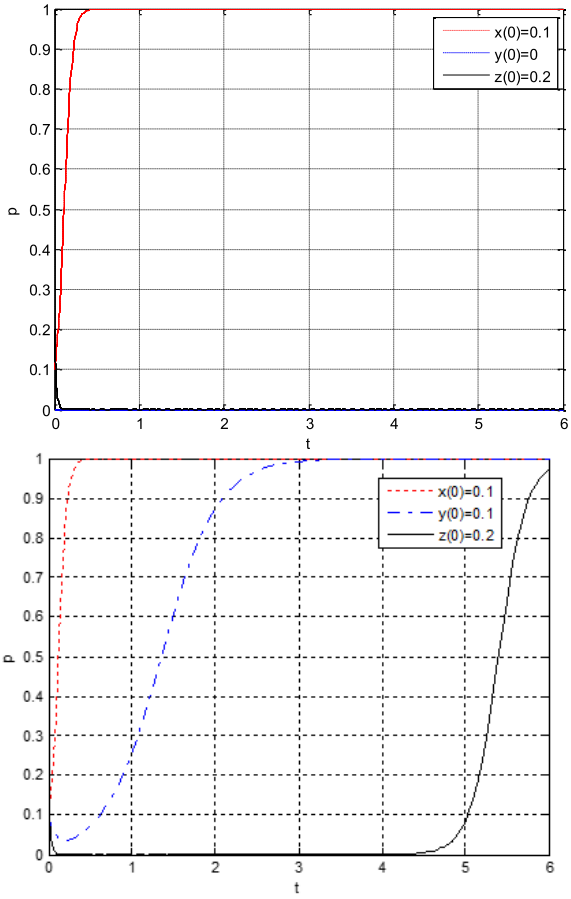

FIGURE 4. Strategy selection under different initial states.

A. CHANGE OF INITIAL RATIO OF THE THREE PARTIES ON THE COOPERATION PROBABILIITY

Here, the parameters' assignment are given as $C_1 = 1$, $C_2 = 1$, $d_1 = 0.2$, $d_2 = 0.2$, $C_4 = 40$, $C_5 = 7$, $p = 0.4$, $q = 25$, $w = 1$, $G_1 = 52$, $G_2 = 39$, $G_3 = 33$, $G_4 = 61$, $M = 12$, $C_3 = 3$, $S_1 = 10.5$, and $S_2 = 15$. Among them, x0, y0, and z0 represent the initial proportion of the bank's choice of supervision strategy, the supplier's choice of implementation strategy, and the retailer's choice of adoption strategy, respectively.

Table 3 shows that eight evolution results of the three parties under different initial ratios. These evolution results are consistent with the previous evolution analysis results. Two cases are selected for comparison. The solid line in Figure 4 represents the strategic choice of the retailer; the thick dashed line represents the strategic choice of the supplier and the thin dotted line represents the strategic choice of the bank. When the supplier does not implement a return policy, it is not willing to change the status quo to participate in supply chain finance even if the bank adopts a regulatory system. When the supplier initially implements the return

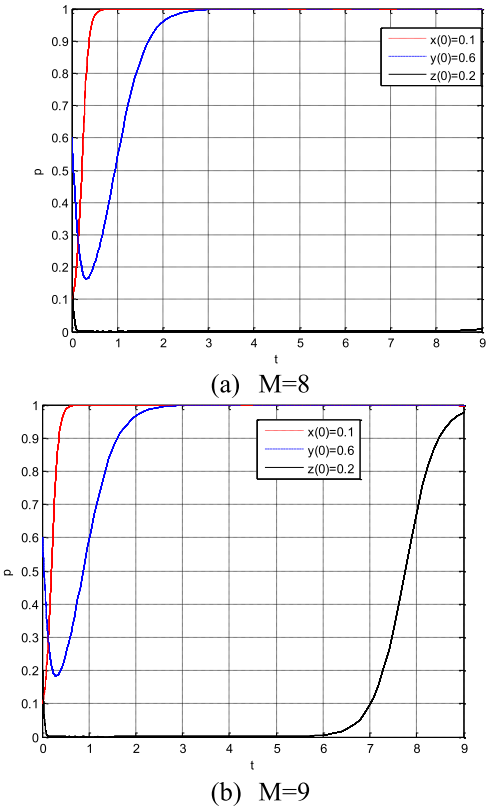

FIGURE 5. Influence of the bank default on the evolutionary results.

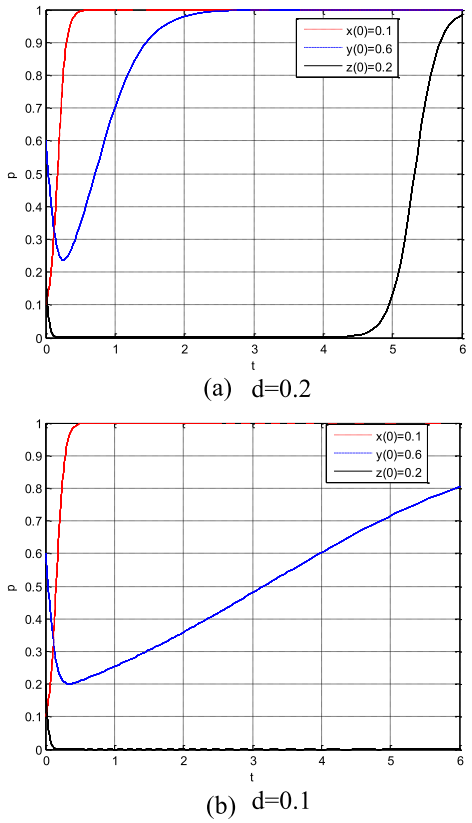

FIGURE 6. Influence of the bank subsidy on the evolutionary results.

policy, even if the initial implementation of the return policy is very small, the initial ratio is only changed by 0.1, and the evolution strategy of the retailer and the supplier will start to change. When the percentage of suppliers implementing return policy is very high, retailers are beginning to accelerate their participation in supply chain finance. The reason why different evolution results occur is closely related to the change of the initial ratio of the return policy. It shows the important role of return policy in the financial operation of supply chain. Return policy can effectively mobilize the enthusiasm of retailers to participate in supply chain finance and become a natural barrier for the operation of supply chain financial system.

Figure 5 does not change the initial ratio, only changes the value of M. That is to change the bank's default for the retailer not to take the supply chain. At $M = 8$, although the incentives for suppliers to implement return policy increased, the proportion of retailers participating in supply chain finance was extremely small and the rate of participation increased slowly. When $M = 9$, the enthusiasm of retailers to participate was significantly improved, which reflects the bank's punishment for retailers has significantly improved the retailer's participation in the operation of supply chain finance.

Figure 6 compares the different d1 values that reflect the bank's subsidy factor to suppliers. When d1=0.1, the supplier's enthusiasm for implementing return policy is not high, showing a slow growth state. The proportion of participation in a return policy also affects the enthusiasm of retailers to participate in supply chain finance. This situation results in a very small proportion of retailers participating in supply chain finance, which seriously affects the operation of supply chain finance. When d2=0.2, although the increase of the subsidy coefficient is small, the supplier has shown very positive feedback measures on the change of the coefficient. The proportion of implementing a return policy is rapidly increasing. When the proportion of supplier implementing a return policy is almost 100%, the retailer is also actively involved in the supply chain financial system, achieving the benign operation of the supply chain financial system. Therefore, the chain effect can be utilized reasonably to achieve the long-term development of the supply chain by adjusting the values of the various parameters in a small range.

VI. CONCLUSION AND FUTURE RESEARCH

A. CONCLUSION

In this paper, evolutionary game was presented to study evolutionary stable strategy of three parties, namely, one bank, one supplier and one retailer. In the strategic interaction among the three parties, we found that different parameters, such as bank subsidy and default coefficient, significantly affect on evolutionary dynamics of strategies. Also, we discussed long-term and short-term stable states of banks, suppliers and retailers by comprehensive analysis.

If the main channel for retailer financing is to use its own assets as collateral, then retailers with small self-owned funds are likely to have higher ordering levels due to limited liability for repayment of risks, making banks more vulnerable to losses [6]. Compared with traditional retailer external financing channels, return policy has the advantages of high speed and large amount of financing supported by supplier's credit, What's more, return policy does not cause retailers to bear high borrowing costs. This paper firstly introduces return policy into the supply chain financial system. Compared with the case of no return policy, it is found that return policy can optimize the system structure, stimulate the enthusiasm of retailers to participate in the supply chain and significantly improve the benign operation of the supply chain system. In the initial introduction of return policy at a low ratio, a series of chain reaction can be generated which will lead to the sound and orderly development of the entire supply chain.

Our work reveals the potential impact of bank incentives and penalties on the three parties from the perspective of return policy. Furthermore, this paper gives the answer how the corresponding policies of the bank in the financing process are formulated. First of all, punishment has a certain warning effect on the overall composition of suppliers and retailers, thus moderately increasing the amount of punishment can promote retailers to participate supply chain finance and drive linkage and transmission in the supply chain. Secondly, the appropriate increase in bank subsidies can give retailers a positive feedback. The corresponding bank incentive policy is also conducive to retailers with less free capital to obtain more high-quality financing funds and reduce their own cost pressures. Finally, using financing channels rationally can improve the financing efficiency of retailers and bring positive promotion effectiveness of the whole supply chain.

Practically, return policy applied into the supply chain can better obtain sustainable and healthy development. Also, supply chain integration is contributed to virtuous circle of capital. Specifically, banks should adopt information system technology and use the advantages of the platform fully to reduce asymmetric information. In addition, dynamic adjustments to incentives and penalties also rely on real-time tracking and regulation of the debt of suppliers and retailers. For suppliers, increasing the initial participation degree and forming chain effect will drive the supply chain to an efficient and orderly track. For retailers, they should speed up circulation and reduce the single order cost so as to minimize their cost risk to promote their sustainable development.

B. FUTURE RESEARCH

This study only considers the three parties of the bank, supplier and retailer, while the logistics enterprise has a certain right to speak in the process of supply chain. Any turbulence in the inventory pledge of the logistics enterprise will greatly affect the normal operation of the supply chain finance. Therefore, the role of logistics enterprise is indispensable and it is also one of the factors should be considered. It is possible to introduce logistics enterprise in the future game. Also, this paper only covers the financing stage and has not yet considered the issue of profit distribution between suppliers and retailers. Suppliers use their own credit advantages to bear retailers' certain cost risk when financing, thus suppliers should be considered in the stage of profit distribution.

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