Risk regulation strategy analysis of supply chain financing from the perspective of game theory

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Abstract. In terms of solving the financing difficulties, supply chain financing plays a role in lowering the financing threshold of upstream and downstream enterprises, breaking the bottleneck of upstream and downstream financing, and improving the competitiveness of core enterprises and supporting enterprises, which is of great significance in accelerating the capital operation and making commercial transactions more efficient and convenient. This article takes the supervision game in game theory research methods, to supply chain financing risk supervision game model is established, from the third party logistics enterprises to participate in, the third party logistics enterprise and financing enterprises union and government security three aspects analyzes the different roles of regulatory policy, and for financing enterprise, financial institution, third party logistics enterprise and government,. The conclusion shows that each party should enhance its own credibility and ability, and increase the opportunities for communication and cooperation with other parties, so as to promote the long-term operation and development of supply chain financing.

1. Introduction

1.1. Research background and significance

According to the data analysis provided by China National Data Network, in terms of industry alone, by 2018, the total profit of industrial enterprises was 6635.114 billion yuan, among which the total profit of small industrial enterprises was only 1870.15 billion yuan, accounting for 28.2% of the total profit of the whole industrial enterprises, and that of medium-sized industrial enterprises was 1552.05 billion yuan. Accounting for 23.4% of the total, large industrial enterprises reached 3212.94 billion yuan, accounting for 48.4%. The details are shown in Figure 1:

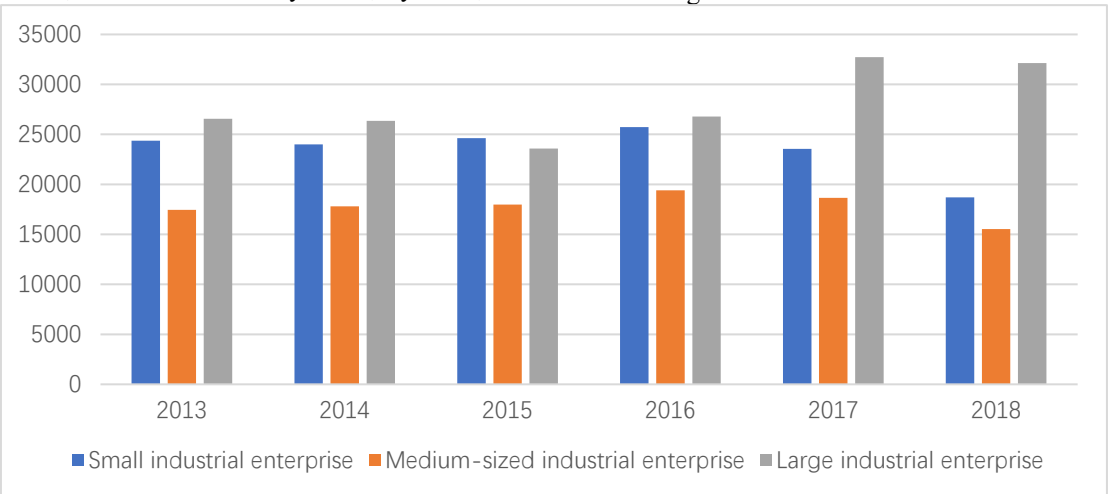

Figure 1. Profit change of Chinese industrial enterprises from 2013 to 2018

However, there were only 9,103 large industrial enterprises, accounting for 2.4% of the total.

From this, it can be analyzed that although the number of small and medium-sized enterprises far exceeds that of large enterprises, they do not match their quantitative advantage in total profits.

However, in the process of the development of small and medium-sized enterprises, they are faced with more difficulties than before, among which the financing problem is the outstanding difficulty faced by small and medium-sized enterprises. In order to continue to expand the loan scale of financial institutions, more and more financial institutions pay attention to the supply chain, and supply chain finance is born.

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1.2. Research Purpose

This paper aims to make use of the supervisory game research method in game theory to conduct an analogy study on the credit risk between financial institutions and financing smes. First, the game model is established, the preliminary results are obtained, and the influence of various factors on the results is analyzed. Then add the third-party logistics and the government and other factors, combined with the game model to get specific results.

1.3. Research Ideas

The first part is the introduction, which mainly introduces the research background and significance of supply chain finance and its risks.

The second part elaborates the theoretical basis of this paper from three aspects: the game between financial institutions and financing enterprises, the game of joining the third-party logistics enterprises and the game formed by the government guarantee.

The third-part is the summary and suggestion part, which summarizes the above analysis and provides suggestions to the parties according to the results.

2. Three game models of financing regulation

2.1. Game model of financing supervision without participation of third-party logistics enterprises

In supply chain finance, when financing enterprises apply for loans from financial institutions, smes applying for financing have two kinds of action decisions: scheduled repayment of loans and non-scheduled repayment of loans. If smes get loans and repay them on time, they will get the financing income from the loans; If the financing enterprise is unwilling or unable to repay the loan in time due to active or passive reasons, the financial institution can auction the collateral of the financing enterprise to reduce some losses of the financial institution itself. In addition, if small and medium-sized enterprises plan not to repay on time, in order to increase the possibility of investigation and supervision before providing loans through financial institutions, they will use all means to whitewash their own credit and information, so as to obtain loans from financial institutions.

Financial institutions also have two kinds of action decisions: supervision and non-supervision. If financial institutions choose to investigate and supervise the financing smes, obtain the credit level of financing enterprises and reduce the risk of fraud, high credit investigation costs will occur. If we choose not to supervise, on the one hand, the financial institution will lose the principal, on the other hand, there may be other losses.

Basic assumptions of the model:

(1) Participants only include financial institutions and financing enterprises.

(2) Supervision of financial institutions, so the supervision cost is a. Assuming that the fraudulent behaviors of financing enterprises are found through investigation and supervision, on the one hand, the principal can be timely retrieved, on the other hand, the superior unit will be rewarded for its supervision. If the financial institution does not supervise, if the financing enterprise chooses to default, the financial institution will not only lose the principal, but also get the penalty c for non-supervision by the superior unit.

(3) If the financing enterprise chooses not to commit fraud, it can obtain financing income R, and the loan interest to the financial institution is r; If the financing company chooses to commit fraud and the financial institution fails to supervise, the financing company will get a part of the extra revenue ΔR, but if the financial institution chooses to supervise, the financial institution will punish it for breach of contract e.

(4) When financing enterprises cheat financial institutions, there is a whitewash cost f.

(5) The probability of supervision by financial institutions is p, and the probability of fraud by financing enterprises is q. The payment matrix is shown in Table 1.

Table 1. Payment matrix without the participation of third-party logistics enterprises.

		Financing enterprise	
		fraud	non-fraud
Financial institution	supervision	$(r-a+b,\ R-e-f)$	$(r-a,\ R)$
	non-supervision	$(-d-c,\ R+\triangle R-f)$	$(r,\ R)$

Strategies of financial institutions:

$$p\times(R-e-f)+(1-p)\times(R+\triangle R-f)=p\times R+(1-p)\times R \quad (1)$$

The solution is $p=\frac{\triangle R-f}{\triangle R+e}$.

Strategies for financing enterprises:

$$q \times (r - a + b) + \ （1 - q） \times \ （r - a） = q \times (-d - c) + (1 - q) \times r \quad (2)$$

The solution is $q = \frac{a}{r+b+c+d}$.

If the probability of supervision of financial institutions is less than $p = \frac{\triangle \mathrm{R-f}}{\triangle \mathrm{R+e}}$, the best choice for financing enterprises is fraud; If the probability of supervision of financial institutions is greater than $p = \frac{\triangle \mathrm{R-f}}{\triangle \mathrm{R+e}}$,the optimal choice of financing enterprises is not to cheat; If the probability of supervision of financial institutions is equal to $p = \frac{\triangle \mathrm{R-f}}{\triangle \mathrm{R+e}}$, the financing company randomly chooses whether to commit fraud or not.

Similarly, financing enterprise is also analyzed in this way.

Therefore, financial institutions supervise with probability $p = \frac{\triangle \mathrm{R-f}}{\triangle \mathrm{R+e}}$, and financing companies cheat with probability $q = \frac{a}{r+b+c+d}$.

2.2. Game model of financing supervision in the alliance between third-party logistics enterprises and financing enterprises

In supply chain finance, besides financial institutions and financing enterprises, there is another important participant: third-party logistics enterprises. Third-party logistics enterprises act as a bridge between financial institutions and financing enterprises. On the one hand, they provide a place for financial institutions to store pledges and supervise them; on the other hand, they also provide financing enterprises with logistics, warehousing and other services, providing the basis for the normal operation of supply chain finance. There is still a lot of room for development because there are few third-party logistics enterprises joining supply chain finance. Therefore, more and more logistics enterprises begin to involve supply chain finance.

Therefore, the third-party logistics enterprises are added into the model. In reality, in order to make the financing of small and medium-sized enterprises succeed, logistics enterprises and small and medium-sized financing enterprises will cooperate with each other to deceive financial institutions. Therefore, logistics enterprises and financing enterprises can be regarded as a whole.

Basic assumption

(1) Suppose that in order to obtain greater benefits and development, the third-party logistics forms an alliance with the financing enterprise, and the risks and benefits are shared by the two parties. At this time, the loan amount is A, the loan interest is a, the commission is b, the value of the pledge is c, the income of the logistics enterprise is d, and the income of the small and medium-sized enterprise is e; The additional revenue of the alliance is f;

(2) The financial institution has two kinds of decisions: lending and not lending (assuming that loans must be investigated and supervised), and the alliance has two choices: fraud and not fraud;

(3) If the alliance chooses to commit fraud, in order to increase the possibility of investigation and supervision before providing loans through financial institutions, it will use all means to whitewash its credit and information, so as to obtain loans from financial institutions, thus resulting in whitewash cost g;

(4) Financial institutions will conduct investigation and supervision on logistics enterprises and financing smes before lending, obtain the credit level of logistics enterprises and financing enterprises through various ways, and reduce the risk of fraud of the alliance. Therefore, the cost of credit investigation is h

(5) The opportunity cost of financial institutions not to lend is i;

(6) If the financing enterprise is unwilling or unable to repay the loan in time due to active or passive reasons, the financial institution can auction the collateral of the financing enterprise to reduce the loss of some financial institutions. Therefore, the auction income j. The payment matrix is shown in Table 2.

Table 2. Payment matrix involving third-party logistics enterprises.

		alliance	
		fraud	non-fraud
Financial institution	supervision	$（b - A + j - h，$ $A + d + e + f - b - c - g）$	$（a + b - h，$ $d + e + f - a - b）$
	non-supervision	$（0，$ $-d - e - f - g）$	$（-i，$ $-d - e - f）$

Strategies of financial institutions:

$$p \times (A + d + e + f - b - c - g) + (1 - p) \times (-d - e - f - g) = p \times (d + e + f - a - b) + (1 - p) \times (-d - e - f) \quad (3)$$

The solution is $p = \frac{g}{\mathrm{A+a-c}}$,And $q = \frac{h-a-i-b}{j-a-i-A}$.

If the probability of the financial institution lending is less than $p = \frac{g}{\mathrm{A+a-c}}$, the optimal choice of the alliance is fraud; If the probability of the financial institution lending is greater than $p = \frac{g}{\mathrm{A+a-c}}$, the optimal choice of the alliance is no fraud; If the probability of the financial institution lending money is equal to $p = \frac{g}{\mathrm{A+a-c}}$, the alliance randomly selects fraud or not.

Similarly, alliance is also analyzed in this way.

Therefore, financial institutions with $p = \frac{g}{\mathrm{A+a-c}}$ probability of supervision, alliance with $q = \frac{h-a-i-b}{j-a-i-A}$ the probability of fraud.

2.3. Game model of financing supervision under government guarantee mechanism

The government and relevant departments will formulate a series of laws and policies, on the one hand, to protect small and medium-sized enterprises, so that the credibility of small and medium-sized enterprises can be objectively and accurately assessed, accelerate the speed of cooperation; On the other hand, the interests of financial institutions should also be protected. For small and medium-sized enterprises that break the trust, they should not only be punished, but also be included in the list of small and medium-sized enterprises that break the trust.

Basic assumptions of the model are based on 2.2:

(1) Participants include financial institutions, financing enterprises, third-party logistics enterprises and the government.

(2) The cost of credit investigation is greatly reduced due to the help provided by the government such as the trust-breaking list, so it is ignored.

(3) Due to the intervention of the government, when financial institutions choose loans and the alliance chooses fraud, it is assumed that the government will not only punish k for the alliance, but also put the faithless enterprise on the list of faithless enterprises, which greatly reduces the possibility of the alliance's successful loan in the future. When financial institutions choose loans and the alliance chooses fraud, the government gives additional rewards to the alliance, such as loan interest reduction, which is provided by the government, and reward for its honest behavior, etc., the overall value is l. The payment matrix is shown in Table 3:

Table 3. Payment matrix of tripartite game under the government guarantee mechanism.

		alliance	
		fraud	non-fraud
Financial institution	supervision	$(a+b+j,$ $d+e+f-a-b-c-g-k)$	$(a+b,$ $d+e+f-a-b+l)$
	non-supervision	$(0,$ $-d-e-f-g)$	$(-i,$ $-d-e-f)$

The payment matrix is analyzed. For the financial institution, when the affiliate chooses fraud, if the financial institution chooses loan, its income is $(a+b+j)$; if the financial institution chooses no loan, its income is 0. Because the income obtained by choosing loan is higher than that obtained by choosing no loan, the financial institution will choose loan. When the alliance chooses not to defraud, if the financial institution chooses to make a loan, its income is $(a+b)$; if the financial institution chooses not to make a loan, its income is $(-i)$. Since the income obtained by choosing a loan is higher than that obtained by choosing not to make a loan, the financial institution will choose to make a loan.

By the same token, the alliance will choose not to commit fraud regardless of whether the financial institution lends money or not.

Therefore, financial institutions will choose to lend money regardless of whether the alliance is fraudulent, and the alliance will choose not to commit fraud regardless of whether the alliance is fraudulent. The intervention of the government not only helps small and medium-sized enterprises to finance, but also reduces the possibility of fraud and fraud to a certain extent.

3. Summary

With the continuous development of the society, small and medium-sized enterprises are still a huge pillar of social development. In order to better solve the financing problem of small and medium-sized enterprises, all parties are looking for new solutions. In the process of searching, they gradually focus on the whole supply chain with dominant enterprises as the core. This paper uses the supervisory game research method in game theory to analyze the influence of various factors on the results, and then adds other factors such as third-party logistics and government, and combines the game model to get specific results. It concludes that the measures and actions of financial institutions, financing enterprises, third-party logistics and government have a huge impact on supply chain finance, and puts forward suggestions for all parties.

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