Research on Construction of Supply Chain Finance Model and Enterprise Innovation in the Internet Era

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ABSTRACT

The Internet era has brought changes to corporate business models. Based on the game analysis of bank and SMEs behaviors in supply chain finance, this paper deduces the relationship between supply chain finance, financing constraints and corporate innovation. We also use the 2008-2019 Shanghai and Shenzhen A-share listed companies as data sample, test the impact of the supply chain finance on corporate innovation and the mediating effect of financing constraints. We found that supply chain finance increases the number of firms' patent output and improves the level of corporate innovation. The paper helps shed light on the role of supply chain finance in microenterprises in terms of their innovation barriers and financial constraints.

Keywords: *Supply Chain Finance Model Construction, Big Data, Business Model Innovation, Corporate Innovation Level*

1 INTRODUCTION

As a new financing method, supply chain finance can effectively provide efficient financing for small and medium-sized enterprises under the third wave of informatization marked by big data. In recent years, supply chain finance, as an innovation alternative of financial transactions, has been widely used by commercial banks. Supply chain finance originated from the supply chain industry model, under which the industrial organization has gradually evolved into a landscape where core enterprises make up most of the market share, and the small and medium-sized enterprises (SMEs) participate in collaboration along the supply chain. In order to maximize their own profits, the core enterprises of the supply chain will also have to aim for collective benefits for their partner firms along the supply chain. One of the innovative methods to achieve the win-win scenario is when the core company helps its partner firms get access to loans from the commercial banks through credit intervention, in order to relieve them from the cash flow shortage, thereby improving the operational efficiency of the entire supply chain.

Bank loans are one of the main sources of corporate financing in China, where the financial system is dominated by commercial banks. As a long-term and high-risk investment, innovation is often difficult to persist relying only on internal funds, which makes a sufficient source of external funds essential. However, due to the information asymmetry, companies are restricted from obtaining external financing at a lower cost [6]. As a result, the financing constraints faced by companies hinder innovation activities. The emergence of supply chain finance has solved the financing dilemma of corporate innovation. The core company of the supply chain uses its own credit guarantees to enable its partner firms to obtain cash flow from banks.

In light of this, this paper discusses the impact of supply chain finance on corporate innovation. Our study enriches the literature on the influencing factors of corporate innovation from the perspective of supply chain finance. The mechanism of supply chain finance promoting corporate innovation has yet to be explored in the existing studies. We found that the supply chain finance can serve as a guarantee to help the SMEs gain access to the external funds from the banks through the strong credit of the core enterprises. This in turn alleviates the financing constraints of innovation investment of the entire supply chain, and improves innovation overall. We also extend the literature of the economic consequences of supply chain finance from the perspective of financing constraints. We conclude that

supply chain finance can not only solve the problem of "financing difficulties" for SMEs, but also promote the innovation of the SMEs, thereby having positive spillovers in economic and social development.

2 THEORETICAL ANALYSIS

2.1 Game analysis of SMEs and Banks in supply chain industry model

Supply chain finance is composed of financial institutions, core enterprises and SMEs, breaking through the shackles of traditional credit review mechanisms, based on the credit of core enterprises and quality of the entire supply chain. In the supply chain industry model, the participating core enterprises and various SMEs are relatively stable, and will not give up long-term cooperation and transactions for a single benefit, which conforms to the repeated game assumption.

(1) Game model hypothesis: (i) Participants are rational and pursue the maximization of benefits. (ii) Participants are core enterprises, SMEs and commercial banks. (iii) There are information acquisition costs. (iv) There are default costs.

(2) The game between banks and SMEs: The main reason for financing difficulties of SMEs is the information asymmetry between enterprises and banks, which resulting moral hazard and adverse selection problems [5]. The game model between banks and SMEs in the traditional mode is as follows: (i) Suppose SME S needs to raise funds R for innovation projects, which has certain risks. The probability of outcome is γ, and the probability of failure is $1 - \gamma$. If the project succeeds, S can get the income R_1, if the project fails, S can only get R_2 ($R_2 < R < R_1$). As SME S lacks funds, it needs to apply for a loan from commercial bank B, and the cost of applying for a loan is c. (ii) The borrowing rate provided by Commercial Bank B is β_0, The opportunity cost rate of funds is o. (iii) If SME S does not repay the loan on time, S will gain L_S by taking up the funds extra time, while the loss of commercial bank will be L_b. (iv) There are two types of SMEs in the market, S1 with high credibility and S2 with low credibility. The probability of occurrence of S1 is m, and the probability of occurrence of S2 is $1 - m$. (v) If the innovation project succeeds, S1 will repay the loan on time, while S2 will try to default. If the innovation project fails, S1 will repay the loan as soon as possible, and S2 will try to default. The losses caused to Bank B are L_{1b} and L_{2b} ($L_{1b}<L_{2b}$). The income matrix of SMEs and bank are shown in Table1.

Table 1: The income matrix under the traditional model

income			SMEs S	
			S1 high credibility: m	S2 low credibility: 1-m
Bank B	loan	project succeeds γ	$R \times \beta_0$, $R_1 - R(1+\beta_0) - c$	$R \times \beta_0 - L_{2b}$, $R_1 - R(1+\beta_0) - L_{2s} - c$
		Project fails $1 - \gamma$	$R \times \beta_0 - L_{1b}$, $R_2 - R(1+\beta_0) - L_{1s} - c$	$R \times \beta_0 - L_{2b}$, $R_2 - R(1+\beta_0) - L_{2s} - c$
	No loan	——	$-c$, $R \times o$	$-c$, $R \times o$

The process is as follows: In the first stage, SMEs S1 and S2 appear in the market with random probabilities m and $1 - m$ to raise funds for innovative projects. In the second stage, to ensure its own interest, Bank B determines the loan interest rate β_0 by the probability of different types of SMEs in the market. In the third stage, SME S chooses whether to accept the borrowing rate. If S does not accept, the game ends. Income of S is 0 and income of bank B is R × o. In the fourth stage, if the SME S applies for a loan for the innovative project, which will succeed or fail with the probability of γ and $1 - \gamma$. In the fifth stage, S repays the loan on time or not.

While applying for a loan, the expected return of the company S1 with high credibility and the company S2 with low credibility are as follows.

$$E_{S1} = \gamma[R_1 - R(1+\beta_0) - c] + (1-\gamma)[R_2 - R(1+\beta_0) - L_{1s} - c] \quad (1)$$

$$E_{S2} = \gamma[R_1 - R(1+\beta_0) - L_{2s} - c] + (1-\gamma)[R_2 - R(1+\beta_0) - L_{2s} - c] \quad (2)$$

The expected return E_b of Bank B is follows.

$$E_b = m[\gamma \times R \times \beta_0 + (1-\gamma)(R \times \beta_0 - L_{1b})]_0$$
$$+ (1-m)[\gamma(R \times \beta_0 - L_{2b}) + (1-\gamma)(R \times \beta_0 - L_{2b})] \quad (3)$$

In order to guarantee its own interests, bank B requires β_0 to be as follows.

$$E_b = R \times \beta_0 - (1-\gamma)mL_{1b} - (1-m)L_{2b} \geq R \times o \quad (4)$$

The expected return E_{S1} of SME S1 is less than E_{S2} of SME S2. In order to minimize losses, Bank B will increase the loan interest rate. When β_0 is increased so that $E_{S1} \leq 0$, S1 will exit the loan market leading to adverse selection.

2.2 The Tripartite Game of Banks, SME and Core Enterprises in supply chain industry model

The reason why the supply chain finance model can alleviate adverse selection is to bind the credit of SMEs with the high-quality credit of core enterprises, thereby improving the credit quality of borrowers. The tripartite game among banks, SMEs and core enterprises in supply chain industry model is as follows. (i) Suppose that the SME S receives the accounts receivable from the core company C as Q, the probability of repayment of the core company is α, and the probability of non-repayment is $1 - \alpha$. The rate of return on investment of core enterprise is β_1. Ans the default loss of non-repayment is M.(ii) SME S needs to raise funds R for the innovation project, which has certain risks. The probability of success is γ, and the probability of failure is $1 - \gamma$. If the project succeeds, S can get the income R_1. if the project fails, S can only get R_2 ($R_2 < R < R_1$). (iii) The borrowing rate provided by Commercial Bank B is β_0, The opportunity cost rate of funds is o. (iv) As SME S lacks funds, it needs to apply for a loan from a commercial bank B, which is guaranteed by the core enterprise's accounts receivable Q. If S defaults, the bank B will exercise its claims on the core enterprise, the default loss of the SME is N. (v) If the supply chain is functioning well, as well as S and C is trustworthy, the benefit that can be obtained from the supply chain is P. (vi) If the core enterprise C does not pay the accounts receivable on time, C will gain L_C by taking up the funds extra time, and the SME S will lose W_S. If SME S does not repay the bank loan on time, S will gain L_S, while bank B will lose W_B as well. The income matrix of core enterprise C, SME S and bank B are shown in Table 2.

Table 2: The income matrix under the supply chain industry model

income			SME S	
			Repay: τ	Delay: $1 - \tau$
core enterprise C	Repay α	project succeeds γ	$Q \times \beta_1 + P$, $R_1 - R(1+\beta_0) + P$, $R \times \beta_0$	$Q \times \beta_1 - R(1+\beta_0)$, $R_1 - R(1+\beta_0) + L_S - N$, $R \times \beta_0$
		Project fails $1 - \gamma$	$Q \times \beta_1 + P$, $R_2 - R(1+\beta_0) + P$, $R \times \beta_0$	$Q \times \beta_1 - R(1+\beta_0)$, $R_2 - R(1+\beta_0) + L_S - N$, $R \times \beta_0$
	Delay $1 - \alpha$	project succeeds γ	$Q \times \beta_1 + L_C - M$, $R_1 - R(1+\beta_0) - W_S$, $R \times \beta_0$	$Q \times \beta_1 + L_C - M$, $R_1 - R(1+\beta_0) - W_S + L_S - N$, $R \times \beta_0 - W_B$
		Project fails $1 - \gamma$	$Q \times \beta_1 + L_C - M$, $R_2 - R(1+\beta_0) - W_S$, $R \times \beta_0$	$Q \times \beta_1 + L_C - M$, $R_2 - R(1+\beta_0) - W_S + L_S - N$, $R \times \beta_0 - W_B$

The process is as follows: In the first stage, when SME S applies for a loan, whether bank B provide a loan or not. If it does not provide a loan, the game ends. The income of SME S and core enterprise C is 0, and the income of the bank is R × o. In the second stage, it depends whether the core enterprise C is in compliance with the contract, that is whether it will return the accounts payable on time. And whether the SME S defaults on repayment, or when it will return the loan of bank B. In the third stage, the innovation project of SME S succeeds or fails with the probability of γ and $1 - \gamma$. In the fourth stage, whether S repays the loan on time. Assume the expected return of SME S when repay on time is E_S:

$$E_S = \gamma\left[R_1 - R(1+\beta_0) + P\right] + (1-\gamma)\left[R_2 - R(1+\beta_0) + P\right] \quad (5)$$

In the final stage of the game, if the project is successful, assume the expected return of S when repay on time is π_1, while the expected return when S delay the loan is π_2.

$$\pi_1 = R_1 - R(1+\beta_0) + P \quad (6)$$

$$\pi_2 = R_1 - R(1+\beta_0) + L_S - N \quad (7)$$

Because of L_S, the SME S may still default on repayments, and core enterprises need to bear the losses. In the supply chain model, there are the revenue P brought by the supply chain and the punishment N by the core enterprise when SME S fail to repay the loan on time. When $P + N > L_S$, SME S will repay on time, because of $\pi_1 > \pi_2$.

If the current stage of the game is repeated as the project succeeds, even if the income of SME S choosing

delay is π_1, it will affect future financing, and the future income is 0. Choose to repay on time in each subsequent stage, will get the expected return of E_S each time. Assume the discount factor is δ, then even if $P + N < L_S$, SME S will repay the loan on time at each stage when the following conditions are met.

$$\left[R_1 - R(1+\beta_0)+P\right] + Es \times \left(\delta+\delta^2+\delta^3+...\right) > R_1 - R(1+\beta_0)+Ls - N \quad (8)$$

In supply chain industry model, only when the core enterprise and SME both default, the expected return of bank will be $R\beta_0 - W_B$,or else $R\beta_0$. Because the probability of default by the core enterprise is extremely small, the bank's willingness to provide loans to SMEs S is increased. Based on the above, we explore the role of supply chain finance in promoting corporate innovation activities from the perspective of alleviating financing constraints.

2.3 Research Hypothesis

Corporate innovation is a high-risk investment. Studies have discussed the importance of financing for innovation [1]. Although increasing internal funds, bank loans, equity financing etc. can effectively promote corporate innovation, how to overcome the financing difficulties faced by innovation activities has not been discussed fully.

The uncertainties of innovative activities and the information asymmetry make it difficult for investors to accurately estimate the benefits and risks of innovation projects. Meanwhile, the principal-agent problem also leads to moral hazard [3][7]. This in turn increases the potential costs of external investment, and therefore raising the financing barriers. This paper hypothesizes that the supply chain finance can improve the corporate innovation via alleviating the financing constraints faced by the enterprises.

The influencing power and the reputation of the core enterprises in the supply chain can serve as a credit guarantee, which reduces the banks' expected riskiness of the guaranteed firms. This reduces friction caused by information asymmetry, and overcomes the SME financing difficulties, improving financing efficiency [4]. Specifically, with the guarantee of the core company, it is possible to reduce the information collection costs for the commercial banks ex ante, and to reduce negotiation costs by allowing the commercial banks to see the indebted firms are able to repay the loans on time, and to reduce the supervision costs for the commercial banks to avoid problems such as repayment disputes ex post. Through the credit bundling with the core companies, the credibility of the entire supply chain can be improved, thereby reducing the credit risk exposure of the commercial banks. Mutual trust between the banks and the companies can increase banks' risk-bearing abilities, and help the banks acquire the "soft" information on the companies, and provide lower interest rates [2]. In this case, companies will pay more attention to credit building to avoid the risk of default. Therefore, supply chain finance can help companies to obtain external loans, ease the financing constraints of innovation activities, and promote enterprise innovation.

Thus, we propose the following hypotheses:

H1 (direct effect): Supply chain finance can promote corporate innovation.

H2 (indirect mechanism): The development of supply chain finance can alleviate corporate financing constraints, thereby promoting corporate innovation.

3 EMPIRICAL ANALYSIS

3.1 Data

We use the 2008-2019 Shanghai and Shenzhen A-share listed companies as our data sample, and exclude (i) financial and insurance companies; (ii) companies that have been listed for less than 2 years; and (iii) companies with missing data. The financial data and stock transaction data are from the CSMAR database. In order to eliminate the interference of the outliers, the main variables are Winsorized at 1%. The final sample contains 15687 observations.

3.2 Variables

(1)Main variables: Supply chain finance (Scf): the degree of supply chain finance is measured by the ratio of the sum of short-term loans and notes payable at a certain year to the total assets at the end of the same year (Yao et al., 2017); Corporate innovation (Innoeff): the corporate innovation level is measured by the logarithm of the number of enterprise patent grants plus1; Financing constraints (SA): financing constraints is measured by the SA index .

(2)Control variables: The selection of the control variables is mainly referenced from previous research. Enterprise-level control variables include enterprise age (Age), enterprise size (Size), leverage ratio (Lev), profitability (ROA), intangible assets (Intangible) and main business income growth rate(Growth). In addition, we control the property right (State), which equals 1 for state-owned enterprises and 0 for non-state-owned enterprises, industry (Ind) and year (Year).

(3)Regression model: To test the impact of the supply chain finance on corporate innovation, the regression model for H1 is as follows:

$$INNOEFF_{i,t+1} = \phi_0 + \phi_1 SCF_i + \phi Controls_{i,t} + \varepsilon_{i,t} \quad (9)$$

To test H2, we test the mediating effect of financing constraints (SA):

$$SA_{i,t+1} = \varphi_0 + \varphi_1 SCF_i + \varphi' Controls_{i,t} + \eta_{i,t} \quad (10)$$

$$INNOEFF_{i,t+1} = \phi_0 + \phi_1 SA_{i,t+1} + \phi_2 SCF_i + \phi Controls_{i,t} + \varepsilon_{i,t} \quad (11)$$

3.3   Results

The regression results of the impact of the supply chain finance on corporate innovation are shown in Table 3. Column (1) tests the impact of supply chain finance on the level of corporate innovation, and columns (2) and (3) test the intermediate effect of the financing constraints. The estimated coefficient of Scf is 0.1278, which is significant at the 5% statistical level, indicating that the supply chain finance significantly improves the innovation efficiency of companies, supporting the

hypothesis H1. Columns (2) and (3) further provide evidence for the intermediary mechanism of supply chain finance affecting the level of corporate innovation. In column (1), the coefficient of Scf is positive, indicating that the supply chain finance promotes the corporate innovation; in column (2), the coefficient of Scf is significantly negative, meaning supply chain finance reduces the financing constraints of companies; in column (3), the coefficient of SA is significantly positive, indicating that financing constraint has partial mediating effect between the positive impact of supply chain finance on corporate innovation, thus proving evidence in support for H2.

Table 3: Results of the impact of supply chain finance on corporate innovation

	(1) Innoeff	(2) SA	(3) Innoeff
Scf	0.1278** (2.12)	-0.1926*** (-15.41)	0.1445** (2.38)
SA			0.0865* (1.79)
Controls	Yes	Yes	Yes
Year/ Ind	Yes	Yes	Yes
Cons	-1.0377*** (-8.03)	-2.9166*** (-93.14)	-0.7853*** (-4.33)
R-squared	0.0765	0.8033	0.0766
N	15687	15687	15687

Note: *、 ** and *** indicate significance levels at the 10%、5% and 1% respectively, and t-value is in brackets.

4   CONCLUSION

Based on the game analysis of bank and SMEs behaviors in supply chain finance, this paper deduces the relationship between supply chain finance, financing constraints and corporate innovation. We also explore the impact of the supply chain finance on corporate innovation and the mediating effect of financing constraints in empirical test. The results show that supply chain finance has increased the number of patent output of companies and promoted the development of corporate innovation. Supply chain finance indirectly affects corporate innovation through relaxing the financing constraint. This paper enriches the research on the microeconomic consequences of the supply chain industry model.

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