Research on credit line of supply chain enterprises based on data sharing

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Abstract. Based on the deficiencies of the existing research on the credit line of supply chain enterprises, this paper taking data sharing as research perspective, established the credit model of supply chain enterprises using data sharing. Through the case study of L Corporation Group, it is found that: 1) the supply chain can integrate information advantages, increase credit line and reduce financing costs; 2) the credit line of supply chain enterprises increases with the increase of data sharing degree; 3) the existing credit models of the banks are conservative, the actual credit line of enterprises is insufficient. The credit model constructed in the paper fully considers the effects of data sharing of related transactions between enterprises on the credit line in the context of supply chain, which can provide ideas for realizing the win-win situation of maximizing the financing scale of supply chain enterprises and minimizing the risk of banks.

1. Introduction

The credit line is the maximum number of loans that commercial banks promise to provide to borrowers according to the agreements in a certain period or at a certain time [1]. Access to the bank's credit line is one of the most flexible financing channels for enterprises [2]. As a financial product of commercial banks, previous researchers started with the influencing factors of the establishment of credit line model, and they believed that the size of credit line granted by banks to enterprises was related to the size of enterprises, profitability, current assets, mortgage conditions, etc.[3-7]. In addition, Thakor [8], Chateau [9] and Hau [10] studied the price fixing of credit line. The credit line of an enterprise is mainly related to its credit rating. However, there is a lack of professional rating agency in China, which makes it difficult to unify the evaluation indicators. With the development of big data and information technology, structured and unstructured data information of enterprises has become an important standard for banks to evaluate the credit rating of enterprises [11-13]. Based on big data technology, it is helpful for commercial banks to better evaluate credit line and control credit risk by tracking customer transaction information and monitoring cash flow [14-15].

For example, the Kabbage company of the United State uses "big data" to reconstruct the credit system and provide "loans" for different risk types of enterprises by distinguishing interest rate. Enterprises can not only reduce financing costs, but also expand the amount of financing through data sharing [16-17]. In view of the lack of the previous research on the credit line of supply chain enterprises, this paper explores the credit line of commercial banks to supply chain enterprises from the perspective of data sharing, aims to provide new ideas for the financing of supply chain enterprises. The difference of credit line model of supply chain enterprises constructed in this paper and the
existing credit line model is that this model fully considers the role of data sharing of related transactions between enterprises on the credit line in the context of supply chain. This paper finds that banks can not only determine the credit line of supply chain enterprises through big data mining and enterprise data sharing, but also inspire their own risk control schemes. The banks can determine the credit line of the supply chain enterprises through the application of the model constructed in this paper to achieve the purpose of precise credit, and the win-win situation of maximizing the financing scale of supply chain enterprises and minimizing the risk of commercial banks.

2. Model constructing

The more comprehensive the bank's information on upstream and downstream enterprises in the supply chain, the lower the risk, and the lower the financing difficulty of enterprises [18-19]. Based on this, this paper argues that Banks under the financial model of supply chain to the supply chain enterprise credit mainly includes the following three parts:

The first part: the credit line without supply chain. This part is mainly based on the existing traditional credit models and fully relies on the relevant basic business indicators, cash flow reports, and real estate of the proposed credit enterprise, calculated through the relevant credit models. This part of the credit line is called the credit line without the background of supply chain.

The second part: the increase credit line based on supply chain. This part of the increase credit line is mainly that the bank views the proposed credit enterprise as a whole, the increase credit line obtained when the entire supply chain is granted credit.

The third part: the increase credit line based on data sharing. In the context of data sharing, commercial banks' credit lines for supply chain enterprises have two effects: the adjustment of corporate credit ratings and the adjustment of discount factor and the scope of hypothecated property. The credit line in this section is mainly the adjustment of the credit line obtained by dynamically adjusting the credit rating of the enterprise itself and its hypothecated property in the first part.

2.1. Model assumption

ASSUPTION 1: The supply chain has a trading platform database that relies on core companies. In this database, the transaction information of core enterprises and supply chain enterprises, as well as the basic financial information of core enterprises, upstream and downstream enterprises, are all real data.

ASSUPTION 2: There are a responsibility for core enterprises to improve the competitiveness of the entire supply chain and are willing to share the information in the database of the trading platform with banks.

ASSUPTION 3: Core enterprises are willing to cooperate with banks to repurchase their goods when necessary, repay their accounts payable and return funds on account collected in advance.

ASSUPTION 4: Supply chain enterprise data will not be repeatedly pledged, and commercial banks have the obligation to keep data pledged by supply chain enterprises confidential.

2.2. Credit line model

2.2.1. The credit line without supply chain. Supply chain enterprises are generally non-listed companies, financial information is difficult to obtain, so the traditional credit line model is used to calculate their credit line without supply chain. In the traditional credit line model, the bank measures the credit rating of the enterprise, takes the solvency of the enterprise as the center, and calculates the maximum unified credit line by combining the adjustment coefficient of the industry and the adjustment coefficient of the enterprise credit rating [3]:

\[ L_i = \left( \frac{R_{0i}}{R_{mi}} - 1 \right) \times \frac{NA_i}{T_i} \times C_i \times K_i \]  

Among them, \( L_i \) is the credit line size determined by the bank according to the credit status and financial status of the enterprise. \( R_{0i}, NA_i, L_{0i} \) respectively refer to the base period asset-liability ratio,
the base period effective net assets and the base period total liabilities of enterprise \( i \). \( R_{mi} \) is the highest asset-liability ratio of the enterprise \( i \) acceptable to the bank,

\[
R_{mi} = R_{0i} \times FC
\]  

(2)

\( FC \) is the ratio between the credit rating score of the enterprise \( i \) and the benchmark score of A-level customer. \( T_i \) is the ratio of the interest-bearing liabilities to the total liabilities, it depends on the industry, which is also the adjustment coefficient of the industry. \( C_i \) is the adjustment coefficient of enterprise credit rating. \( K_i \) is balance of interbank financing, which is jointly determined by the risk attitude of the bank and the risk degree of the enterprise \( i \).

Enterprises can also get the credit line of the bank by mortgaging or pledging their own fixed assets. Specifically, \( \rho_{ij} \) represents the discount factor of the hypothecated property \( j \), \( W_{ij} \) is the evaluation value of the bank's mortgage of the hypothecated property \( j \). The enterprise credit line obtained by mortgaging or pledging its own fixed assets is \( \sum \rho_{ij} W_{ij} \).

Therefore, the total amount of credit line without supply chain \( G_1^* \) can be expressed in formula (3):

\[
G_1^* = [\left( \frac{R_{0i} \times FC}{1-R_{0i}} \times R_{0i} \right) \times NA_i + L_0] \times T_i \times C_i \times K_i + \sum \rho_{ij} W_{ij}
\]  

(3)

2.2.2. Increase credit line based on supply chain. The larger the transaction volume with core enterprises, the more information can be released, the lower the degree of information asymmetry between banks and enterprises, and the larger the increase credit line. First of all, we need to obtain the total credit risk cardinal \( F_m \) of the core enterprises that the bank can bear, and this is the upper limit of the credit line that the bank can give to the core enterprise without any risk mitigation measures. Then, combined with the factors such as customer risk degree and operation variety risk degree of the supply chain enterprise, the adjustment coefficient is set to enlarge the credit line, and the cluster contingent credit line based on the risk sharing ability of the core enterprise is determined, which is the sum \( T_m \) of the core enterprise's own credit line in the supply chain and the credit line it may transfer to the upstream and downstream enterprises. The acquisition method is to set the customer risk adjustment coefficient \( C \) according to the average risk degree corresponding to the supply chain enterprises in the bank credit business, and then set the industry risk adjustment coefficient \( C \) according to the industry variety risk degree, that is,

\[
T_m = F_m \times C \times C
\]  

(4)

Finally, the cluster contingent credit line \( T_m \) minus the core enterprise's own credit line is used to obtain the maximum credit line \( T \) that the overall strength of the core enterprise and the supply chain can increase for the upstream and downstream enterprises. If the number of supply chain enterprises is \( \theta \), the maximum credit line that a single enterprise can transfer is \( T/\theta \)

\[
T = T_m - F_m = F_m \times C \times C \times F_m
\]  

(5)

As the supply chain enterprises are transaction based clusters, the proportion of transaction volume of upstream and downstream enterprises and core enterprises of the supply chain platform in the total transaction volume of the enterprise itself, that is, the proportion of transaction volume \( M_i \), is used as an indicator to measure the relationship between the enterprise \( i \) and core enterprises, and the increase in credit line due to the alleviation of information asymmetry is \( M_i T/\theta \). Therefore, the enterprise credit line \( G_1^* \) based on supply chain can be expressed by formula (6):

\[
G_1^* = [\left( \frac{R_{0i} \times FC}{1-R_{0i}} \times R_{0i} \right) \times NA_i + L_0] \times T_i \times C_i \times K_i + \frac{M_i \times F_m \times C \times C}{\theta} + \sum \rho_{ij} W_{ij}
\]  

(6)

2.2.3. Increase credit line based on data sharing. Under the data sharing environment, the credit line of supply chain enterprises is influenced by commercial banks in two aspects. One is the adjustment of enterprise credit rating. Commercial banks can dynamically adjust the credit rating of supply chain enterprises based on the large database and rating system of supply chain enterprises, and set the
adjustment coefficient as $\alpha$ ($\alpha > 0$) ($0 < \alpha < 1$ means that the bank reduces the credit rating of the enterprise after the data is shared; $\alpha=1$ means that the bank does not change the credit rating of the enterprise; $\alpha>1$ means that the bank raises the credit rating of the enterprise), and the adjusted enterprise credit rating score as $\alpha FC$. Then, the scope of hypothecated property and the discount factor are expanded. The increased credit line due to the expansion of the scope of hypothecated property is represented by $\sum \hat{\rho}_{ij} \hat{W}_{ij}$. Where $\hat{\rho}_{ij}$ is the adjustment coefficient of the discount of a certain hypothecated property $j$ of the supply chain enterprise $i$ after data sharing. It is the discount proportion after the bank adjusts various collateral after data sharing, which is used to describe the quality of the hypothecated property. $\hat{W}_{ij}$ is the increased quantity of hypothecated property $j$ of the supply chain enterprise $i$. To sum up, under the background of data sharing, the credit line $G_i$ of the supply chain enterprise $i$ can be shown in formula (7):

$$G_i = \left( \frac{R_0 - R_{0i}}{R_{0}^{\alpha FC} - R_{0i}} \right) \times NA_i + L_{0i} \times T_i \times C_i \times K_i \times \frac{M_i}{\theta} + \sum \hat{\rho}_{ij} \hat{W}_{ij}$$  

(7)

3. Case study

L Corporation Group is a large backbone brewery, and we select this enterprise for the following reasons: first, L Corporation Group formed a strategic pattern including the wine industry and financial industry; second, it has set up a bonding company and a small loan company to form a sound financial service chain, which has the function of providing supply chain finance for other small and medium-sized enterprises in the supply chain with L Corporation Group as the core enterprise.

3.1. Parameter setting and data acquisition

(1) $G_{i}^{\ast \ast}$ is the credit line without supply chain background. The acquisition of $G_{i}^{\ast \ast}$ requires the financial information and rating information of the enterprise. Among them, the financial information is provided by transaction platform database while the rating information is provided by Bank of China.

(2) $T$ is the maximum credit line that L Corporation Group and the overall strength of the supply chain can increase for upstream and downstream enterprises (N).

(3) $k_i$ is the ratio of trading volume. Based on the characteristics of business transactions in the supply chain, this paper describes the relational degree ($k_i$) by the proportion of the accumulated transaction amount in 6 months.

(4) $\theta$ represents the number of supply chain enterprises, we collect 100 enterprises on the supply chain platform of L Corporation Group, thus $\theta = 100$.

(5) Discount factor is determined by guiding principles of anti-guarantee measures of Bank of China financing bonding company. The authorized value of real estate assets shall not exceed 70% and the authorized value of factory shall not exceed 50%. For account receivable and inventory product, the authorized value shall be 50% of the book value. In practice, the value added of Commercial Banks against hypothecated property of supply chain enterprises is mainly reflected in the value of factory buildings and the pledge of movables. Without the supply chain, Commercial Bank does not recognize the value of the factory without the property right certificate and the verification level of movable property value is relatively low. Thus, $\rho_{ij} = 0$. Through data sharing and the effect of increase credit line of the supply chain, the Bank of China accepts the factory and the pledge of movables, but the discount factor given is small. This article defines the $\hat{\rho}_{ij} = 0.3$.

(6) $W_{ij}, \hat{W}_{ij}$ refer to the amount of hypothecated property due to the bonding company’s expanding the scope of hypothecated property and raising the discount rate of pledge of movables.

(7) $G_i$ is the theoretical credit line calculated by the model while $\hat{G}_i$ is the actual credit line of the Bank of China.

(8) $\alpha$ is defined as the bank’ adjustment of enterprise credit rating. With regard to the constructed model in current study, the value of $\alpha$ is related with enterprise assets, profit margin, the trading
volume ratio of L Corporation Group. In the early days when the Bank of China contact with the enterprise, the data of supply chain enterprises has been collected by Banks. Due to the lack of new information, the adjustment coefficient of the credit rating ($\alpha$) given by the bank through priori information is “1” at the initial stage.

3.2. Sample analysis

In this paper, the transaction data of 2015 of L Corporation Group and its upstream and downstream enterprises in the liquor supply chain were selected as samples, which came from the transaction platform database of L Corporation Group and Bank of China that provided financial services for it. We select 100 upstream and downstream supply chain enterprises of L Corporation Group from the data provided by the transaction platform (denoted as $A_i$, $i=1,2...100$). And according to the principle of consistent research period, same or similar industry, similar asset scale and hypothecated property, 100 paired samples were selected from the small and medium enterprises (SMEs) that obtained credit line from Bank of China (denoted as $B_i$, $i=1...100$) as a comparison sample.

It can be seen from Table 1 that SMEs with supply chain financial background have greater advantages over SMEs with non-supply chain financial background in terms of credit line and financing cost. In hypothecated property value of the same or similar cases, SMEs with the background of supply chain finance are often able to obtain higher credit line and lower financing cost. The existence of the background of supply chain finance not only creates conditions for enterprises to carry out credit guarantee, but also reduces Information search costs for enterprises and improves the enthusiasm of banks to lend. For the credit line difference of enterprises with supply chain financial background is higher than that of enterprises with non-supply chain financial background, the explanation is that the bank takes the proposed credit enterprises as a whole to obtain the additional credit line when granting credit to the whole supply chain, which is the difference value between formula (6) and formula (3).

| Supply Chain Enterprises | Credit Line | Financing Cost | Non Supply Chain Enterprises | Credit Line | Financing Cost |
|--------------------------|-------------|----------------|-------------------------------|-------------|----------------|
| $A_1$                    | 1900        | 200            | $B_1$                        | 700         | 85             |
| $A_2$                    | 1700        | 190            | $B_2$                        | 1490        | 182            |
| $A_3$                    | 2350        | 240            | $B_3$                        | 650         | 70             |
| $A_4$                    | 600         | 62             | $B_4$                        | 268         | 38             |
| $A_5$                    | 700         | 75             | $B_5$                        | 850         | 90             |
| $A_6$                    | 1950        | 210            | $B_6$                        | 1000        | 132            |
| $A_7$                    | 990         | 100            | $B_7$                        | 296         | 30             |
| $A_8$                    | 1000        | 100            | $B_8$                        | 800         | 84             |
| $A_9$                    | 1410        | 150            | $B_9$                        | 1188        | 140            |
| $A_{10}$                 | 900         | 95             | $B_{10}$                     | 809         | 85             |

On the other hand, for enterprises with supply chain financial background, we obtain the relationship between credit line and data sharing degree by controlling enterprise scale and taking the proportion of transaction volume between these enterprises and L Corporation Group as the data sharing degree index (See Figure 1A). Under the control of enterprise scale, with the increase of data sharing degree between other enterprises and core enterprises in the supply chain, the credit line obtained also increases. The conclusion that the increase of data sharing degree can expand the credit line of enterprises is basically consistent with the results of field surveys: by maintaining close information sharing with core enterprises, supply chain enterprises can expand the credit guarantee role of core enterprises and improve the credit rating. On the one hand, the expanded credit line is reflected in the increase of basic credit due to the adjustment of credit rating of supply chain...
enterprises by banks and other financial institutions. On the other hand, due to the expansion of data sharing degree among supply chain enterprises, banks further bring the movable property and products in transit into the scope of mortgage through the comprehensive understanding of enterprise information through big data, so as to expand the value of hypothecated property of enterprise, which was explained in the difference value between formula (7) and formula (6).

![Figure 1. Granted credit line.](A)

3.3. Model calculation
Applying the credit line model above, 100 enterprises subordinate to the supply chain of L Corporation group were selected, the corresponding financial data were brought into the model to calculate the theoretical credit line. Then we compared the theoretical credit line with the actual credit line obtained by matching the comparison sample (See Figure 1B). The theoretical credit line of supply chain enterprises is generally higher than the actual credit line, which indicates that the existing supply chain enterprises generally have insufficient credit. However, the trend of the theoretical credit line and actual credit line of the supply chain enterprises is basically consistent, which indicates that the model is inherently consistent with the actual credit line of the bank. On the other hand, non-supply chain enterprises actually get the lowest credit line, which confirms the advantages of supply chain background in financing for small and medium-sized enterprises. There is a difference between the trend of the actual credit line of non-supply chain enterprises and the trend of the actual credit line of supply chain enterprises, which shows that the information of enterprises with a supply chain background can be organized in the form of supply chains, and banks can directly obtain effective information from the supply chain, reducing the difficulty in information search and identification, which can reduce the cost of corporate financing. In Table 1, the difference of unit financing cost between supply chain enterprises and non-supply chain enterprises reflects the degree of information acquisition and discrimination. Thereby, the validity of the credit line model proposed in this paper is better proved.

4. Conclusions and prospects
The development of supply chain finance extends a new domain for banks, and data sharing has become a new way to solve the financing dilemma of medium, small and micro enterprises. It is a perfect combination of increasing the financing scale of enterprises and expanding the business scope of commercial Banks in a reasonable degree of risk. This paper analyses the advantages of financing through data sharing mode under supply chain finance over traditional financing, and establishes the credit line model of supply chain enterprises based on this. And the conclusions are: 1. Supply chain can integrate information advantages, increase credit line and reduce financing cost; 2. As the degree of data sharing increases, the credit line of supply chain enterprises increases; 3. The existing credit model of the bank is conservative, and the actual credit line of the enterprise is insufficient. The
problem of insufficient bank credit will restrict the development of supply chain enterprises, thus reducing the efficiency of the whole supply chain and weakening the advantages of supply chain finance. Once the development of the supply chain is affected, it will also have a negative effect on the healthy growth of the bank's business. Banks can use the credit model established in this paper to determine their credit line to achieve the purpose of accurate credit, so as to achieve the win-win situation for the supply chain enterprises to maximize the financing scale and minimize the risks of commercial banks.

References
[1] Martin J S and Santomero A M 1997 Investment opportunities and corporate demand for lines of credit[J]. Journal of Banking & Finance 21(10) 1331-1350
[2] Chava S and Jarro R 2008 Modeling loan commitments[J]. Finance Research Letters 5(1) 11-20
[3] Dell'Ariccia G and Marquez R 2004 Information and bank credit allocation[J]. Journal of Financial Economics 72(1) 185-214
[4] Taylor J 2002 A unified approach to credit limit setting[J]. RMA Journal 84(10) 56-61
[5] Stanhouse B, Schwarzkopf A and Ingram M 2011 A computational approach to pricing a bank credit line[J]. Journal of Banking & Finance 35(6) 1341-1351
[6] Zambaldi F, Aranha F, Lopes H and Politi R 2011 Credit granting to small firms: A Brazilian case[J]. Journal of Business Research 64(3) 309-315
[7] Norden L and Weber M 2010. Credit line usage, checking account activity, and default risk of bank borrowers[J]. Review of Financial Studies.
[8] Thakor A V 1982 Toward a theory of bank loan commitments[J]. Journal of Banking & Finance 6(1) 55-83
[9] Chateau J P D 1990 Valuation of ‘capped’variable rate loan commitments[J]. Journal of Banking & Finance 14(4) 717-728
[10] Hau A 2011 Pricing of loan commitments for facilitating stochastic liquidity needs[J]. Journal of Financial Services Research 39(1-2) 71-94
[11] Srivastava U and Gopalkrishnan S 2015 Impact of big data analytics on banking sector: Learning for Indian banks[J]. Procedia Computer Science (50) 643-652
[12] Bosch O and Steffen S 2011 On syndicate composition, corporate structure and the certification effect of credit ratings[J]. Journal of Banking & Finance 35(2) 290-299
[13] Grunert J, Norden L and Weber M 2005 The role of non-financial factors in internal credit ratings[J]. Journal of Banking & Finance 29(2) 509-531
[14] Tsao Y C 2017 Managing default risk under trade credit: Who should implement Big-Data analytics in supply chains?[J]. Transportation Research Part E: Logistics and Transportation Review (106) 276-293
[15] Summers B and Wilson N 2000 Trade credit management and the decision to use factoring: An empirical study[J]. Journal of Business Finance & Accounting 27(1-2) 37-68
[16] Begena J, Farboodi M and Veldkamp L 2018 Big data in finance and the growth of large firms[J] Journal of Monetary Economics (97) 71-87
[17] Gong D, Liu S, Liu J and Ren L 2019 Who benefits from online financing? A sharing economy E-tailing platform perspective[J]. International Journal of Production Economics 9(11) 1-10
[18] Wuttke D A, Blome C, Foerstl K and Henke M 2013 Managing the innovation adoption of supply chain finance—Empirical evidence from six European case studies[J]. Journal of Business Logistics 34(2) 148-166
[19] Pfohl H C and Gomm M 2009 Supply chain finance: optimizing financial flows in supply chains[J] Logistics research 1(3-4) 149-161