Financial Credit Risk and Core Enterprise Supply Chains*

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Abstract

Supply chain finance has broken through traditional credit modes and advanced rapidly as a creative financial business. Core enterprises have played a crucial role in the credit enhancement of supply chain finance. Through the analysis of the core enterprise credit risks in supply chain finance, by means of Fuzzy Analytical Hierarchy Process (FAHP), the paper constructs a supply chain financial credit risk evaluation system, leading to quantitative measurement and evaluation of core enterprise credit risk. This novel approach should assist enterprises in taking appropriate measures to control credit risk, thereby promoting the healthy development of supply chain finance.

Keywords: Supply chain finance; Core enterprises; Credit risk; Fuzzy analytic hierarchy process (FAHP).

JEL: P42, H81, D81, G32.

1. Introduction

With the development of the national economy in China, small and medium-sized enterprises (SMEs) have played the most significant role in developing growth in the economy. Chinese SMEs have recently achieved great progress, which has accounted for over 98% of all enterprises, and have contributed more than 60% of the growth in GDP and foreign trade for economic development nationwide, provided over 80% job opportunities, and generated more than 50% of business revenue. Although SMEs have achieved significant outputs and performance, and have played an irreplaceable role in the process of promoting the national economy, their financial environment is widely seen as being rather grim.

SMEs face greater financial constraints than larger firms, so there are measures to alleviate the financial constraints facing SMEs, such as leasing and factoring that are helpful in facilitating access to finance without having well-developed financial institutions. Numerous studies have argued that SMEs are financially more constrained than are large firms.

SMEs are major players in the economy, and the current market failure is an obstacle to growth, so they need support from all forms of government. However, despite growing interest in subsidizing SMEs, there are serious concerns as to whether these measures are actually helpful. According to the statistics of the Bank of China, SMEs have obtained bank loans that only account for 16% of the loans of financial institutions, the rate of bank supporting loans to SMEs can only reach 30% to 40%, and nearly 80% of SMEs are involved in capital circulation problems.

Therefore, SMEs have not received proportionately the financial support relative to the contributions that they have made. Indeed, their financial problems have become an important barrier regarding the sustainable development of SMEs. In this context, the financial supply chain has become absolutely crucial in the face of increasing financial credit risk.

The plan of the remainder of the paper is as follows. Section 2 provides a literature review, followed by the theory of supply chain financial core enterprise risk in Section

3. The Fuzzy Analytical Hierarchy Process is discussed in Section 4. Section 5 presents and discusses the empirical results. Some concluding comments are given in section 6.

2. Literature Review

Research on supply chain finance started internationally, and outside China, with the modes of operation relatively mature and the achievements rather substantial. Regarding the relationship between supply chains and financing, Berger et al. (2006) suggested a conceptual framework for the development of the global small and medium-sized enterprises to finance them, and thereby created the idea of supply chain finance. Klapper (2005) provided an analysis of the principle of the inventory financing model and discussed the operations that small and medium-sized enterprises had adopted in the supply chain.

The development of China's supply chain finance began around 2000. In 2005, the financing mode of "1 plus N" implemented by the Shenzhen Development Bank (since renamed the Ping An Bank) offered a $250 billion credit line, leading to a 25% profit. The non-performing loans involved accounted for only 0.57% of all supply chain finance that had been used in practice.

In recent years, supply chain finance has developed rapidly. Statistics show that by the end of 2015, 60% of SMEs had chosen to access supply chain finance to alleviate the shortage of business liquidity problems. However, as an innovative financing method, supply chain finance has certain risks, such as the financing of small and medium-sized enterprise core bank clients. It is possible that one client's credit problems could cause the failure of supply chain financing, with a loss to the other clients. SMEs are undoubtedly the engine of economic growth, but their speed of growth can be affected detrimentally by market imperfections and institutional weaknesses.

2.1 Definition of Supply Chain Finance

According to the definition of Supply Chain Finance (SCF) by Hofmann (2005), SCF relies on two or more independent organizations in the supply chain to cooperate on financial resources to create extra value jointly. Pfohl and Gomm (2009) suggest that SCF could also raise the values of participating firms in the supply chain, in addition to the values of leading firms in the supply chain.

According to Gupta and Dutta (2011), with greater and fiercer competition, it becomes increasingly important to improve the efficiency of working capital by the use of cash that is trapped in the financial supply chain (FSC). Mathis and Cavinato (2010) argue that banks should play a more active role in the FSC to integrate the resources in the chain. Silvestro and Lustrato (2014) show that banks are key players to offer alternative supply chain solutions in SCF.

Blackman et al. (2013) proposed a formal definition, as follows: a financial supply chain is the network of organisations and banks that coordinate the flow of money and financial transactions via financial processes and shared information systems in order to support and enable the flow of goods and services between trading partners in a product supply chain.

SCF can be defined in many ways. The analysis carried out on the different definitions and conceptual contributions highlights two major perspectives on SCF, which can be identified as “financial-oriented” (from which a further“buyer-driven perspective”can be identified), and “supply chain-oriented”. The financial perspective interprets SCF as a set of (innovative) financial solutions (Caniato et al., 2016).

SCF has increasingly become a hot topic in supply chain management, and a growing product category of financial institutions (FIs). In China, SCF is experiencing a rapid development stage, and numerous FIs have begun to focus on developing and designing new SCF services and products to solve the financing issues facing SMEs. SCF is a type of channel for financing, which manages, plans and controls all cash flows across supply chain members to improve the turnover efficiency of working capital.

In SCF, SMEs obtain loans with looser constraints from banks through expanded credit lines, core enterprises (CEs) alleviate the pressure of funding, and financial intermediaries dramatically increase their incomes. More specifically, SCF significantly decreases the credit risk of SMEs for FIs.

Nevertheless, SCF cannot eliminate credit risks completely, which continue to be one of the major threats to FIs. Moreover, SCF has been promoted for almost ten years and has experienced slow development in China as there is no appropriate SME credit risk

evaluation index system, or an outstanding prediction model, both of which can hinder SCF (Zhu et al., 2016).

SCF is concerned with the capital flows within a supply chain, an area that has often been neglected in the past, although SCF does have an impact on a firm's capability to adopt sustainable supply chain management (SCM) practices (Liu et al., 2015).

2.2 Credit Risk Evaluation of Supply Chain Finance

In China, SMEs are the main applicants of SCF, so that the bank suffers from credit risk in SCF when the SMEs are unable to honour an agreement. Researchers and bankers emphasize that structuring the SME credit risk evaluation index system is the largest and most critical challenge to bank management of SCF, and is also the fundamental work in credit loan decision making. A good credit risk evaluation index system can guarantee profitability and stability of a FI, whereas a poor system can potentially lead to serious losses (Zhu et al., 2016).

In previous studies, experts and scholars have paid greater attention to the credit risk of SMEs, while neglecting the credit risk of core enterprises, which is one of the main financial entities in the supply chain. In fact, the core enterprise credit risk is the key to influencing the effective implementation of supply chain finance.

Feldmann and Müller (2003) emphasize the role of asymmetric information held by supply chain partners that behave opportunistically. Silvestro and Lustrato (2014) argue that the following factors could affect the risk of SCF, such as supply chain co-ordination, cooperation, and information sharing.

Berger and Udell (1998) find that small firms have less access to external financing, and are more constrained by their operations, both in developing and developed countries. Galindo and Schiantarelli (2003) draw the same conclusion several years later.

Schiffer and Weder (2001) find that smaller firms consistently face greater growth obstacles than do larger firms, which suggests that size is one of the most reliable factors for determining a firm's financing obstacles, apart from age and ownership of firms (see Beck et al, 2006).

Stephens (2009) and Zipkin (2009) point out the methods of determining the quality of goods in the pawn finance process. Moreover, an investigation undertaken by Wuttke et al. (2013) indicate that it is better for the supply chain enterprises of SMEs to adopt a “pre-shipment” financing mode rather than using a “post-shipment” funding mode. Furthermore, both corporations and banks are very interested in using SCF techniques to ease tensions in the supply chain, and making large corporations maintain shorter payment periods for key suppliers (see Randall et al., 2009).

Zhu et al. (2016) propose an SME credit risk evaluation index system specifically for SCF. This system is used to evaluate the credit risks from different points of view, which not only consists of evaluating the financial and non-financial conditions of SME, but also contain the financial and non-financial conditions of CEs, the operational status of the entire supply chain, and the transactional relationship between SMEs and CEs (Zhu et al., 2016).

Therefore, measuring and evaluating the credit level of core enterprises, and controlling the credit risk of the core enterprise, is the key to using supply chain finance effectively, and then make supply chain finance run more efficiently.

2.3 Suggestions for Risk Control in Supply Chain Finance

As mentioned above, there has been substantial research on supply chain finance for SMEs, of which many have attained and maintained great success. However, some serious flaws remain. First, there has been little research on collaborative supply chain finance for SMEs. Second, the various studies are not quite systematic. Some studies concentrate on one aspect to solve the “Macmillan gap", but ignore the systematic analysis and the overall optimization of supply chain finance for SMEs.

Lee and Rhee (2011) demonstrate that, through the coordination and establishment of commercial credit among SMEs, the results of risk control for supply chain finance of SMEs are superior to the financial risk control exercised by financial institutions for the individual company.

The apparent ability of some supply chains to recover from inevitable risk events more effectively than others has more recently triggered a debate about supply chain resilience

(SCRES). Whereas SCRM focuses on the identification and management of risks for the supply chain in order to reduce its vulnerability, SCRES aims at developing the adaptive capability to prepare for unexpected events, and to respond to disruptions and learn how to recover from them (Jüttner and Maklan, 2011).

3. Theory of Supply Chain Financial Core Enterprise Risk

In supply chain finance, core enterprises are the exchange centers of capital flows, information flows and logistics, play an important role in supply chain financing. The risks can be highly varied, including the major risks, which are described below.

3.1 Credit Risk

In supply chain finance, the core enterprises play an important role. In fact, they play a key role in connecting the supply chain capital flows, information flows, and logistics. Banks are based on the core enterprise strong comprehensive strength and credit guarantee, and select the upstream and downstream enterprises to carry out credit business. Therefore, the core enterprise conditions and development prospects determine the smooth operation of the supply chain. The credit status of core business problems will inevitably spread to the supply chain through the upstream and downstream enterprises, thereby affecting the overall security of supply chain finance security and operational efficiency. These combined problems can lead to failures in financing the supply chain.

Core enterprise credit risk is mainly manifested in two outcomes. On the one hand, it is necessary and important to decide whether the core enterprise can undertake the entire supply chain finance guarantee function when they are under poor management themselves. The core enterprises may be confronted with a credit crisis due to bonding credit, which exceeds its credit capacity, resulting in the failure of financing.

On the other hand, when the core enterprise development prospects are not profitable, their power can be diminished. Core enterprises may conceal their real transaction records with different parties in the supply chain, thereby resulting in false financing. This outcome can affect their ability to perform adequately, so that they will not be able

to complete the agreement already undertaken with the bank, with the result that the SMEs financing may eventually fail.

3.2 Guarantee Risks

For the core enterprises, the so-called guarantee risks are mainly in financing when SMEs break a contract, that is, they cannot reimburse the bank for their loans. The core enterprises, as a guarantor of SMEs, need to bear the bank losses. In supply chain finance, guaranteeing the role of the core enterprise of the credit situation of SMEs, and the core enterprise with the core enterprise bundle, requires strong economic strength, the possibility of reducing the risk of banks that are willing to lend money to SMEs, promoting the enterprise production and business development, will enable the enterprising core enterprises to provide credit to SMEs. Therefore, the core enterprises should be very careful in selecting the SMEs in the supply chain.

3.3 Operational Risks

There are substantial administrative processes in supply chain financing, with the various steps having to be confirmed manually, so the operational risk is also an objective reality. The operation of the three main financing risks are also different. For example, the operational risk of the accounts receivable financing mode focuses primarily on the management of accounts receivable.

First, the existence of sales discounts will incur errors when the accounts receivable are checked, coupled with the fact that the receivables financing is a regular act. The specific payments and the actual deviations occur when the core enterprises confirm the payments. Second, when the accounts receivable settlements are made, as it involves different enterprises and additional settlement accounts, with complicated repayment procedures, and frequent changes in the payment of the accounts receivable transfers, errors are prone to recur.

In summary, the greatest impact on the supply chain of the three risks discussed above is financial credit risk. As the main participant in the supply chain, the core enterprise credit level has a great influence on the success of financing. In order to reduce the financial risks in the supply chain, effective control of core enterprise credit risk is absolutely crucial.

4. Fuzzy Analytical Hierarchy Process (FAHP)

Saaty (1990) introduces a multi-factors decision making approach, in which factors are arranged in a hierarchic structure. In order to apply the AHP method, it is necessary to construct a hierarchy that expresses the relative values of a set of attributes. Decision-makers evaluate the relative importance of the attributes in each level based on the AHP scale which, in turn, is used to direct decision-makers to express their preferences between each pairwise comparison. They are required to select whether the element is of equal importance, somewhat more important, much more important, very much more important, or absolutely important to another.

These important intensities are, respectively, converted to numeral values in the AHP Scale as 1, 3, 5, 7, 9, and 2, 4, 6, 8 as the intermediate values (Table 1). By using this scale, the qualitative judgments of evaluators are converted into quantitative values, which construct a pairwise comparison matrix. The pairwise comparison matrix is made for all elements to be considered in the construct hierarchy, and the results from these comparisons are used to calculate a list of relative weights and importance of the factors (eigenvectors) based on the rapid application development (RAD) method.

4.1 Establishment of Fuzzy Judgment Matrix

Fuzzy judgment matrix can be used to compare the importance of different indicators. The level of importance of two elements are assumed to be in index T, and the hierarchical element a1, a2, a3 represent the existing fuzzy relation, all of which constitute a fuzzy matrix.

In fuzzy matrix, r_{ij} denotes judgment value, which represents the extent to which a_i is much more important than a_j when comparing the two elements a_i and a_j:

T	a_1	a_2	⋯	a_n
a_1	r_{11}	r_{12}	⋯	r_{1n}
a_2	r_{21}	r_{22}	⋯	r_{2n}
a_n	r_{n1}	r_{n2}	⋯	r_{nn}

Pairwise comparisons among the main factors, sub-factors, and alternatives are produced based on the typical nine-point scale that is combined with fuzzy numbers. The next step is to calculate the priority weights of factors, sub-factors, and alternatives by adopting the FAHP approach. The idea of calculating the priority weights of attributes is based on the pairwise comparisons given in the questionnaire. In doing so, a set of comparison questions was made to ask experts for their opinions. The higher is the evaluation, the greater will be the importance of a factor.

Corresponding to three levels of the hierarchical model, the experts first evaluate the four main factors in the second level with respect to the overall goal. Second, in the third level, pairwise comparisons of alternatives are made with respect to the overall goal. In order to obtain the quantitative value of the compared importance between each two indicators, fuzzy numerical values from 1 to 9 are used, as shown in Table 1. Undertaking comparisons between each two factors, the fuzzy judgement matrix can be obtained.

Table 1

FAHP scale

Intensity of AHP Scale	Linguistic Variable	Positive Value	Positive Reciprocal Value
1	Same importance	(1, 1, 1)	(1, 1, 1)
3	Weakly more important	(2, 3, 4)	(1/4, 1/3, 1/2)
5	Fairly more important	(4, 5, 6)	(1/6, 1/5, 1/4)
7	Strongly more important	(6, 7, 8)	(1/8, 1/7, 1/6)
9	Absolutely more important	(8, 9, 10)	(1/10, 1/9, 1/8)
2, 4,6,8	Intermediate values		

4.2 Fuzzy Judgment Matrix Consistency Check

Consistency check is the first condition to calculate the weights, and only if the consistency meets the requirements can the model can be solved. A relatively simple judgment method uses the following formula:

$$\text{CI (A, W)} = \frac{1}{n2}\sum_{i=1}^{n}\sum_{j=1}^{n}\left|aij - \omega ij\right| .$$

.

The acceptable condition of consistency judgment is CI (A, W) $\leqslant \alpha$, where the implication of α is the attitude of the decision maker. The higher is the consistency of the fuzzy judgment matrix that the decision maker requires, the smaller will be the value of α, which is most suitable when set to 0.01.

4.3 Weight Vector of Criterion Layer B

The determination of the weight vector is the key to the fuzzy judgment matrix. The fuzzy judgment matrix is obtained after sorting out the results of the questionnaire given by the experts. Formula (1) is used to solve the weight vector of each criterion layer, the weight given to each expert is multiplied by the weight vector, and the weight vector of the elements at the B layer, such that $\omega_B = (\omega_1, \dots, \omega_n)$, can be obtained:

$$\omega i = \frac{\sum_{j=1}^{n} aij + 1 - \frac{n}{2}}{n} \qquad \text{for any } i = 1,2,\cdots, \ n. \tag{1}$$

4.4 Weight Vector of Index Layer C to Criterion Layer B

Each decision expert takes the B layer elements as the criterion, and gives the fuzzy judgment matrix, which is obtained by the C level elements. After comparing two fuzzy judgment matrices with the same method, the weight vector of each element of the C layer can be obtained.

4.5 Composite Weight Vector

After calculating the priority weight vectors of the B and C layers, the following formula (2) is used to compute the composite weight vector, and the priority weight vector of different indexes to credit risk can be obtained, and the key risk factors can be identified:

$$\omega j = \sum_{i=1}^{n} wiw_j^i \qquad (2)$$

where ω_j is the index values of No. j element, w_i is the weight vector of the No. i criterion layer of the No. j index value.

5. Empirical Analysis

5.1 Core Enterprises

Wuhan Iron and Steel Group is affiliated with the state-owned SASAC important backbone enterprises. Wuhan Iron and Steel Group Company has a good credit status and strong financial strength, and is among the core enterprises in the supply chain finance. Wuhan Iron and Steel Group is in the production stage in three stages of the product supply, production, and sales. The upstream enterprises mainly act as steel materials suppliers, which are responsible for the production of steel, and has applied to banks for loans by means of the receivables documents in the financing process.

Downstream enterprises are mainly steel dealers, which are responsible for the sale of steel. In the financing process, they select the financing mode of prepayment to purchase and apply for loans based on sales contracts. China Industrial Bank (CIB) has been cooperating with Wuhan Iron and Steel Group in supply chain finance since 2002.

Until December 2015, China Industrial Bank had 53 credit lines among the upstream and downstream dealers of Wuhan Iron and Steel Group, with a credit amount exceeding RMB 1.536 billion. The non-performing loan ratio of the upstream and downstream enterprises is very low, almost zero, which is a successful case of implementing supply chain finance.

5.2. Build Evaluation System of the Core Enterprise Credit Risk

The core enterprise risk control is the most important factor in the supply chain risk, so the construction of the core enterprise credit risk system is crucial. The paper makes layer analysis from four aspects, that is, the core enterprise industry position, management situation, asset status, and credit record.

The core enterprise industry status (B1): The achievement of inter-enterprise transactions not only relies on the quality of goods. Industry status is also the focus of attention and, in general, the core enterprise industry status greatly affects their business conditions. The paper selects the macroscopic environment and the development situation of the enterprises as the secondary index of industry status evaluation.

Core enterprise operations (B2): Banks are more concerned about the operation of the core enterprises with guarantees, the reason being that the core enterprises need to assume the guarantee obligation in the case of default of the SMEs. If the core enterprises do not have high solvency, banks will find it difficult to offer loans to the SMEs in financing, considering their own interests. The operating performance of the core enterprises are mainly reflected in the three indicators of profitability, operating capacity, and solvency. The paper selects these three indexes as secondary indicators of the evaluation system.

Asset status of the core enterprises (B3): The main premise of bank loans is that the core enterprises provide security for SMEs such that, when SMEs breach contracts, the core enterprises will take responsibility for guarantees, compensating banks, thereby reducing bank losses. Therefore, the asset status of the core enterprises is also the focus of bank inspections, and the ability of the enterprises to cash assets is stronger than that of the monetary funds, receivable accounts and inventory. The paper will take the three items as the secondary index of the current asset status evaluation.

Core enterprise credit history (B4): The key to the successful financing of SMEs is that the core enterprise credit guarantee can be bundled together with SMEs to form overall credit. However, if the credit situation of the core enterprises is poor, even if the

SME and the core enterprises credit are bundled, the bank will not permit loans. The paper selects credit rating and previous performance as a secondary index.

The hierarchy of evaluation system of core enterprise credit risk is constructed as shown in Figure 1.It is divided into three levels, and arranged in descending order. The first level presents the overall goal, which is risk evaluation of supply chain financial core enterprises (A), and is located at the top of the hierarchy.

In the second level, four major factors drawn are inserted into the model, namely industry status (B1), operation condition (B2), asset state (B3), and credit record (B4). Each factor includes several sub-factors in the third level of the hierarchy. Industry status is explained by two sub-factors, namely macro-environment (C1) and enterprise development (C2). Operation condition includes operation ability (C3), profitability (C4) and solvency (C5). Asset state consists of monetary fund (C6), accounts receivable (C7) and inventory (C8). Credit history includes enterprise credit rating (C9) and past performance (C10).

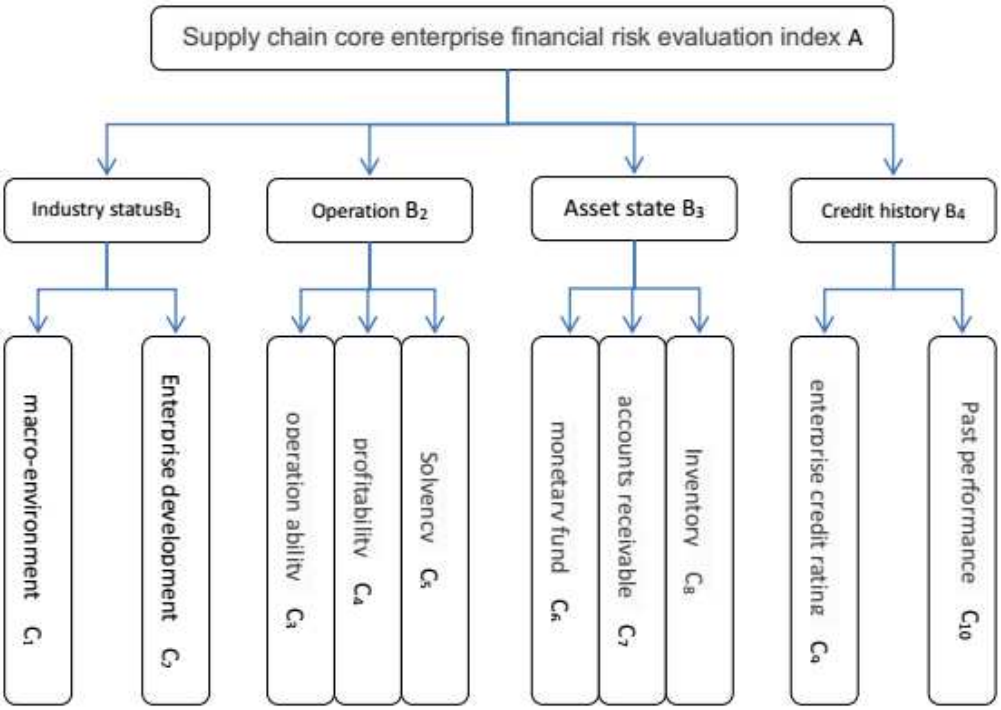

Figure 1

Core enterprise credit risk evaluation system hierarchy graph

5.3 Model Construction and Solution

By using the risk evaluation system described above, including 4 risk categories and 10 risk factors, the risk identification model is established by the fuzzy analytic hierarchy process (AHP), and the model can be solved. In this paper, core enterprise employees are divided into four categories: managerial staff, senior engineers, middle-level employees, and general employees, and score the questionnaire according to four types of employees, leading to the four fuzzy matrices, B1, B1, B2, B3, B4. These 4 categories of employees are given different weights, with managerial staff given 0.3, senior engineers 0.3, middle-level staff 0.2, and general employees 0.2. Various types of employees on the B-layer elements of the two pairs are compared, and the fuzzy judgment matrix is obtained, as shown below:

$$B_1=\begin{bmatrix}0.5 & 0.7 & 0.6 & 0.4\\ 0.3 & 0.5 & 0.4 & 0.4\\ 0.4 & 0.6 & 0.5 & 0.3\\ 0.6 & 0.6 & 0.7 & 0.5\end{bmatrix} \qquad B_2=\begin{bmatrix}0.5 & 0.8 & 0.7 & 0.6\\ 0.2 & 0.5 & 0.5 & 0.4\\ 0.3 & 0.5 & 0.5 & 0.3\\ 0.4 & 0.6 & 0.7 & 0.5\end{bmatrix}$$

$$B_3=\begin{bmatrix}0.5 & 0.7 & 0.8 & 0.6\\ 0.3 & 0.5 & 0.6 & 0.4\\ 0.2 & 0.4 & 0.5 & 0.3\\ 0.4 & 0.6 & 0.7 & 0.5\end{bmatrix} \qquad B_4=\begin{bmatrix}0.5 & 0.8 & 0.9 & 0.5\\ 0.2 & 0.5 & 0.7 & 0.2\\ 0.1 & 0.3 & 0.5 & 0.3\\ 0.5 & 0.8 & 0.7 & 0.5\end{bmatrix}$$

Fuzzy judgment matrices are used to determine the fuzzy consistency of the four matrices B1, B2, B3, B4, and the weight order vectors ω_{B1}, ω_{B2}, ω_{B3}, ω_{B4}, respectively, can be solved.

For example, consider B1 as an example to solve:

$$\omega_{B11}=\frac{1}{4}\left(0.5+0.3+0.4+0.6+1-\frac{4}{2}\right)=0.2$$

$$\omega_{B12}=\frac{1}{4}\left(0.7+0.5+0.6+0.6+1-\frac{4}{2}\right)=0.35$$

$$\omega_{B13}=\frac{1}{4}\left(0.6+0.4+0.5+0.7+1-\frac{4}{2}\right)=0.3$$

$$\omega_{B14}=\frac{1}{4}\left(0.4+0.4+0.3+0.5+1-\frac{4}{2}\right)=0.15$$

Thus, $\omega_{B1}=(0.2\ 0.35\ 0.3\ 0.15)$

In a similar manner, it follows that: $\omega_{B2}=(0.1\ 0.35\ 0.35\ 0.2)$ $\omega_{B3}=(0.1\ 0.3\ 0.4\ 0.2)$ and $\omega_{B4}=(0.075\ 0.35\ 0.45\ 0.125)$

On this basis, the weights of the four categories of employees are added, and the B-level weight vector can be obtained:

$$\omega_{B1}=0.3\times0.2+0.3\times0.1+0.2\times0.1+0.2\times0.075=0.125$$

$$\omega_{B2}=0.3\times0.35+0.3\times0.35+0.2\times0.4+0.2\times0.35=0.34$$

$$\omega_{B3}=0.3\times0.3+0.3\times0.35+0.2\times0.4+0.2\times0.45=0.365$$

$$\omega_{B4}=0.3\times0.15+0.3\times0.2+0.2\times0.2+0.2\times0.125=0.17$$

As a result, the weight vector of the criterion layer to the target layer is determined as (0.125, 0.34, 0.36, 0.17). From the above, the total weight vector of the criterion layer to the target layer can be seen, the core enterprise asset weight is 0.365, ranked first; operating weight is 0.33, ranked second; credit record weight is 0.17, ranked third; and industry position weight is 0.125, ranked fourth. This ranking shows that commercial banks are most concerned about the asset status of the core enterprise, followed in second place as the core enterprise operations, the third is the credit record of the core enterprise, and the final is the core enterprise industry status.

Under the premise of calculating the weights of the criterion layer, the weight value of each risk factor in the index layer can be obtained. According to the questionnaire survey results of four kinds of employees, the 10 risk factors in the index layer are compared with each other, the fuzzy judgment matrix can be constructed, and the single ranking weight vector can be obtained according to the judgment matrix. In this paper, the weight vector of the criterion layer B to the each element in the C layer is taken as an example. The fuzzy judgment matrix C_{1k}（k = 1,2,3,4）is constructed as follows:

$$C_{11}=\begin{bmatrix} 0.5 & 0.4 & 0.3 & 0.5 & 0.7 & 0.3 & 0.5 & 0.2 & 0.4 & 0.5 \\ 0.6 & 0.5 & 0.6 & 0.4 & 0.6 & 0.3 & 0.3 & 0.7 & 0.5 & 0.4 \\ 0.7 & 0.4 & 0.5 & 0.6 & 0.3 & 0.5 & 0.6 & 0.8 & 0.5 & 0.6 \\ 0.5 & 0.6 & 0.4 & 0.5 & 0.7 & 0.8 & 0.2 & 0.4 & 0.3 & 0.5 \\ 0.3 & 0.4 & 0.7 & 0.3 & 0.5 & 0.5 & 0.2 & 0.9 & 0.5 & 0.3 \\ 0.7 & 0.7 & 0.5 & 0.2 & 0.5 & 0.5 & 0.6 & 0.8 & 0.3 & 0.5 \\ 0.5 & 0.7 & 0.4 & 0.8 & 0.8 & 0.4 & 0.5 & 0.3 & 0.2 & 0.4 \\ 0.8 & 0.3 & 0.2 & 0.6 & 0.1 & 0.2 & 0.7 & 0.5 & 0.7 & 0.5 \\ 0.6 & 0.5 & 0.5 & 0.7 & 0.5 & 0.7 & 0.8 & 0.3 & 0.5 & 0.5 \\ 0.5 & 0.6 & 0.4 & 0.5 & 0.7 & 0.5 & 0.6 & 0.5 & 0.5 & 0.5 \end{bmatrix}$$

$$C_{12}=\begin{bmatrix} 0.5 & 0.4 & 0.7 & 0.6 & 0.5 & 0.3 & 0.4 & 0.5 & 0.7 & 0.4 \\ 0.6 & 0.5 & 0.9 & 0.5 & 0.2 & 0.5 & 0.3 & 0.4 & 0.5 & 0.5 \\ 0.3 & 0.1 & 0.5 & 0.5 & 0.4 & 0.7 & 0.6 & 0.4 & 0.5 & 0.5 \\ 0.4 & 0.5 & 0.5 & 0.5 & 0.5 & 0.6 & 0.5 & 0.3 & 0.3 & 0.4 \\ 0.5 & 0.8 & 0.6 & 0.5 & 0.5 & 0.4 & 0.5 & 0.4 & 0.6 & 0.3 \\ 0.7 & 0.5 & 0.3 & 0.4 & 0.6 & 0.5 & 0.2 & 0.5 & 0.6 & 0.5 \\ 0.6 & 0.7 & 0.4 & 0.5 & 0.5 & 0.8 & 0.5 & 0.4 & 0.6 & 0.4 \\ 0.5 & 0.6 & 0.6 & 0.7 & 0.6 & 0.5 & 0.6 & 0.5 & 0.1 & 0.3 \\ 0.3 & 0.5 & 0.5 & 0.7 & 0.4 & 0.4 & 0.4 & 0.9 & 0.5 & 0.5 \\ 0.6 & 0.5 & 0.5 & 0.6 & 0.7 & 0.5 & 0.6 & 0.7 & 0.5 & 0.5 \end{bmatrix}$$

$$C_{14}=\begin{bmatrix} 0.5 & 0.3 & 0.4 & 0.5 & 0.5 & 0.7 & 0.6 & 0.4 & 0.8 & 0.5 \\ 0.7 & 0.5 & 0.6 & 0.9 & 0.4 & 0.7 & 0.5 & 0.3 & 0.3 & 0.4 \\ 0.6 & 0.4 & 0.5 & 0.2 & 0.5 & 0.3 & 0.6 & 0.6 & 0.5 & 0.3 \\ 0.5 & 0.1 & 0.8 & 0.5 & 0.6 & 0.8 & 0.7 & 0.5 & 0.4 & 0.5 \\ 0.5 & 0.6 & 0.5 & 0.4 & 0.5 & 0.6 & 0.7 & 0.2 & 0.2 & 0.4 \\ 0.3 & 0.3 & 0.7 & 0.2 & 0.4 & 0.5 & 0.3 & 0.5 & 0.6 & 0.5 \\ 0.4 & 0.5 & 0.4 & 0.3 & 0.3 & 0.7 & 0.5 & 0.6 & 0.5 & 0.6 \\ 0.6 & 0.7 & 0.4 & 0.5 & 0.8 & 0.5 & 0.4 & 0.5 & 0.3 & 0.4 \\ 0.2 & 0.7 & 0.5 & 0.6 & 0.8 & 0.4 & 0.5 & 0.7 & 0.5 & 0.7 \\ 0.5 & 0.6 & 0.7 & 0.5 & 0.6 & 0.5 & 0.4 & 0.6 & 0.3 & 0.5 \end{bmatrix}$$

$$C_{13}=\begin{bmatrix} 0.5 & 0.3 & 0.4 & 0.6 & 0.5 & 0.5 & 0.7 & 0.4 & 0.6 & 0.7 \\ 0.7 & 0.5 & 0.5 & 0.3 & 0.6 & 0.9 & 0.5 & 0.3 & 0.5 & 0.6 \\ 0.6 & 0.5 & 0.5 & 0.6 & 0.5 & 0.6 & 0.2 & 0.4 & 0.3 & 0.5 \\ 0.4 & 0.7 & 0.4 & 0.5 & 0.4 & 0.3 & 0.7 & 0.6 & 0.5 & 0.4 \\ 0.5 & 0.4 & 0.5 & 0.6 & 0.5 & 0.4 & 0.4 & 0.5 & 0.4 & 0.2 \\ 0.5 & 0.1 & 0.4 & 0.7 & 0.6 & 0.5 & 0.7 & 0.4 & 0.5 & 0.4 \\ 0.3 & 0.5 & 0.8 & 0.3 & 0.6 & 0.3 & 0.5 & 0.2 & 0.6 & 0.5 \\ 0.6 & 0.7 & 0.6 & 0.4 & 0.5 & 0.6 & 0.8 & 0.5 & 0.4 & 0.2 \\ 0.4 & 0.5 & 0.7 & 0.5 & 0.6 & 0.5 & 0.4 & 0.6 & 0.5 & 0.7 \\ 0.3 & 0.4 & 0.5 & 0.6 & 0.8 & 0.6 & 0.5 & 0.8 & 0.3 & 0.5 \end{bmatrix}$$

The same method is used to obtain the weight vectors:

$$\omega_{C11}=\frac{1}{10}(0.5+0.6+0.7+0.5+0.3+0.7+0.5+0.8+0.6+0.5+1-\frac{10}{2})=0.17$$

$$\omega_{C12}=\frac{1}{10}(0.4+0.5+0.4+0.6+0.4+0.7+0.7+0.3+0.5+0.6+1-\frac{10}{2})=0.11$$

$$\omega_{C13}=\frac{1}{10}(0.3+0.6+0.5+0.4+0.7+0.5+0.4+0.2+0.5+0.4+1-\frac{10}{2})=0.05$$

$$\omega_{C14}=\frac{1}{10}(0.5+0.4+0.6+0.5+0.3+0.2+0.8+0.6+0.7+0.5+1-\frac{10}{2})=0.11$$

$$\omega_{C15}=\frac{1}{10}(0.7+0.6+0.3+0.7+0.5+0.5+0.8+0.1+0.5+0.7+1-\frac{10}{2})=0.14$$

$$\omega_{C16}=\frac{1}{10}(0.3+0.3+0.5+0.8+0.5+0.5+0.4+0.7+0.2+0.5+1-\frac{10}{2})=0.07$$

$$\omega_{C17}=\frac{1}{10}(0.5+0.3+0.6+0.2+0.2+0.6+0.5+0.7+0.8+0.6+1-\frac{10}{2})=0.1$$

$$\omega_{C18}=\frac{1}{10}(0.2+0.7+0.8+0.4+0.9+0.8+0.3+0.5+0.3+0.5+1-\frac{10}{2})=0.14$$

$$\omega_{C19}=\frac{1}{10}(0.4+0.5+0.5+0.3+0.3+0.3+0.2+0.7+0.5+0.5+1-\frac{10}{2})=0.02$$

$$\omega_{C10}=\frac{1}{10}(0.5+0.4+0.6+0.5+0.3+0.5+0.4+0.5+0.5+0.5+1-\frac{10}{2})=0.07$$

Therefore, ω_{C1} =（0.17 0.11 0.05 0.11 0.14 0.07 0.1 0.14 0.02 0.07）

and similarly： ω_{C2}=（0.1 0.11 0.15 0.15 0.09 0.12 0.06 0.1 0.09 0.03）

ω_{C3}=（0.08 0.06 0.13 0.11 0.16 0.12 0.14 0.07 0.06 0.07）

ω_{C4}=（0.08 0.07 0.15 0.06 0.14 0.17 0.12 0.09 0.04 0.08）

Based on the weight vectors of the four kinds of employee fuzzy judgment matrices, the weight coefficients of four kinds of employees are added to obtain the group weight vector:

$\omega_{C1}=0.3\times0.17+0.3\times0.1+0.2\times0.08+0.2\times0.08=0.113$

$\omega_{C2}=0.3\times0.11+0.3\times0.11+0.2\times0.06+0.2\times0.07=0.092$

$\omega_{C3}=0.3\times0.05+0.3\times0.15+0.2\times0.13+0.2\times0.15=0.116$

$\omega_{C4}=0.3\times0.11+0.3\times0.15+0.2\times0.11+0.2\times0.06=0.112$

$\omega_{C5}=0.3\times0.14+0.3\times0.09+0.2\times0.16+0.2\times0.14=0.129$

$\omega_{C6}=0.3\times0.07+0.3\times0.12+0.2\times0.12+0.2\times0.17=0.115$

$\omega_{C7}=0.3\times0.1+0.3\times0.06+0.2\times0.14+0.2\times0.12=0.1$

$\omega_{C8}=0.3\times0.14+0.3\times0.1+0.2\times0.07+0.2\times0.09=0.104$

$\omega_{C9}=0.3\times0.02+0.3\times0.09+0.2\times0.06+0.2\times0.04=0.044$

$\omega_{C10}=0.3\times0.07+0.3\times0.03+0.2\times0.07+0.2\times0.08=0.075$

Therefore, the weight vector of the criterion layer B_1 to the index layer is given as:

$\omega_{C1}=$（0.113 0.092 0.116 0.112 0.129 0.115 0.1 0.104 0.044 0.075）

Similarly, the weight vectors of the criterion layers B2, B3, B4 to the index layer (layer C) can be summarized as follows:

The weight vector of the criterion layer B_2 to the index layer is given as:

$\omega_{C2}=$（0.078 0.072 0.127 0.12 0.095 0.135 0.102 0.094 0.072 0.105）

The weight vector of criterion layer B_3 to index layer is given as:

ω C3=（0.079 0.072 0.125 0.141 0.116 0.112 0.097 0.08 0.079 0.099）

The weight vector of criterion layer B_4 to index layer is given as:

ω C4=（0.085 0.089 0.129 0.125 0.107 0.111 0.092 0.116 0.079 0.067）。

The weight vector ω_C of the target layer can be obtained by calculating the criterion layer weight vector for the target layer and the index layer. Taking C_1 as the index, the weight vector of the operating capacity is given as:

$0.125 \times 0.133 + 0.34 \times 0.078 + 0.365 \times 0.079 + 0.17 \times 0.085 = 0.08393.$

Similarly, we can derive the weight vector of 10 risk factors in the index layer, as given below:

ω C=（0.0839 0.0774 0.1252 0.1275 0.1090 0.1200 0.0982 0.0939 0.07230.0926）。

According to the degree of importance, 10 risk factors were ranked: profitability (0.1275), operating capacity (0.1252), monetary fund (0.1200), solvency (0.1090), accounts receivable (0.0982), inventory (0.0939), past performance (0.0926), macro enterprise environment (0.0839), enterprise development (0.0774), and enterprise credit rating (0.0723).

Based on the importance ranking, the index layer (C layer) of the ranking of the indicators and the importance of evaluating the standard level is basically the same. The indicators of business performance and asset status are at the forefront of the core corporate credit risks, and are the two factors that affect core enterprise credit risks most heavily. Thus, by means of the fuzzy analytic hierarchy process, a quantitative risk assessment can be undertaken, which is very helpful in conducting key analysis for financial institutions, and in providing supply chain financing to seize the key financial indicators.

6. Concluding Remarks

6.1 Assessment

Supply chain finance is “good medicine” for solving financing problems of small and medium-sized enterprises, which can effectively alleviate the capital constraints of SMEs and achieve financial benefits to many participants in the supply chain. Therefore, the core enterprises should improve their economic strength by adjusting their business strategies and innovation to enhance their economic strengths and enterprise competitiveness, and improve their asset quality and credit records to enhance the industry status and the core competitiveness of the enterprises.

On the other hand, the core enterprises should carefully select SMEs in the supply chain. This would involve choosing SMEs with a good credit status as and higher industry positions and strong profitability as guarantees to ensure the overall security and stability of the supply chain; and reducing credit risks to enhance the overall competitiveness of the supply chain.

6.2 Suggestions

This subsection suggests three types of recommendations for the development of supply chains, financial risk evaluation, and establishing electronic data bases.

6.2.1 Balance Supply Chain Finance Development

At present, supply chain finance is mainly used in the automobile, steel and related industries that have large industry limitations. As key participants in the supply chain, core enterprises strengthen the strategic cooperative relationship of the supply chain members, so that supply chain financing can be extended to other industries to solve the financing constraints of SMEs. At the same time, core enterprises can also use their own advantages to expand supply chain financing to other industries to maximize the profits of the different among different industry groups. It is clear that core enterprises can and do play an important role in supply chain finance.

6.2.2 Establish Dynamic Supply Chain Financial Risk Evaluation Control System

Supply chain finance is involved in the exchange of capital flows, information flows, and logistics. The main participants include banks, core enterprises and SMEs. In order to maintain the interests of all parties, it is necessary to construct and improve the risk evaluation and control system, which involves: (1) establishing a scientific concept of risk management and risk assessment system based on real transaction; and strictly control the main business objects involved in supply chain financing, carefully preventing possible risks, dynamically adjust the weights, and significantly improve the supply chain financial risk assessment system.

6.2.3 Commercial Banks Should Establish Electronic Databases

A unified information file should be collected based on the core enterprise so that the following information is uploaded on to the database: (i) operating conditions, asset status, industry status, credit record and effective information; and (ii) the related data upstream and downstream of the collection and archives around the core enterprise, data information system, electronic data information. This would ensure and reflect the quality and status of the data in the data base.

Finally, through the establishment of a data base in supply chain finance, supply chain finance and modern information technology would be integrated to realize the sharing of information resources, and accommodate the exchange of information flows, capital flows, and logistics between banks. Core enterprises and SMEs would be able to work more cooperatively, smoothly and efficiently, which would not only improve the efficiency of the supply chain operation, but also effectively reduce risk, thereby ensuring the efficiency and effectiveness of supply chain finance.

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