

Risk Assessment of Internet Supply Chain Finance based on Vague Set

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Abstract: The combination of internet and supply chain finance formed a new finance mode with diversified financing methods, diversified service objects and convenient operation process. Meanwhile, its risk is more complicated and subtler. This paper analyzed and assessed risks of the internet supply chain finance. Firstly, the analysis mode was defined. Then, elements of internet supply chain finance were analyzed, and risks were identified from five aspects: environmental, supply chain system, transaction object, core enterprise and the relation between e-commerce and bank, and then the risk assessment index system was established. Finally, based on vague theory, the risk assessment model of internet supply chain finance was built. The model was used to assess the supply chain financial risk of two e-commerce enterprises, JD and SN. The results show that the overall risk of JD finance is less than SN finance, and differences lies mainly in the transaction object risk, core enterprise strength and the status of cooperative banks. The analysis mode, risk assessment index system and risk assessment model based on vague set can effectively analyze and assess risks of internet supply chain finance.

1. Introduction

Supply chain finance is defined as “1+N” credit business that caters for the supply chain of 1 core enterprise, for which financing is provided in the form of accounts receivable, confirming storage, and financing warehouse [1]. In May 2006, Shenzhen Development Bank (SDB) announced that this new business would be offered to inject funds into upstream and downstream enterprises which are considered to be relatively vulnerable in the supply chain. The purpose of this business is to solve problems of supply chain imbalance and the financing difficulties faced by small and medium size enterprise (SMEs).

Internet and supply chain finance combine to form a new financial mode, that is internet supply chain finance [2]. The internet broadens financing channels, opens up financing methods and promotes the development of traditional supply chain finance [3]. This new financial mode is exposed with some risks. Risk analysis and assessment is particularly important to ensure the healthy development of internet supply chain finance. However, risk analysis and quantitative assessment of the internet supply chain finance remain in the exploring stage. Hu [4] and Lu [5] analyzed the characteristics and operation mode of internet supply chain, and performed risk assessment based on grey relevance analysis and fuzzy analytic hierarchy process. However, fuzzy sets cannot express neutral evidence. Vague sets express membership degree in interval form. The degree of support and opposition to the evidence is given, so vague sets can deal with the fuzzy information which cannot be processed by fuzzy sets. In this paper, modes of internet supply chain financial risk were analyzed. Risk factors were selected from five elements of the supply chain finance system. Based on vague set theory, the risk assessment model was established. This study can quantify the weak factors of internet supply chain finance and provide decision-making basis for risk management and control.

2. Analysis Mode of Internet Supply Chain Financial Risk

Internet supply chain finance differs from the traditional mode in the application of large data platform and the simplification of operation process. On the one hand, core enterprises have accumulated a large amount of transaction data with upstream and downstream enterprises in their long-term cooperation. Based on these data, strengths of the partners can be evaluated, and the admittance conditions are set up. This can effectively avoid transaction and investment risks. On the other hand, internet simplifies plenty of complicated steps and procedures required in supply chain finance. It improves the operation efficiency, but it also brings some risks. The analytical category of internet supply chain finance remains to be identified. Current researches mainly discuss in terms of the following three modes.

Mode 1. Financial services provided by bank to the whole supply chain

This kind of financial service takes the bank as the main body, and revolves around the core enterprises. Internet platform is used to obtain data, simplify the operation procedures, and manage the capital flow and logistics of upstream and downstream SMEs. The uncontrollable risk of a single enterprise is transformed into the controllable risk of the whole supply chain, and risks can be controlled in the lowest.

Mode 2. Financial services provided by core electronic commerce enterprises to their upstream and downstream trading enterprises

The core enterprise evaluates the credit rating of other enterprises in the supply chain based on the existing transaction data. Accordingly, financial services are provided to upstream suppliers and downstream consumers. This business is generally separated from the main business of the core enterprise.

Mode 3. Combination of the mode 1 and the mode 2

Electronic commerce enterprise with complete supply chain is regarded as the core enterprise. Taking the credit value of the core enterprise and the overall strength of the supply chain as surety, the bank provides loans to the upstream and downstream enterprises of the supply chain more conveniently and quickly. At the same time, core enterprise provides financial services to upstream suppliers and downstream consumers by credit rating based on the existing transaction data.

The third mode is a combination of the first two modes. It revolves around the whole process of financing, purchasing, operating and selling, and includes the basic elements of the supply chain. The financial risks of each link in the supply chain will affect the core enterprise. Therefore, this paper focuses on the third mode to analyze supply chain financial risk.

2.1 Analysis of Components of Internet Supply Chain Finance

Participants in internet supply chain finance mainly include core enterprises, banks, suppliers and consumers, which are closely linked through the operation of capital flow, logistics and information flow. Supply chain finance takes the form of various financial services provided by core enterprises to other participants. These financial services mainly include providing loans to upstream suppliers, providing credit sales and installment of payment services to downstream consumers.

2.2 Loan Services Provided by Core Enterprise to Their Upstream Suppliers

Core enterprises borrow money from banks with credit guarantees and provide loan services to suppliers. Taking Jingdong as an example, its loan services mainly includes purchase order financing, warehousing entry financing, accounts receivable financing and entrusted loan financing.

2.3 Financial Services Provided by Core Enterprise to Their Upstream Suppliers

Many electronic commerce enterprises such as Ali, Jingdong and Suning provide financial services to their upstream suppliers. Taking Jingdong as an example, there are asset package transfer plan and trust plan. Asset package transfer plan is a process in which suppliers raise funds from banks through pledge and resale of accounts receivable. Banks package accounts receivable into some asset packages. Jingdong and its suppliers purchase financing plans and obtain income.

Jingdong trust products include two types. They are purchase and redemption at any time, and regular purchase and redemption.

2.4 Credit Sales, Installment Payment and Financial Services Provided by Core Enterprises to Their Downstream Consumers

Many electronic commerce enterprises provide credit sales and installment payment to their downstream consumers. Consumers can choose a new payment means of "consumption before payment". Taking Jindong as an example, there are mainly two forms, Jindong white stripes and campus white stripes. In addition, some electronic commerce enterprises expand the supply chain finance to various financial products, crowd funding, insurance, etc.

2.5 Analysis of Financial Risk Factors in Internet Supply Chain

Financial risks exist in each part of the internet supply chain finance system, and closely relate to the strength of the supply chain system. In addition, because the system must be in a certain environment, the influence of the environment cannot be ignored. This paper analyzes the financial risks of internet supply chain from the following aspects.

2.6 Environmental Risk

The environmental factors affecting the development of internet supply chain finance mainly include macro environment and industry environment. A good macro-economic environment is the foundation of the stable development of internet supply chain finance, and the unstable factors in macro-economic environment will be an important part of financial risk. Internet supply chain finance is still in its exploring phase. The loopholes in the laws and policies are also an important risk factor. In addition, more and more electronic commerce enterprises are constantly developing the internet supply chain financial business. This makes the competition increasingly fierce, and the risk of the internet supply chain finance increases to some extent.

2.7 Supply Chain System Risk

The core enterprise in the supply chain is closely related to suppliers, banks and consumers. This bundled financial mode brings conveniences as well as risks to the supply chain. The interests of all participants are closely related, and their close cooperation affects the effectiveness of the supply chain. Trust and information sharing are the cornerstones of supply chain cooperation. Supply-demand matching can effectively avoid the bullwhip effect which is ubiquitous in supply chain. Logistics is an important part of the supply chain system, and it is a link between the participants. The blockage of logistics will affect the normal operation of the whole supply chain, and even lead to the paralysis of the supply chain system.

2.8 Transaction Object Risk

The transaction objects are the upstream and downstream enterprises in the supply chain. As most of these enterprises are small and medium-sized enterprises, there may be various internal problems, such as chaotic management structure, insufficient use of funds, unreasonable production structure and low production efficiency. These problems make the risks of solvency and guarantee inventory realization prominent. This not only enlarges the trading and management risks of core enterprises, but also makes the supply chain face the risk of economic chain breakage. Therefore, it is very important to control the risks of transaction objects.

2.9 Core Enterprise Risk

Core enterprise dominates the whole supply chain. Once something goes wrong with the core enterprise, it will bring incalculable risks. Therefore, it is particularly important to measure and control the risks of core enterprises. The technology, capital and internal personnel quality of core enterprises will affect the supply chain. Here we divide these risk factors into three categories: operational risk, financial risk and quality of enterprise.

2.10 Relationship Risk between Electronic Commerce Enterprise and Bank

In the supply chain finance, core enterprises often serve as a bridge between banks and SMEs. That is, the core enterprise uses its own credit as a guarantee to help SMEs to obtain loans from banks. As a result, banks become an important part of the supply chain. The success rate and convenience of bank financing approval also play a vital role in ensuring the continuity of the supply chain.

Based on the above analysis of risks in internet supply chain finance, data analysis and expert experience methods are used to construct the risk assessment index system as shown in Table 1.

Table 1. Assessment index system of internet supply chain financial risk

	First level index	Second level index	Third level index
Internet supply chain finance risk	Environmental risk	Macro environment	Macro-economic situation c_1
			Legal and policy environment c_2
		Prospects of the industry	Development stage of the industry c_3
			Industry competitive intensity c_4
	Supply chain system risk	Supply chain cooperation risk	Trust risk c_5
			Information risk c_6
			Supply and demand matching c_7
		Logistics risk	Vulnerability and perishability of commodities c_8
			Storage conditions c_9
		Supply chain financial operations	Bad debt rate in financial business c_{10}
		Financing mode c_{11}	
	Transaction object risk	Solvency risk	Total assets of the transaction object c_{12}
			Repayment period c_{13}
			Lending rate c_{14}
		Guarantee inventory realization risk	Market capacity of inventory c_{15}
			Sales account period of inventory c_{16}
			Price risk c_{17}
	Core enterprise risk	Operational risk	Process risk c_{18}
			Technology risk c_{19}
			Payment risk c_{20}
		Financial risk	Quick ratio c_{21}
			Asset-liability ratio c_{22}
			Ratio of income as a percentage of sales c_{23}
		Quality of enterprise	Staff quality c_{24}
			Management quality c_{25}
			Cooperation time c_{26}
	Relationship risk between e-commerce enterprise and bank	Status of commercial banks	Successful ratio of financing approval c_{27}
			Convenience of financing c_{28}

3. Financial Risk Assessment of Internet Supply Chain based on Vague Set

Vague set is an extension of the fuzzy set which allows for the quantitative assessment of the fuzzy risk information. In vague set, the membership of each element can be divided into support and opposition aspects, and the evidence of support and opposition can be provided, thus fuzzy information is expressed in an all-around way. The mathematical model of vague set theory can be described as follows.

3.1 Vague Set and Score Function

Set X as a domain in which each element can be denoted as x . One vague set A on X is composed of the true membership function t_A and the pseudo membership function f_A . $t_A : X \rightarrow [0,1]$, $f_A : X \rightarrow [0,1]$. For $\forall x \in X$, $t_A(x)$ and $f_A(x)$ are the lower bounds of the affirmative and negative membership, respectively, and $t_A(x) + f_A(x) \leq 1$. The membership function of x about A can be represented by $[t_A(x), 1 - f_A(x)] \subseteq [0,1]$. $\pi_A(x) = 1 - t_A(x) - f_A(x)$ is the unknown degree of x about A . It is the measure for the unknown information of x with respect to A . $S_A(x) = t_A(x) - f_A(x)$ is called the score value of x , which reflects the contrast in existing data between two degrees, support of x and opposition to x . Constructing score function $S_A(x)$ is the key to decision-making. It processes uncertain information contained in the attribute values in the form of vague value, and finally the certain decision results can be obtained.

Depending on different preferences of decision maker for risk neutrality, proneness or aversion, the neutral score function $S_A^N(x)$, the risk-prone score function $S_A^{RP}(x)$ and the risk-averse score function $S_A^{RA}(x)$ are constructed. These three types of score functions are shown in Equation (1) to Equation (3).

$$S_A^N(x) = t - f \quad (1)$$

$$S_A^{RP}(x) = \begin{cases} 1 - f + (1 + \pi) \cdot (t - f) & t > f \\ 1 - f & t = f \\ 1 - f + (1 - \pi) \cdot (t - f) & t < f \end{cases} \quad (2)$$

$$S_A^{RA}(x) = \begin{cases} t + (1 - \pi) \cdot (t - f) & t > f \\ t & t = f \\ t + (1 + \pi) \cdot (t - f) & t < f \end{cases} \quad (3)$$

3.2 Conversion from Linguistic Indexes to Vague Values

The conversion results from 11-level linguistic indexes to vague values are given in Table 2[6-7]. No matter what kinds of score functions are selected, the extreme values of vague score are equal. Taking $2 \cdot (1 - f) - 1$ and $2 \cdot t - 1$ as the maximum and minimum values of vague score $[t, 1 - f]$, respectively, the maximum S_{\max} and the minimum S_{\min} of 11-level linguistic indexes are given in Table 2.

Table 2. Conversion from 11-level linguistic indexes to vague values

Level	Range of vague value	Typical vague value	S_{\min}	S_{\max}
Absolutely good (AG)	[1,1]	[1,1]	1	1
Very good (VG)	[0.9,1]	[0.9,0.95]	0.8	0.9
Good (G)	[0.85,0.9]	[0.8,0.9]	0.6	0.8
Fairly good (FG)	[0.7,0.85]	[0.7,0.85]	0.4	0.7
Slightly good (SG)	[0.5,0.7]	[0.55,0.7]	0.1	0.4
Medium (M)	[0.4,0.6]	[0.4,0.6]	-0.2	0.2
Slightly poor (SP)	[0.4,0.6]	[0.4,0.55]	-0.2	0.1
Fairly poor (FP)	[0.3,0.45]	[0.3,0.45]	-0.4	-0.1
Poor (P)	[0.15,0.3]	[0.2,0.3]	-0.6	-0.4
Very poor (VP)	[0,0.15]	[0.1,0.15]	-0.8	-0.7
Absolutely poor (AP)	[0,0]	[0,0]	-1	-1

3.3 Steps of Assessment

The object A_i contains J_i assessment indexes. The weight of each index constructs the vector $\omega_i = (\omega_{i,1}, \omega_{i,2}, \dots, \omega_{i,J_i})$. The steps of assessing the risk of A_i with the vague set are as follows.

Step 1: Linguistic attribute values are converted into vague values, and the maximum value $S_{i,j}^{\max}$ and the minimum value $S_{i,j}^{\min}$ of each index are obtain according to Table 2.

Step 2: For the assessment object A_i , $S_{\max}(A_i)$ and $S_{\min}(A_i)$ are calculated according to Equations (4) and (5).

$$S_{\max}(A_i) = \sum_{j=1}^{J_i} \omega_{i,j} \cdot S_{i,j}^{\max} \quad (4)$$

$$S_{\min}(A_i) = \sum_{j=1}^{J_i} \omega_{i,j} \cdot S_{i,j}^{\min} \quad (5)$$

The score value of the assessment object A_i in the form of vague value is calculated according to Equation (6).

$$V(A_i) = [S_{\min}(A_i), S_{\max}(A_i)], i = 1, 2, 3, \dots, m \quad (6)$$

Step 3: $S(V(A_i))$ are calculated, and the assessment objects are ranked according to $S(V(A_i))$. The greater value of $S(V(A_i))$ means the higher risk of A_i .

4. Case Analysis

JD (A_1) and SN (A_2), the two major electronic commerce enterprises which are the first to develop the supply chain finance business in China, were taken as assessment objects. The supply chain financial risks of these two enterprises were assessed based on the risk assessment index system and vague set model.

The 28 risk indexes c_1, c_2, \dots, c_{28} in Table 1 were rated by 11 experts. They used 11-level uncertain linguistic in Table 2 to measure the risk indexes of the two enterprises. After redefining the 11-level linguistic descriptions, the definition of linguistic scale R was obtained as follows.

$$R = \left\{ \begin{array}{l} \text{Absolutely low (AL), Very low (VL), Low (L), Fairly low (FL)} \\ \text{Slightly low (SL), Medium (M), Slightly high (SH), Fairly high (FH),} \\ \text{High (H), Very high (VH), Absolutely high (AH)} \end{array} \right\} \quad (7)$$

Suppose that the linguistic used by the h -th expert for evaluating the j -th index of the enterprise A_i was $z_{i,j}^h, h = 1, 2, \dots, H$. Assessment linguistics of 11 experts formed a vector $(z_{i,j}^1, z_{i,j}^2, \dots, z_{i,j}^{11})$. The most numerous elements in the vector are used as the evaluation linguistic $z_{i,j}$ of the index c_j . If the number of each element is the same, these elements are sorted in order of values from large to small, and the median of the vector is used as the evaluation linguistic of the index. The assessment results of 11 experts are shown in Table 3.

Table 3. Risk assessment linguistics for supply chain finance enterprises

A_i	c_1	c_2	c_3	c_4	c_5	c_6	c_7	c_8	c_9	c_{10}	c_{11}	c_{12}	c_{13}	c_{14}
A_1	SG	FG	SG	FG	FG	FG	SG	FG	FG	SG	SG	SG	SG	SG
A_2	SG	FG	SG	FG	SG	G	FG	SG	SG	M	FG	SG	FG	SG
A_i	c_{15}	c_{16}	c_{17}	c_{18}	c_{19}	c_{20}	c_{21}	c_{22}	c_{23}	c_{24}	c_{25}	c_{26}	c_{27}	c_{28}
A_1	SG	SG	FG	FG	SG	SG	M	SG	M	M	SG	M	M	M
A_2	FG	FG	SG	G	FG	FG	SG	SG	SG	SG	SG	SG	M	M

The maximum score of each index was selected from Table 2, and the weight vectors of indexes were set as $\omega_i = [1, 1, \dots, 1]_{1 \times 28} / 28, i = 1, 2$. The minimum and maximum values of possible scores were calculated according to Equations (4) and (5).

$$S_{\min}(A_1) = 0.12, S_{\max}(A_1) = 0.44, S_{\min}(A_2) = 0.20, S_{\max}(A_2) = 0.50.$$

The score values of the two enterprises in the form of vague values are $V(A_1) = [0.12, 0.44]$ and $V(A_2) = [0.20, 0.50]$. The score function values of $V(A_1)$ and $V(A_2)$ under three risk preferences are shown in Table 4.

Table 4. Score function values of $V(A_1)$ and $V(A_2)$ under three risk preferences

$V(A_i)$	$S_A^N(V(A_i))$	$S_A^{RP}(V(A_i))$	$S_A^{RA}(V(A_i))$
$V(A_1)$	-0.44	0.1408	-0.4608
$V(A_2)$	-0.3	0.29	-0.19

According to Table 4, no matter what score function the decision maker chosen, the assessment value of $S_N(A_2)$ is always greater than that of $S_N(A_1)$. This means that the risk of $S_N(A_2)$ is higher than that of $S_N(A_1)$.

5. Summary

In this paper, risks of supply chain finance under the background of internet plus were analyzed. The risk assessment index system and model were established. Two cases of JD and SN were used

to test the effect of the system and model. The results show that the risk of SN supply chain finance is greater than that of JD. The main reasons are as follows: (1) JD is superior to SN in storage and analysis of supply chain transaction data. (2) In the aspect of financing mode, JD finance uses the methods of bank pledge loans, private placement, and stock. These methods do not occupy supply chain funds. SN finance is not completely separated from its main business, and it will occupy funds. When supply chain problems arise, SN will be affected more than JD. (3) In the aspect of borrowing, JD formulates differentiated lending modes and processes according to the identities of the borrowers. Its risk is less than SN which does not distinguish identities of the borrowers. (4) In the aspect of repayment cycle, the longest repayment period of JD is half a year, while that of SN is five years. Compared with JD, there are risks of difficulties in capital turnover in SN. (5) After calculating quick ratios of the two enterprises, we can see that in recent two years, the quick ratios of JD were 1.15012 and 0.94103, while that of SN were 0.85 and 0.77. The quick ratio of JD was closer to 1 and the risk was smaller than SN.

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