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Research on Operational Risk of Online Supply Chain Finance Based on the Third Party B2B e-commerce Platform

Aimin Deng, Yuying Xue

***Abstract*—Online supply chain finance based on the third party B2B e-commerce platforms as an efficient, convenient and controllable business mode has been developing rapidly.It sharing of whole process information, but also involves more complex operational risk factors, which puts forward higher requirements for commercial banks' operational risk management.This paper firstly construct the operational risk index system of online supply chain finance based on third party B2B platform.And then use the blind number and fuzzy mathematics theory to analyse the chance and consequences of risks , so as to establish the risk assessment model; Finally taking the online supply chain financial cooperation between HC and Minsheng Bank as an example, the case analysis shows the feasibility and effectiveness of the risk assessment model, so as to guide the online supply chain finance operational risk management.**

***Index Terms*—Online supply chain finance; Operational risk; Blind number theory; Risk evaluation**

I. INTRODUCTION

With the rise of B2B platforms, it has solved the obstacle backward the informatization level of SMEs. However, the problem of financial pressure and financing difficulties is still the biggest pain for them. Online supply chain finance based on the third party B2B e-commerce platforms can help B2B platforms attract more users, increase their revenue and profits , and at the same time, alleviate the financing difficulties of online SMEs .And a considerable number of SMEs on the third party B2B e-commerce platform can become premium customers of commercial bank financing businesses.Such an efficient, convenient and controllable business mode has been developing rapidly.Online supply chain finance realizes real-time information manipulation and sharing of whole process information, but it also involves more complex operational risk factors, which puts forward higher requirements for commercial banks' operational risk management.

All operations of online supply chain finance based on the third party B2B platform are completed through the network. The complexity of backstage operation of banks and e-commerce enterprises is much higher than that of traditional supply chain financing businesses, and operational risk is the main risk. Overall, most of the existing research using deterministic method to directly evaluate the online operational risk of supply chain finance.But online supply chain finance operational risk assessment will inevitably have a lot of uncertainty, it's difficult to give effective solution for the uncertainty which may even lead to distortion of assessment results. Moreover, operational risk includes a large number of uncertain information, such as random information, fuzzy information and grey information, which belong to typical blind information. In view of this, this paper use the blind number theory to evaluate the possibility of operational risk, and use fuzzy mathematics to evaluate the consequences of operational risk loss, so as to establish a risk assessment model of online supply chain finance operation system.

II. LITERATURE REVIEW

A. Literature on the operational risk of the online supply chain finance

Dan Huang (2012)[1] studied the possible operational risks in the e-business transactions, online payments and other processes in the online supply chain financial business.JE Guo (2014)[2], through the comparison with the traditional supply chain finance, points out that the online supply chain financial business of commercial banks will face greater operational risk.Dröge,O.T(2014)[3] analyzed the supply chain finance of online platform by using the key factor method, and concluded that the online operation mode of online supply chain finance is the key index to affect its risk.Tian Haotian(2014)[4] combined with the specific operation process of online supply chain finance financing mode, from the perspective of credit review, loan approval, out of account and post loan management, we put forward control measures for these risks.Shengxuan He(2016)[5] constructed the risk evaluation system of online supply chain finance based on third party B2B platform, which is composed of macro and industry risk, credit risk, pledge risk, supply chain relationship risk, operational risk and risk of bank relationship with platform.

B. Literature on the application of blind number in risk assessment

The blind number theory is a theoretical method, which is proposed by academician Wang Guangyuan in 1990s, and is effective in solving the chaos of information based on the experience of the expert group.Wang Guangyuan (1990)[6] put forward "unascertained mathematics" because of the

Aimin Deng, the School of Economics and Trade, Hunan University, Changsha, China, (+86)18975184867;
Yuying Xue, the School of Economics and Trade, Hunan University, Changsha, China, (+86)15211198919.

needs of architectural engineering theory research, and started a new way to study the mathematical expression and processing of unascertained information.Then Liu Kaidi, Wu Heqin (1997)[7] developed and established the blind number theory on the basis of unascertained mathematical theory.Li Juan (2010)[8] analyzed the questionnaire survey data, and applied the blind number and fuzzy mathematics evaluation model to analyze the risk factors of fresh agricultural products supply chain systematically.Jin Wang(2011)[9] introduced the blind number theory based on fault tree analysis, and established the the blind fault tree of product sales decline for top event, obtained more comprehensive evaluation results of the risk factors of virtual marketing cooperation.Kai Li (2016)[10] based on the optimization and improvement of the A-FA comprehensive evaluation method, starting from the basic attributes of marketing risk indicators,applied the blind number and the grade membership function synthetically to build the marketing risk index evaluation model.Wenli Liu(2017)[11], aiming at the characteristics of the supply chain finance operation system based on the bank self operated platform with multiple uncertainties coexisting, introducing the blind number theory into the field of operational risk assessment.It has great guiding significance for the research in this paper.

C. Literature on the of fuzzy mathematics in risk assessment

Qiang Tao(2012)[12] analyzed the logistics finance mode based on the third party B2B e-commerce platform, established a set of risk evaluation indicators, and made a comprehensive evaluation of the banking risks in the business by fuzzy evaluation.Shengxuan He(2016)[5] through the combination of analytic hierarchy process and fuzzy comprehensive evaluation method to make risk assessment of the overall risk of online supply chain finance.Qian Zhao(2016)[13] combined the catastrophe progression model and fuzzy mathematics to quantify the overall risk of supply chain finance, and removed the step of assigning weight to risk factors, which made the evaluation result more objective and accurate.Zhigang Liu (2014)[14] used the analytic hierarchy process and fuzzy mathematics comprehensive evaluation method to quantify the four kinds of risks. It was concluded that the risk level of four kinds of risks was from credit risk, market risk, operation risk to legal risk.

D. Summary of literature review

From the perspective of online supply chain financial operation risk, scholars have got the conclusion that operational risk has become the main risk of online supply chain finance through factor analysis.But in terms of risk assessment, scholars mostly use various technologies to measure credit risk, but there is not much research on operational risk that is difficult to define and evaluate.From the study of risk assessment based on the blind number theory, the blind number theory has been widely applied to the economic fields of investment project evaluation, real estate risk assessment and so on.But only in recent years, it has been applied to the evaluation of financial risk in supply chain. Now, the research on this application is very small, and it is still in its infancy.From the perspective of risk research based on fuzzy mathematics, most scholars use the combination of analytic hierarchy process and fuzzy mathematics to build models,this method is very common, but the combination of blind numbers and fuzzy mathematics is very rare.

III. CONSTRUCTION OF OPERATIONAL RISK ASSESSMENT MODEL

A. Set Up an Index System for Operational Risk Assessment

On the basis of the requirements about operational risk in "The New Basel Capital Accord (Third Edition)", draw lessons from the domestic existing online supply chain finance operational risk assessment experiences as in [1-5] and access to the business' practitioners, operational risk evaluation index system established as shown in "Tab. I".

B. Estimation of possibility of each risk index based on Blind Number Theory

This paper uses the blind number theory to estimate the risk level of each operational risk index to describe the uncertainty risk of the online supply chain financial operating system. The following are the specific model construction and operation methods.

Firstly,the expert group scores every risk indicator:

The operational risk of online supply chain finance based on the third party B2B platform is divided into 5 levels,the risk grade is classified as shown in "Tab. II".

According to the risk level shown in "Tab. II", experts estimate and score each risk index. The lower the index score is, the greater the possibility of risk is. The scoring range of the index is [0,100], of which 0 indicates that there must will be a risk, and 100 means that there is no risk.

Secondly,calculate the credibility of an Individual expert:

Assuming a certain evaluation activity, an expert group $Y(i)$ is composed of n experts to evaluate the evaluation object set $X(j)$ which include m evaluation objects X_1, X_2,..., X_m .The evaluation result of each expert Y_i to each evaluation object is.Then according to the evaluation results $d_i(X_j)$ of each expert, the evaluation results $D(X_j)$ of the expert group are formed. $d_i(X_j)$ and $D(X_j)$ are the evaluation order on each evaluation object of the experts and the experts group .In general, the evaluation opinion of the Expert individual is not completely consistent with the opinion of the expert group. Therefore, the credibility is measured from the two aspects of the "correct rate" and the "close rate" when the opinion is not consistent.If:

$$\Phi_i : d_i(X_j) = D(X_j)$$
$$\overline{\Phi}_i : d_i(X_j) \neq D(X_j) \quad (1)$$

The evaluation opinion space of the expert individual Y_i can be expressed as $\Phi_i \cup \overline{\Phi}_i$,when $d_i(X_j) \in \Phi_i$, the eigenfunctions was taken as:

(2)

At the same time, the correct rate α_{1i} of expert individual opinion is defined as:

$$\alpha_{1i} = \frac{1}{m}\sum_{j=1}^{m} \pi_i(X_j) \quad (3)$$

The values determined by (3) can reflect the consistency of expert individual opinion and opinions of the expert group.

When $d_i(X_j) \in \overline{\Phi}_i$,the ranking results of experts are not consistent with the expert group. At this time, the concept of "close degree" is introduced.The degree of closeness of the experts to the expert group is expressed as α_{0i} ,and the credibility α_i of the expert Y_i is defined as:

$$\alpha_i = \alpha_{1i} + \alpha_{0i} \quad (4)$$

Because $\alpha_i \le 1$,there is $\alpha_{0i} \le 1 - \alpha_{1i}$ .In order to describe α_{0i} quantifiably, the following functions are introduced:

$$\gamma_i(X_j) = \frac{1}{m}\sum_{j=1}^{m} \frac{|d_i(X_j) - D(X_j)|}{m-1} \quad (5)$$

As in (5) can reflect the opinions of individual expert and expert group in the degree of deviation from the disagreement.Taking into account the monotonous requirements and the prior "$\alpha_{0i} \le 1 - \alpha_{1i}$" constraints,we use the following formula to approximately describe the "close degree" α_{0i} :

$$\alpha_{0i} = (1 - \beta \bullet \gamma_i(X_j)) \bullet (1 - \alpha_{1i}) \quad (6)$$

β in (6) is the coincidence coefficient,and we can make $\beta = 1$,so the credibility α_i of an expert individual can be obtained:

$$\alpha_i = \frac{1}{m}\sum_{j=1}^{m} \pi_i(X_j) + (1 - \gamma_i(X_j)) \bullet (1 - \frac{1}{m}\sum_{j=1}^{m} \pi_i(X_j)) \quad (7)$$

As in (7) can reflect the expert's personal evaluation level to a certain extent, so this paper will use the above models to quantify the expert's personal credibility in the blind number risk assessment model.

$$\pi_i(X_j) = \begin{cases} 1, d_i(X_j) = D(X_j) \\ 0, others \end{cases}$$

As a result, the personal credibility of each expert of the expert group can be obtained:

$$\alpha_1, \alpha_2, \ldots, \alpha_n, 0 < \alpha_i \le 1, \quad (8)$$
$$\overline{\alpha_i} = \alpha_i / (\alpha_1 + \alpha_2 + \ldots + \alpha_n)$$

As in (8) is called comprehensive credibility of the expert Y_i concerning expert group Y ,the comprehensive credibility of the expert Y_i for short.

Finally,list the blind number representation of each risk index:

Suppose $A_{ij} = [a_{ij}, b_{ij}]$ is an expert $Y_i (i = 1,2,\ldots, n)$ scoring interval for risk index $j (j = 1,2,\ldots,m)$ .For the risk index x_j , it is assumed that the scoring interval given by the n experts is

$$f_j(x) = \begin{cases} \beta_{ij1}, x = A_{ij1} \\ \beta_{ij2}, x = A_{ij2} \\ \vdots \\ \beta_{ijk}, x = A_{ijk} \\ 0, others \end{cases}$$

$[a_{1j}, b_{1j}]$、$[a_{2j}, b_{2j}]$、…、$[a_{nj}, b_{nj}]$,the expert individual reliability of each corresponding interval is $\alpha_1, \alpha_2, \ldots, \alpha_n$ .However, there may be a cross between the intervals,so all the numbers in the number set $A_{ij} (i = 1,2,\ldots, n, j = 1,2,\ldots, m)$ is reordered from small to large as $A_{ij1}, A_{ij2}, \ldots A_{ijk}$,and the corresponding expert reliability is recalculated. Assuming that the new interval corresponding experts' reliability is $\beta_{ij1}, \beta_{ij2}, \ldots, \beta_{ijk}$, then the score of operational risk index x_j is quantified by blind number as follow:

(9)

In order to quantify the expert opinion, the concept of blind number mean is introduced.Set a and b as real numbers, $a \le b$, $(a+b)/2$ is called the heart of rational grey number, written as: $\Theta[a,b] = (a+b)/2$,so the first order unascertained rational number as follow is the mathematical expectation for blind numbers $f(x)$:

$$E[f(x)] = \begin{cases} \alpha, x = \frac{1}{\alpha}(\Theta \sum_{i=1}^{n} \alpha_i x_i) \\ 0, others \end{cases} \quad (10)$$

This paper uses $E[f(x)]$ to quantify experts' opinions on the risk occurrence of each risk indicator.

C. Calculation of the consequences of risk loss in each risk index based on Fuzzy Mathematics

Next, we use fuzzy mathematics to calculate the loss consequence of every risk index in online supply chain finance after risk occurs. The specific mathematical methods and calculation steps are as follows:

Firstly,according to the impact of each risk index on the online supply chain finance, the risk level of all risk indicators is divided into five levels.The five risk levels can be expresses as a vector :

$$V=\{V_1, V_2, V_3, V_4, V_5\} \quad (11)$$

And V_1-V_5 mean very dangerous, dangerous, medium, safe, and very safe.The five levels has been divided into numerical interval according to the possibility of risk. Now, referring to the data of risk level put forward as in[18-19], we assign the consequences of the five levels of risk loss as $\{0.01,0.02,0.05,0.08,0.09\}$.

Secondly,experts estimate the possibility of each risk index occurring at each risk level, thus obtaining the membership matrix of each risk index:

$$X=\begin{bmatrix} x_{11} & x_{12} & .. & x_{1n} \\ x_{21} & x_{22} & .. & x_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ x_{n1} & x_{n2} & .. & x_{nn} \end{bmatrix} \quad (12)$$

Finally,calculation of the risk loss consequences of each risk index:

$$Z^T = X \bullet V^T \quad (13)$$

D. Weight determination based on Analytic Hierarchy Process（AHP）

This paper uses AHP to determine the weight of each index. According to the evaluation index system of online supply chain finance operational risk, invite experts who are engage in online supply chain finance business composed of expert group to make comparison between any two risk factors' importance .So we can build a judgment matrix $C=|c_{ij}|$ for each risk index. C_{ij} represents the relative importance of risk indicators i and j .Then the weight coefficient W of each level index is determined, and the consistency check is carried out.

E. Calculation of risk values at each stage of risk

The index system factor layer established in this paper is divided into four stages according to credit financing assessment, online business and logistics transaction, loan and post loan management , and reimbursement and cancellation.In the calculation of the value of risk, the occurrence of risk in a certain stage may be the comprehensive effect of several risk indicators.Since the importance of each index may be different, the AHP has been used to determine the weight $W(t,i)$ of the risk factor index i at the risk stage t.The blind number expression of the comprehensive failure probability of a risk stage is obtained by combining the blind number mean value:

$$P_f=\sum_{i=1}^{m} W(t,i)E[f_i(x)] \quad (14)$$

$$R_f=\sum_t W_t R_f(t)$$

At the same time, we can calculate the consequences of the comprehensive loss at each risk stage through the loss consequences of the risk index Z^T:

$$C_f = W(t,i) \bullet Z^T \quad (15)$$

According to the general definition of the risk, it can be described as in (16) in a mathematical language.Risk value of each risk stage is expressed by (16), and the definition formula is as follows:

$$R_f(t)=f(P_f,C_f)=1-(1-P_f)(1-C_f)=P_f+C_f-P_fC_f \quad (16)$$

Using (16) can obtain the value of risk of each index and each stage on online supply chain finance system.

F. Calculation of the risk value of the whole online supply chain financial system

The overall risk values of the entire online supply chain financial system can be calculated by (17) :

(17)

Among them, R_f is the risk value of the whole online supply chain finance system. W_t is the weight of a risk stage (first level index) for the target level, and $R_f(t)$ is the specific risk value of each risk stage.

IV. CASE ANALYSIS

This paper selects the online supply chain financial cooperation between Huicong network and Minsheng Bank for the sample analysis.A questionnaire was adopted to invite an expert group composed of three experts from the Minsheng Bank and the two experts in charge of the supply chain finance service in HC.The content of the questionnaire is to score and sort the evaluation indicators constructed in this paper. After obtaining the data of the questionnaire, the operational risk is evaluated using the model established in this paper. The results are as in "Tab.III".

V. CONCLUSION

According to the above table data, firstly,we can know that from the perspective of risk indicators, the related indicators of logistics enterprises and the risk index about the abnormal cooperation between bank and B2B platform are both below 40 points, which is a risk index of dangerous state, which is consistent with reality:For the related indicators of logistics enterprises, the third party logistics enterprises are divorced from the e-commerce platform and bank supervision. The operation of pledge and cancellation which controlled by them is easy to happen operational risk;For the risk index about the abnormal cooperation between bank and B2B platform,in reality, there are many examples of banks and the third party B2B platform to dissolve the online supply chain financial cooperation as a result of the cooperation model and profit distribution.Secondly, from the perspective of the risk stage, the credit financing evaluation stage is the most risky, which is consistent with the difficulty of the real assessment and the backwardness of the system construction.Finally, starting from the overall risk value of the case, it is at a relatively safe state, which is consistent with the reality that the business cooperation between Huicong network and Minsheng Bank has long existed and has great potential for development.

According to the above analysis, we can know that the conclusion of the model is basically consistent with the actual situation.According to this, it can be considered that the evaluation model established in this paper is feasible and effective.

Table I The assessment index system of operational risk of online supply chain finance based on the third party B2B platform

Target	primary indexs	secondary indexes
operational risk of online supply chain finance based on the third party B2B platform X	Risk of credit financing assessment X_1	Abnormality of bank audit x_{11}
		Abnormality of B2B platform audit x_{12}
		Mistake of cooperation agreement x_{13}
		Misoperation of approval x_{14}
		Loan enterprise fraud x_{15}
	Risk of online business and logistics transaction X_2	Transaction disputes x_{21}
		Error of order contract x_{22}
		Abnormality of B2B platform trading system x_{23}
		Abnormity of warehouse receipt x_{24}
		Abnormality of pledge x_{25}
	Risk of loan and post loan management X_3	Erroneous payment x_{31}
		Abnormality of financing system x_{32}
		Poor supervision of logistics enterprises x_{33}
		Abnormality of customer collaboration x_{34}
		Abnormality of loan management x_{35}
	Risk of reimbursement and cancellation X_4	Received payments error x_{41}
		Abnormality of received payments system x_{42}
		Abnormality of logistics enterprises' pledge release x_{43}
		Abnormal operation of verification x_{44}
		Abnormal cooperation between Commercial banks and platforms x_{45}

Table II Operational risk level division of online supply chain finance based on the third party B2B platform

Risk Rank	$V1$	V_2	V_3	V_4	V_5
Security Situation	Very dangerous	Dangerous	Medium	Safe	Very safe
Evaluation Score	[0,20]	(20,40]	(40,60]	(60,80]	(80,100]

Table III The risk values of each index and each stage

Risk index x_{ij}	The risk values of each index $E[f(x)]$	Z_x	R_x	Risk index weight at risk stage $W(t,i)$	Risk stage X	The risk values of each stage P_f	C_f	R_f	The weight of the risk stage at the target layer W_t	Total risk value
x_{11}	44.85	0.0436	42.94	0.0768						
x_{12}	42.28	0.0376	40.73	0.0497						
x_{13}	47.88	0.0470	45.68	0.1732	X_1	63.66	0.0692	59.32	0.0699	
x_{14}	68.63	0.0747	63.58	0.2741						
x_{15}	72.76	0.0829	66.81	0.4262						
x_{21}	73.44	0.0800	67.64	0.1883						
x_{22}	76.66	0.0831	70.37	0.4350						
x_{23}	58.49	0.0618	54.94	0.0597	X_2	74.38	0.0803	68.49	0.4874	
x_{24}	78.48	0.0849	71.90	0.2878						
x_{25}	38.43	0.0318	37.24	0.0292						66.02
x_{31}	78.01	0.0840	71.54	0.4288						
x_{32}	73.32	0.0818	67.40	0.1894						
x_{33}	40.41	0.0347	39.04	0.0500	X_3	71.28	0.0775	65.83	0.3049	
x_{34}	47.04	0.0471	44.87	0.0773						
x_{35}	71.85	0.0809	66.12	0.2545						
x_{41}	73.86	0.0809	67.97	0.4441						
x_{42}	66.24	0.0737	61.43	0.2676						
x_{43}	40.62	0.0356	39.21	0.0721	X_4	65.67	0.0714	61.05	0.1379	
x_{44}	62.07	0.0714	57.71	0.1691						
x_{45}	36.46	0.0228	35.65	0.0471						

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Dr. Aimin Deng is a full time professor and doctoral supervisor at the School of Economics and Trade of Hunan University; the founder and Director of the Institute of transport and logistics (www.tl-hnu.cn, 2006)；the founder and Director of Sino-German Center for transportation and logistics of Hunan University (www.tl-cnde.org,2008). Research areas: logistics and supply chain management (including finance) systems, transportation systems, e-commerce and IOT systems. She studied in Germany, has a certificate of advanced English to study abroad by the Ministry of Education in China, and was the head of E-Commerce and Logistics Management Department and Information Management and Information System. She has a wide range of exchanges and cooperation with national and international enterprises, institutions and Governments, and social and academic positions; hosted and completed nearly more than 40 domestic and international projects, published more than 100 papers and guide more than 100 graduate students.

Yuying Xue is now studying in the School of Economics and Trade of Hunan University, majoring in International Business. Her major research direction is logistics and supply chain finance under the guidance of tutor Professor Aimin Deng. After two years studying, she has got the basic research quality and understanding of her research field. In addition, she have taken several social internships in China Minsheng Banking Corp., Ltd.（CMBC）,Robert Bosch motor (China) Co., Ltd., mainly engaged in investment and market operations,which greatly improved her feasibility in academic research. In a word, she is a graduate student with lots of energy, innovation and research ability.