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Research on Operational Risk Control for Online Supply Chain Finance of Commercial Banks

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Abstract. In this paper, we select electronic warehouse receipt pledge financing model as the analyzing subject which is based on the online supply chain finance platform under the trend of the "Internet + strategy", focusing on risk control management on the operational risks. By setting key risk indicators, we build control model of operational risks based on Multi-Agent system and analyze its mechanism and adaptability. It concluded that the risk control system could effectively reflect the potential operational risks and the Agent technology could be both distinguish and highly adaptable in the area of risk control management.

Introduction

With the popularization of the Internet technology and big data applications, online supply chain finance (OSCF) has become the trend of supply chain finance (SCF).It has some features: intelligentizing, networking, and online. OSCF strengthens credit of financing corporate largely than the traditional SCF and also converts the financing corporates' business credit to financial credit. Simultaneously, the online and electronic operations of the OSCF further enhance the efficiency of overall financing and create a chance for the bank to realize the risk control management of the whole SCF.

Considering OSCF's fast and high-frequency operation characteristics, the operational risks which are electronic, systematic, multi-node, gradually become the main risk of SCF. While OSCF is no longer assessing the financial situation of individual companies with static data, isolated data and off-line data, but pays more attention to the dynamic data, overall data and on line data. Therefore, this paper considers the transformed OSCF risks, discussing potential key risk areas in supply chain financing process, focusing on exploring how the bank find out, control and quantify operational risks and analyzes how to apply quantified analysis to the operational risks control.

Literature Review

The literature involves the concept and operational risks of online supply chain finance and the MAS, Berger (2004) used the SCF to solve the financing problem for SMEs, and discussed the potential risks in the SCF[1]. Moriz (2010) revealed that SCF could not only be used to solve the problem of high cost financing, but also could be used to reduce production and transportation costs based on the theory of financial analysis[2]. With the development of SCF, its risks became the focus of scholars when researching. Buzacott and Zhang (2004) studied some key indicators about the SCF in business and explored their effects on the SCF[3]. Busch (2008) summarized the aggregating risk characteristics about external environment and internal subjects of SCF and proposed some effective risk control methods to reduce financing costs and risks[4]. Yu and Zhou (2014) summarized that the foreseeable operational risk loss paths, improved IMA method and identified operational risks through the financing process assessment[5]. Guo and Shi (2014) highlighted the conversion of online supply chain finance risk and compared different types of online financing model. Finally, they concluded that differences not only existed between online and offline financing modes, but also existed among different online financing modes[6].

Agent get applied in many areas of research as a new research tool, but some studies using Agent technology in risk management inspired us: Brooks and Davenport (2004) pointed out that Agent technology was autonomous, social and initiative, so it can be used for effective supply chain risk management, especially when the risk was highly uncertain[7]. Mihalis (2011) reduced highly sophisticated supply chain risk sin manufacture industry by using Multi-Agent technology and stressed that the self-learning ability of Agent made it suitable for uncertainty problems solving in the management of complex supply chain[8]. Su and Lu (2015) combined the bounded rationality assumptions and Multi-Agent simulation technology to analyze credit risks in SCF. The method reduced the credit risk of bank lending, while improving the overall income[9].Xi and Wu(2009) constructed a Multi-Agent supply chain risk management system model based on the Agent theory to identify the sources of risks and concluded that the model could reduce interference among members of the supply chain and improve overall operating efficiency of the supply chain[10].

Combining with the analysis of the aforementioned literatures, the paper will focus on the following three points: First, we focus on the highlighting operational risks of OSCF. Second, we innovatively construct a Multi-dimensional operational risk warning model under the Multi-Agent system and set the key risk indicators (KRIs), then analyze the operation mechanism of the model. Third, we explore the value of the warning model and its Multi-dimensional monitoring ability through simulation, finally we propose some management suggestions.

The Structure of OSCF

The viewpoint that the financial system is a complex system has been widely accepted. And OSCF system, as a field of the financial system, also has such a characteristic. The participants of OSCF include banks, corporations, insurance companies, government and legal institutions etc. These participants hold their own risk preference and master different available information for the purpose of their own interest under the same outside environment. However, each of them will be influenced by the surrounding environment of their own local to do some adjustments and changes, and constantly improves themselves by adaptive and innovative learning independently. Based on this, they make their own decision and judgment under the existing background of financial information while at the same time coordinate, cooperate and compete with others. Mutual influence and relevance make the OSCF system operate in a dynamic process repeatedly. The construction of complex system is shown in Figure 1.

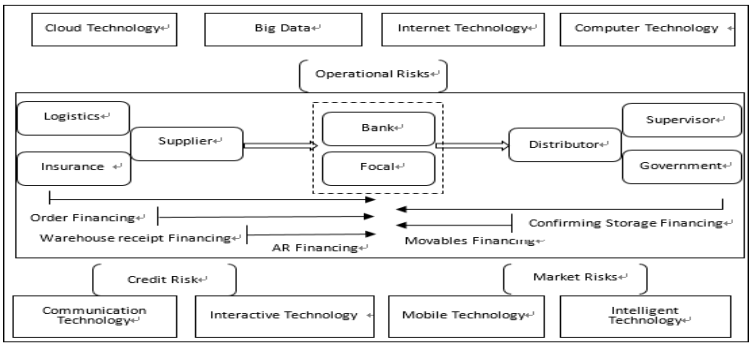

Figure 1. The structure of OSCF complex system.

The Construction of Operational Risk Control Model

Under the environment of supply chain finance system, the relationships among the various interest parties are both competitive and cooperative. The simulation method based on the traditional model can easily lead to deviation from the actual operation because it lacks intelligence and initiative and does not have the ability of data integration and decision analysis. The traditional model may also impair the validity of the simulation process and the persuasion of simulation result. Agent belongs to conceptual models of a class of distributed artificial intelligence and has its own objectives,

knowledge, skills and behaviors. It is an independent operating entity working under some certain circumstances with the characteristic of initiative, intelligence, independence, interactivity, reactivity, etc. Through the combination of multiple Agent, various entities work together and constitute the Multi-Agent system (MAS). MAS operates based on the rational allocation of each Agent's goal, resource and knowledge. The Agent runs independently and also coordinate sand cooperates with others in the system at the same time. On the basis of achieving their respective goal, they can achieve the general goal of MAS. The characteristics above are similar with the reality of supply chain finance business operations.

Be specific to our paper, the applications of the Agent are: On the one hand, we abstract the online supply chain finance subjects, such as focal company, SMEs, logistics company as the Agent by considering their characteristics. What's more, we give the Agent behavior, goal and knowledge similar to the real environment, so the Agent can restore the real financing business. These Agents interact with others and form a MAS. On the other hand, we build functional Agents to achieve risk warning, so their role is similar to the real bank operating staff of financing business. These functional Agents finally identify the key areas of potential operational risks based on shared data analysis and communication with each other.

In addition, combined with the above analysis, the OSCF belongs to the category of complex financial system and Agent technology, as a kind of complex system modeling method, has been applied in a large number of literature research in risk management and proved to be effective. Thus, our paper is based on the above Agent risk management theoretical basis and the superiority of MAS model simulation.

We select the hybrid Multi-Agent system (MAS) as the basic framework. The framework combines the characteristics of the centralized structure and distributed structure. It means that the Agent in the system generally maintains independent running state and the system only sets up high-level Agent in some key areas to manage and control low-level Agent. The hybrid structure not only ensures the independent operation, but also ensures the harmonious and unified action, achieving the reasonable allocation of resources and efficiency.

When constructing the Multi-Agent system (MAS), we build one overall control Agent, three monitoring Agents and four functional Agents. Besides, the subject Agent in the OSCF (the bank, the focal company, SMEs, the logistics company) restore the real business environment in the Multi -Agent system. Different Agent operates independently based on the platform database and exchanges views with the other Agent at the same time, constituting a Multi-Agent system, as shown below in Figure 2.

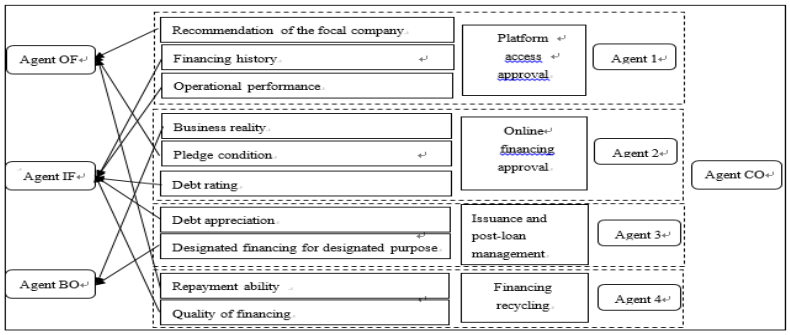

Figure 2. The structure of Multi-Agent system.

Our paper generally forms a four dimensional risk warning system, namely the individual score, process score, type score and total score. The bank can determine the corresponding potential operational risks according to the different dimensional risk score. The process score can reflect potential operational risks in a certain stage of financing. The type score reflects which type of operational risk should be taken seriously. The total score helps to judge operational risks in a financing project and determines whether the bank should continue to execute the financing project and the degree of overall operational risks the bank bearing. By building the four dimensional risk

warning system, the bank finally completes the reverse monitoring of operational risks in OSCF and finds a balance between cost and efficiency.

Notations and Assumptions

We define our notations as follows:

v_1 :Recommendation of the focal company

v_2 : Financing history

v_3 : Operational performance

λ : Business reality

w_1 : Debt rating

w_2 : Pledge condition

q_1 : Debt appreciation

q_2 : Designated funds for designated purpose

x_1 : Repayment ability

x_2 : Quality of financing

Our paper sets individual score which is continuous between 0 and 1. In particular, we set that if the business reality is true, then λ=1and if the business reality is false, then λ=10. (Agent 2 warns).

In order to describe and analyze our quantitative models clearly, we summarize our modeling assumptions as follows.

A1: The pledge used in the electronic warehouse receipt financing is same or similar

A2: The data provided by the online supply chain finance platform is real and effective

A3: Whether the model warns depends primarily on the total score.

Definition

D1: NC_i represents the new customer that never uses the SCF for financing

OC_i represents the old customer that uses the SCF for financing before

D2: i represents a financing business for the financing company, namely the SMEs. rs_1, rs_2, rs_3, rs_4 represents each process score. $rs_{OF}, rs_{IF}, rs_{BO}$ represents each type score

The higher the score is, the more risks may exist. Each process score can be expressed as Equations (1)-(4).

$$\begin{cases} rs_1 = a_1 \cdot v_1 + a_2 \cdot v_2 + a_3 \cdot v_3 & (1) \\ rs_2 = (b_1 \cdot w_1 + b_2 \cdot w_2) \cdot \lambda & (2) \\ rs_3 = c_1 \cdot q_1 + c_2 \cdot q_2 & (3) \\ rs_4 = d_1 \cdot x_1 + d_2 \cdot x_2 & (4) \\ \\ s.t \quad a_1 + a_2 + a_3 = 1, \quad b_1 + b_2 = 1, \quad c_1 + c_2 = 1, \quad d_1 + d_2 = 1 \end{cases}$$

Similarly, type score can be expressed as Equations (5)-(7).

$$\begin{cases} rs_{OF} = v_1 + w_2 + x_1 & (5) \\ rs_{IF} = v_2 + v_3 + w_1 + q_2 + x_2 & (6) \\ rs_{BO} = \lambda + q_1 & (7) \end{cases}$$

$a_1, a_2, a_3; b_1, b_2; c_1, c_2; d_1, d_2$ represents the weight that the bank gives for each KRIs and depends on which type of operational risk that the bank emphasizes most. $a_1, a_2, a_3; b_1, b_2; c_1, c_2 \in [0,1]$。

D3: $TRS_{i,j}$ represents the total score, i represents the financing company, j represents the financing frequency. $TRS_{i,j}$'s Equations as follows.

$$TRS_{i,j}\left(NC_i\right)=rs_1+rs_2+rs_3+rs_4 \tag{8}$$

$$TRS_{i,j}\left(OC_i\right)=\left(rs_1+rs_2+rs_3+rs_4\right)+\eta\cdot TTRS_{i,j}\cdot e^{Q} \tag{9}$$

$$TTRS_{i,j}=\frac{\sum_{j=2}^{n}[TRS_{i,j-1}*\partial(t)]}{j-1} \tag{10}$$

$TTRS_{i,j}$ represents the weighted total score of a financing company i from the first financing. $\partial(t)$ is the attenuation function of total score, derived from the transformation of $\arctan(t)$. t represents the time between the last financing and current financing in month. The attenuation function is shown in Figure 4. Along with the growth of the time interval, the reference score attenuation accelerates. We can understand the $\partial(t)$ as the contribution that past history financing make for the current financing.

If there was no fraud in the financing, then the value of $\partial(t)$ is like Figure 4. On the contrary, the value of $\partial(t)$ is the opposite number of Figure 3.

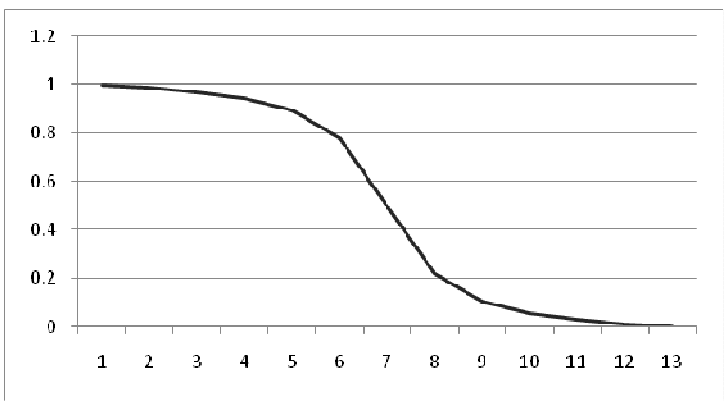

Figure 3. Attention function curve.

η is an influence factor that the past financing do to this financing. For the same financing company and same pledge, the η is same.

e^{Q} represents the punish coefficient. It will be used to punish the financing company that has fraud during a financing project. Q represents the frequency of fraud.

D4: We use the expert consultation method to determine the threshold of our risk warning model.

Model Application

Data Preparation and Simulation Purpose

Based on a bank's SCF data base, we select one financing company (NC_1). After processing, their individual score of KRIs are as follows, shown in Table 1.

Table 1. The individual score of NC_1.

	v1	v2	v3	w1	w2	λ	q1	q2	x1	x2
NC1	0.2	0.2	0.3	0.9	1.8	1	0.5	1.1	0.8	0.5

Then, we set the threshold for the type score and total score, considering the practice in the bank. The threshold is 60% of the maximum, shown in Table 2.We also get the weight for each KRI, $\vec{a}=\{0.2,0.5,0.3\}$, $\vec{b}=\{0.6,0.4\}$, $\vec{c}=\{0.7,0.3\}$, $\vec{d}=\{0.5,0.5\}$ and $\eta=0.05$.

Table 2. The threshold of each score.

	TRS	rsIF	rsOF	rsBO	rs1	rs2	rs3	rs4
Maximum	5.7	7	5	2	1	2.4	1.3	1
Threshold	3.42	4.2	3	1.2	0.6	1.44	0.78	0.6

The numerical studies consist of four sub-simulations, namely single financing, continuous financing, transaction fraud and financing influence factor on the basis of control variates.

Analysis for Each Sub-Simulation

Simulation 1: Transaction Fraud Situation. We assume that there is a fraud in the fifth financing of OC_1 and the rest financing has no fraud. We also let the OC_1 implement the financing 10 times continuously. The Agent gives the individual score of the fifth financing in Table 3. The simulation result can be seen in Figure 4.

Table 3. The individual score of $OC_{1,5}$.

	v1	v2	v3	w1	w2	λ	q1	q2	x1	x2
$OC_{1,5}$	0.2	**0.9**	0.3	0.9	1.8	1	**0.9**	1.1	0.8	**0.9**

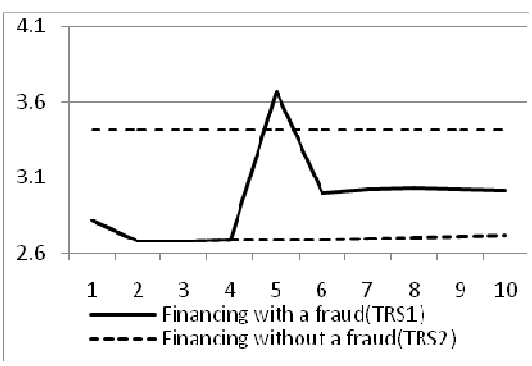

Figure 4. The result of the simulation.

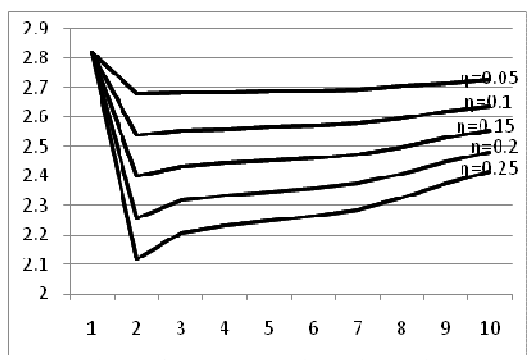

Figure 5. The result of the simulation.

From the Table 3 and Figure 4, we can obtain four important observations. First, the Agent CO successfully warns the risk in fifth financing based on $TRS1_{1,5}$>3.42. Then, with the combination of the warning condition coming from Agent 1, Agent 3, Agent 4, the bank could focus on what the real risks are, like financing history, debt appreciation, quality of financing in this simulation. Second, comparing with the $TRS2$, we see that the $TRS1_{1,6} > TRS2_{1,6}$ even though it is a same financing business. It reveals that a fraud in the past financing would have a negative effect on the current financing. The negative influence would not only increase the financing cost of SMEs, but also increase the risk management cost of the bank. Third, we find that the $TRS1_{1,7} > TRS1_{1,6}$. It means that the punishment influence will transmit to the next financing and the result is useful for the bank to focus on the SMEs who has a fraud before.

Simulation 2: Financing Influence Factor. We assume that the bank adjust the η and the OC_1 implements the financing 10 times continuously. The η varies from 0.05 to 0.25. The simulation result is shown in Figure 5.

From the Figure 5, we observe that the larger the η is, the more influential the past financing is. The result is obvious, because the η reflects the weight of past financing $TTRS_1$ to the TRS_1. And another result we find is as the increasing of η, $TRS_{1,2}$ declines more, but $TRS_{1,3}$ returns to increase more as well. It reveals that the model could automatically adjust the influence of η if the bank sets it inappropriate. So it gives a practical implication that the bank should set η based on SMEs' conditions.

Conclusion

The paper illustrates the warning managementon operational risks in online supply chain finance under the trend of the "Internet +strategy" in China. We build a Multi-dimensional risk warning model based on the analysis of key risk areas and take the electronic warehouse receipt pledge financing model as an example to simulate. The simulation studies show: First, the Multi-dimensional model is better than traditional model in operational risk management and could be applied to different financing companies and projects. Second, the successful financing history could reduce both the SMEs' financing cost and the bank's risk management cost, but the bank must pay more attention to the inertial thinking in financing business. Third, the fraud of SMEs would have negative effects on the next financing and do harm to both the SMEs and the whole supply chain. Finally, the bank should set η based on SMEs' conditions. In conclusion, the model we built is effective and applicable to the warning management of operational risks in online supply chain finance.

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