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FINANCIAL RISK EVALUATION AND ASSESSMENT SYSTEM FOR INTERNET SUPPLY CHAIN FINANCE WITH RCS DEPLOYMENT

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ABSTRACT: While the investment is known prior to the implementation, the stochastic nature of contingencies imposes significant uncertainty on interruption costs. This paper constructs a multiple dimensional intelligent financial risk evaluation and assessment system for Internet Supply Chain Finance (ISCF) using RCS (Remote Controlled Switch) deployment. Then financial risk is evaluated using RCS deployment in distribution networks that usually justified via comparing the required investment with the expected decrease in interruption costs. This method captures the stochastic nature of contingencies through a sequential Monte Carlo simulation approach. A mathematical formulation is developed to optimize post-fault actions minimizing customer's interruption costs. By using the analytic hierarchy process gray assessment theory, a risk assessment model of ISCF is built. The proposed method is applied to a test system where different sensitivity analyses are conducted to identify key affecting parameters. The small and medium sized enterprises in internet supply chain are selected as an example in this paper to evaluate the financial risk using the proposed method.

KEY WORDS: Internet supply chain finance (ISCF), remote controlled switch (RCS), financial risk assessment and evaluation.

I. INTRODUCTION

The financial development of Internet supply chain accelerates the change of enterprise financing mode. In the present time, supply chain finance is combined with Internet. It can improve the information asymmetry of both parties through network function benefit. It can help the decision making department to improve the financing problem of SMES (Small and Medium Sized Enterprises). With the emergence and rapid development of E-commerce, the logistics industry gradually rises. With the rapid development of the Internet there are risks in Internet supply chain finance so the new technologies have not been fully tested in practice, hackers, network fraud and other problems have emerged in endlessly. When the supply chain finance enters the Internet environment, on the one hand, there may be software vulnerabilities, and if the repair is not timely, there will be a lot of losses. On the other hand, there may be information fraud, information leakage, capital loss and other problems. Internet supply chain finance has the characteristics of vertical industry orientation, specialization, vulnerability and instability. The existed literature about ISCF mainly focuses on its risk identification, especially by qualitative analysis, while only a little research by quantitative method. Therefore, it is necessary to provide an accurate quantitative assessment on the risk of ISCF, by which to provide decision-making reference before lending and risk warning after lending.

The increasing need for more reliable electricity supply is among the key challenges faced by the industry. This issue turns attention to distribution networks since they account for a great percent of service interruptions. In order to enhance distribution network reliability, implementing remote controlled Switches (RCSS) has captured growing attention in recent years [1-4]. RCSS reduce interruption durations by enabling remote maneuvers and rapid reenergizing of healthy sections. However, they impose some expenses to distribution companies (Disco) as well. Thus, thorough cost/benefit analyses are necessary to justify RCS deployment in networks. In the existing analyses, RCS deployment is justified if the expected monetary profits of Reliability enhancement exceed the required investment. However, the stochastic nature of contingencies imposes significant uncertainty on the monetary profits thereby imposing substantial financial risks on the disco. This paper aims to evaluate the financial risk and identify associated key affecting parameters. The paper reveals that broad installation of RCSS might be avoided if the risk is considered in cost/benefit analyses.

II. LITERATURE SURVEY

ISCF integrates three elements highly that is, internet, supply chain and finance. SMEs are no longer absolutely dependent on the main company so the traditional "one-to-many" relationship model becomes "many-to-many" model. Therefore, the critical role of ISCF is related to the panoramic data of partners in ISCF, such as financing company, focal company and logistics enterprise. Another important attribute of ISCF is the upstream and downstream data of supply chain such as pledge status, internet status and external environmental industry status. Most of financing enterprises are SMEs and located in the upstream or downstream of supply chain. According to the literature such as [5], to find out the risk of financing to these SMEs, it is necessary to analyze their solvency, operational capability, profitability, development status, credit status and so on. Furthermore, internet financial status should also be considered.

In recent years, the RCS placement problem in distribution networks has been addressed in several articles. In [7], the multi-objective RCSs placement problem was proposed in order to minimize the number of switches and customer interruption costs. In [6], Moradi and Fotuhi-Firuzabad solved the problem, where the number and location of switches and Circuit Breakers (CBs) are optimized. In [9], the search space of a switch placement problem was broken into two subspaces, which are then solved independently. The research reported in [4] developed mathematical models in a Mixed Integer Linear Programming (MILP) format to solve the switch deployment problem. The work presented in [4] solved the problem with a detailed objective function where customers' interruption cost as well as switch investment, installation, and maintenance costs are considered. Safdarian *et al.* [1], examined the impact of RCS malfunction on the RCS worth. Farajollahi *et al.* [2] proposed a mathematical model for joint manual switch (MS) and RCS placement in the MILP format.

Actually, switch deployment cost is deterministic, while its worth totally depends on contingencies, which follow a highly stochastic behavior. The authors believe that it is critical to consider the stochastic nature in the placement problem. To illustrate the importance of considering uncertainties and their induced risk, a few articles focusing on the financial risk in some other power system studies are briefly reviewed here. Value-at-Risk (VaR) and

Conditional value-at-rrisk (CVaR) are the common risk measures to evaluate the financial risk. In [5], VaR was used for the application to power transmission system planning with the aim at minimizing customer interruption costs. Schreiner *et al.* [7] applied the proposed method in [5] on distribution systems. Alvehag and Soder [8] used VaR and CVaR for risk analysis in customer interruption costs of distribution systems.

III. PROPOSED METHOD

The the step-by-step method to evaluate the financial risk induced by the stochastic nature of contingencies and repair time is presented. Then, the formulation of an Optimal Fault Management (OFM) problem is outlined. Finally, in order to measure the induced risk of uncertainties, several financial risk indices are presented. As the main contribution, this paper investigates the level of the risk and determines key affecting parameters such as network size, components failure rates, repair times, customers' damage costs, and switch costs. To do so, the paper presents a step-by- step method for investigating the risk. In the method, the stochastic nature of contingencies is considered through a sequential Monte Carlo simulation (MCS) approach. It is worth mentioning that in the paper the optimal placement of RCS is made before its financial risk evaluation.

3.1 Risk Evaluation

In order to evaluate the risk, the portable Document Format (PDF) file of system interruption cost is calculated first. Then, comparing costs before and after installing RCSs can be used to achieve the PDF of RCS installation profit and the associated risk. So, a step-by-step framework for deriving the PDF of system interruption cost is presented first. Fig. 1 demonstrates the framework whose steps are described as follows. The first step is to prepare technical data associated with network, study horizon, and feeding loads. Network data consist of network topology, failure rate and repair time of components, number and location of RCSs, and times needed for switching RCSs. Study horizon is the time duration over which worth of RCS deployment is going to be studied. Load data consist of load points demand and type, and customers damage functions for different customer types and different interruption durations. The outer loop samples scenarios. A scenario represents up/down status of different components of the network during the study horizon. In this paper, scenarios are sampled through the sequential MCS approach. Without loss of generality, the exponential distribution function for failure time and repair time is considered in this paper. In the approach, up/down status of a component during the study horizon is determined via the MCS approach.

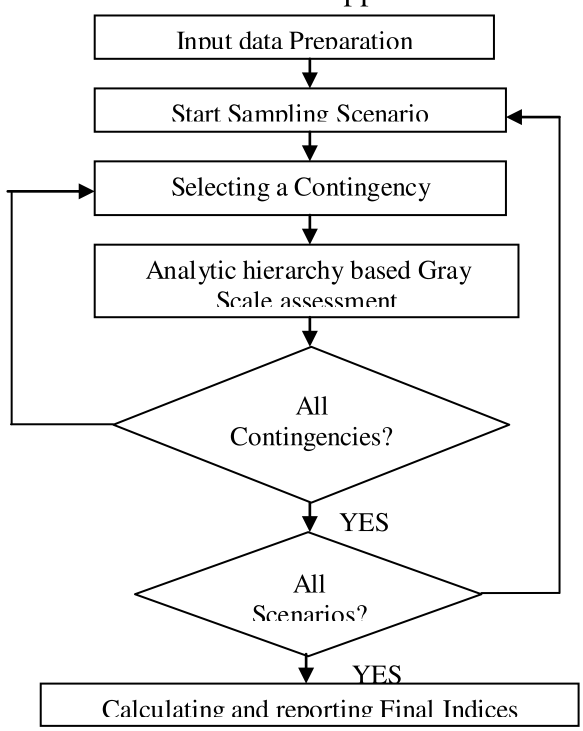

Fig. 1: FLOW CHART OF PROPOSED METHOD

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The inner loop iterates over all contingencies happened within the sampled scenario in the outer loop. A scenario represents up/down status of all system components. It is worth mentioning that the MCS approach samples contingencies based on some randomly generated numbers. So, the number of contingencies varies based on the produced random numbers and varies from one scenario to another. In addition, according to the observations, simultaneous failure of multiple components is almost unlikely and just one component fails to operate properly in a contingency. So, without loss of generality, contingencies with only one faulted section are considered here. Also, the number of contingencies depends on the length of study horizon and failure rate of system components. As either of the parameters increases, more contingencies are expected to happen, and thus, more contingencies should be considered in this step.

3.2 Financial Risk assessment

To assess risk, analytic hierarchy process assessment method can be used, but the method is subjective and may have problems such as information loss. Gray comprehensive evaluation method can also be used to assess, this method can make up the fault of analytic hierarchy process assessment but cannot measure the consistency of expert judgement. Therefore, the paper combines these two methods and builds an analytic hierarchy process gray assessment method to determine the financial risk of the internet supply chain.

3.2.1 Analytic Hierarchy Gray Scale Assessment Process

In the internet supply chain financial risk assessment system, these indicators have different degrees of impact on risk and so their weights are different too. It is necessary to determine the weight of each indicator by means of analytic hierarchy process. According to the corresponding importance of these indicators, experts score and thus form a judgment matrix. Calculate the maximum eigenvalue of the judgment matrix and the corresponding feature vector, and then determine whether the judgment matrix under the maximum eigenvalue satisfies the consistency test. Otherwise, experts will score again until the consistency condition is satisfied.

Assessment Sample Matrix: First of all, with the traditional five-level classification idea of loan risk, the risk indicators of internet supply chain finance are divided into five categories according to the risk level, which are very low risk, low risk, medium risk, high risk and very high risk, respectively. Furthermore, these five kind of risk will be assigned 1 point, 2 points, 3 points, 4 points and 5 points respectively. If the risk level is between two of these indicators, the value will be assigned 1.5 points, 2.5 points, 3.5 points and 4.5 points respectively. There are two methods for expert to deal with score, one is accurate scoring and the other is interval scoring. If the expert judges the score of each indicator according to their own experience, it is necessary to consider the consistency of these scores. Suppose that there are N experts to score the indicators and denote the i^{th} expert's score on the indicator C_{jk} as d_{ijk} , then the Baker concentration factor is:

$$\rho_{jk} = \left[\sum_{i=1}^{N}\left(d_{ijk} - \sum_{i=1}^{N}\frac{d_{ijk}}{N}\right)^2\right]^{\frac{1}{2}}\frac{\sum_{i=1}^{N} d_{ijk}}{N} \text{ --- (1)}$$

The smaller the coefficient, the more consistent tendency of the indicators evaluation results, the better effectiveness of the assessment. In general, if the coefficient is less than 0.05, the expert score satisfies the consistency test; otherwise, experts need to re-score and then determines whether the

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concentration coefficient satisfies the consistency test. When the expert scores the evaluation index according to his own experience, denote the lower limit of the score as $\overline{m_i}$ and the upper limit as $\underline{m_i}$, from the Centralization Statistical Method, the risk evaluation value R can be expressed as

$$R = \frac{\frac{1}{2}\sum_{i=1}^{N}\overline{m_i}^2\underline{m_i}^2}{\sum_{i=1}^{N} d_{ijk}} \text{ -------- (2)}$$

$$c_i = \frac{1}{1+\frac{\sum_{i=1}^{N}\left(\overline{m_i}-R\right)^3-\left(\underline{m_i}-R\right)^3}{3\sum_{i=1}^{N}\left(\overline{m_i}-\underline{m_i}\right)}} \text{ ------- (3)}$$

The higher the confidence, the more accurate the expert's assessment of the indicators, the better the consistency; otherwise the expert scores need to be re-examined and the consistency will also be checked again. Thus, the evaluation sample matrix D of the secondary indicators can be determined

$$D = \begin{bmatrix} d_{111} & d_{211} & \cdots & d_{N11} \\ \vdots & \vdots & \vdots & \vdots \\ d_{116} & d_{216} & \cdots & d_{N16} \\ d_{121} & d_{221} & \cdots & d_{N21} \\ \vdots & \vdots & \vdots & \vdots \\ d_{123} & d_{223} & \cdots & d_{N23} \\ \vdots & \vdots & \vdots & \vdots \\ d_{161} & d_{261} & \cdots & d_{N61} \\ d_{162} & d_{262} & \cdots & d_{N62} \end{bmatrix}_{19\times N} \text{ ----- (4)}$$

Where 19 is the number of the secondary risk indicators.

Gray Class Assessment: To assess the gray class, it needs to know the grade number of gray classifications, the gray number of the gray classifications, and the corresponding whitening weight function. Since the indicator risk is divided into five levels, it is necessary to determine five evaluation gray classes. Assume that the assessment gray class number is r, where $r(1,2,3,4,5)$, the higher the number the lower the risk. For any gray class number r gray number $\oplus_r \in [0, r, 2r]$ whitening weight function f_r can be expressed as

$$f_r\left(d_{ijk}\right) = \begin{cases} d_{ijk}/r \, , d_{ijk} \in [0, r], \\ 2 - d_{ijk}/2r \, , d_{ijk} \in [1,2r] \\ 0 \quad , \quad d_{ijk} \notin [0,2r] \end{cases} \quad (5)$$

Specially, when $d_{ijk} \in [0,1]$, $f_1\left(d_{ijk}\right) = 1$

Then OFM problem is simulated for each of the sampled contingencies to determine load points interruption durations and the respective costs. In the problem, manual and remote switching actions are optimally applied to minimize system interruption cost. Mathematical representation of the problem is outlined later. This PDF of system interruption cost is derived. To do so, total interruption cost within a scenario is calculated by summing up the present value of costs imposed by the contingencies as follows:

$$Cost_{\omega}^{int} = \sum_{c\epsilon C_{\omega}} Cost_{\omega}^{int} \quad \forall \omega \epsilon \Omega \text{ ----- (6)}$$

As total cost in different scenarios is achieved, the PDF is constructed by putting them together. In order to calculate the financial risk associated with RCS deployment, the described framework is applied to calculate the PDF of system interruption costs before and after installing RCSs. The difference of the two PDFs is the PDF of the gross profit achieved by RCS deployment. RCS deployment has costs that are calculated as follows:

$$Cost^{RCS} = \sum_{f\in F}\sum_{s\in S} X_{f,s}^{RCS}\ CI_{f,s}^{RCS} + \sum_{f\in F}\sum_{s\in S} X_{f,s}^{RCS}\ IC_{f,s}^{RCS} + \sum_{t\in T}\sum_{f\in F}\sum_{s\in S} X_{f,s}^{RCS}\ MC_{f,s}^{RCS}\,(1+DR)^{-t} \text{ -------- (7)}$$

Where the first and second terms are capital investment and installation costs of RCSs, respectively. The third term denotes the present value of maintenance costs of RCSs. Subtracting RCS deployment costs from the PDF of the gross profit, the PDF of the net profit of RCS deployment is calculated as follows:

$$Profit_{\omega} = Cost_{\omega}^{int,wo-RCS} - Cost_{\omega}^{int,w-RCS} - Cost^{RCS} \ \forall \omega \epsilon \Omega \text{ ------ } (8)$$

Using the achieved PDF, RCS deployment risk can be calculated.

IV. RESULTS

On the basis of constructing the financial risk control model of Internet supply chain, the experimental data analysis is carried out. In the empirical analysis, 220 small and medium-sized enterprises in Internet supply chain are selected as the source of data and the time limit of data collection is from 2007 to 2017. The data analysis software is Excel 2007 and SPSS (Statistical Package for the Social Science) 19.0, in combination with Matlab mathematical programming, the financial risk management of Internet supply chain is analyzed by mathematical science. The method of MCS analysis is used to analyze the financial risk management ability of Internet supply chain with the deployment of RCSs in the distributed network. Therefore, when investor provides financing service to SMEs in supply chain, risk can be assessed from the above analysis. Tracking and monitoring the partner's panoramic data and the upstream and downstream data in the supply chain, substituting them into assessment model to determine the risk of the financing enterprise real-time, it will be easy to make a decision on whether to lend before the loan and to provide the risk warn after the loan.

Table 1: RISK LEVEL OF INTERNET SUPPLY CHAIN FINANCE

Risk Value Range	Risk Classification	Risk Attribute
[0,1]	1st	Very low risk
[1,2]	2nd	low risk
[2,3]	3rd	medium risk
[3,4]	4th	High Risk
[4,5]	5th	Very high risk

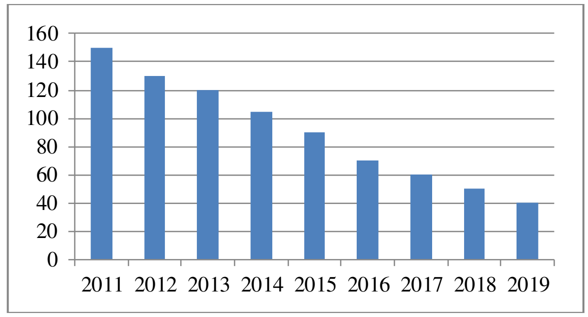

Fig. 3: RESULTS OF PROPOSED FINANCIAL RISK ANALYSIS OF INTERNET SUPPLY CHAIN

The result for the MCS analysis of financial risk in Internet supply chain from past decade is shown in figure (3).

V. CONCLUSION

This paper presented a financial risk assessment and evaluation method of ISCF with RCS deployment in distribution networks. In the method, the stochastic nature of contingencies was considered through the MCS approach. Also, it was observed that the number of installed RCSs, length of study horizon, system size, RCS costs and components failure rates and repair times have significant impacts on the risk. Risk assessment of ISCF is usually based on partner's panorama data and the upstream and downstream data in the supply chain. It can be useful to improve the risk control level of internet supply chain finance. It is also easier to obtain information flow such as the price changes, liquidation status of the pledge and management status in the supply chain, which can effectively lighten the information asymmetry between supply side and demand side. Those data can be obtained easily and used efficiently, therefore reduce risk in the ISCF.

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