Research on the Risk Early Warning Method of Material Supplier Performance in Power Industry

Peng Chen a, Xi Zhang b
School of Traffic and Transportation, Beijing Jiaotong University, Beijing 100089, China.

a pengchen@bjtu.edu.cn, b xizhang@bjtu.edu.cn

Abstract: The early warning of supplier performance risk is still in the initial stage interiorly, and research on the early warning mechanism to identify, analyze and prevent the performance risk is few. In this paper, a new method aiming at material supplier performance risk in power industry is proposed, firstly, establishing a set of risk early warning indexes, then use the ECM method to classify the indexes to form different risk grades. Then, improving Crock Ford risk quantization model by considering three indicators, including the stability of power system, economic losses and successful bid ratio to form the predictive risk grade, and ultimately using short board effect principle to form the ultimate risk grade to truly reflect the supplier performance risk. Finally, making empirical analysis on supplier performance and putting forward the countermeasures and prevention strategies for different risks.

Keywords. Power Industry; Supplier Performance Risk; Risk Early Warning; ECM; Short Board Effect; Improved Crock Ford Risk Quantify Model.

1. Introduction
The safety and stability of power grid is very important for ensuring the development of national economy and ensuring the normal operation of production and life. Power grid corps focus on building and operating the grid with the equipments provided by the corresponding suppliers. The type of the equipments is very complicated, the suppliers is in large number and quite different levels, so various types of risks may occur during the performance process. At present, Power grid corps are still in the initial stage of the risk early warning, they usually take remedial action only after the risk has occurred or prevent the risk through the subjective judgment of the managers. Therefore, it is necessary to study the performance risk early warning of grid suppliers.

Domestic and foreign scholars have conducted some research on risk early warning. In the research on risk early warning evaluation in supply chain disruption, Hao Chen classify the supply chain disruption cases into 8 types, take principle of control chart to construct a early warning evaluation model, using 3σ principle to confirm the threshold of the index and using fuzzy comprehensive evaluation method to make risk early warning evaluation [1]. Aiwu Zhao put forward the method of using fractal theory to construct supplier risk early warning model which has self-similarity, self-organization and self optimization feature that can help to improve efficiency [2]. Yin Wang use improved EMC method and Gray relative analysis method to improve the integration efficiency of risk
information [3]. Lisha Zhou selected some key indexes of low-carbon benefit of smart grid [4]. Their researchs are helpful but can not be used directly on power industry’s supplier performance risk early warning.

2. Research Methods and Models

2.1. Elections for Risk Early Warning Index

Based on the domestic and foreign scholars’ research on supplier performance evaluation and consulting experts from power enterprises, this paper designed a set of indexes starting from the three dimensions of credit, delivery service and quality. Qualitative indicators are quantified by experts’ scoring. The evaluation indexes are shown in table 1.

| Evaluation Dimension | Indexes                                                                 | Description                                                                 |
|----------------------|-------------------------------------------------------------------------|-----------------------------------------------------------------------------|
|                      | Serial Number | Index Name                      | Description                                                                 |
| Credit Standing and  | A1            | Net Assets Income Rate          | Measure the profitability of suppliers                                       |
| Respectability       |               |                                |                                                                             |
|                      | A2            | Record of Bad Behavior          | Refer to the supplier’s bad behavior management measures                     |
|                      | A3            | Management System Certification | ISO9001 certification is essential, ISO28001 and ISO14001 certification are bonus items |
|                      | A4            | Signing and Settling Accounts   | Whether the supplier issues the invoice and relevant settlement certificate in time |
|                      |               | service                        |                                                                             |
|                      | A5            | Timeliness of Delivery          | Measure whether the supplier delivers goods on time                          |
|                      | A6            | Service Satisfaction            | Whether the supplier work efficiently to solve problem for the owner          |
|                      | A7            | Quality Inspection Before      | Qualified rate before supply                                                 |
|                      |               | Supply                         |                                                                             |
|                      | A8            | Quality Inspection After       | Qualified rate after arrival                                                 |
|                      |               | Arrival                        |                                                                             |
|                      | A9            | Product Operation Condition     | Whether there exists any fault during operation and repaired in time          |

2.2. Index threshold division and risk grade

Considering that the data of risk early warning is derived from many suppliers, and the overall distribution of the data is concentrated in a certain interval, the raw data can be regarded approximately obey skewed distribution, so the threshold can be divided by the Efficiency Coefficient Method (ECM). The early warning evaluation matrix \( A_{mn} \) is composed of \( N \) (N=9) indexes and \( M \) (M=the number of evaluation units) evaluation units. Use \( a_{min}, \bar{a} - \sigma, \bar{a}, \bar{a} + \sigma \) and \( a_{max} \) these 5 values to divide 4 threshold intervals shown in table 2.

| Classification of Risk Grades in One Index |
|-------------------------------------------|
| High risk                                 |
| \([a_{min}, \bar{a} - \sigma]\)           |
| Medium risk                               |
| \([\bar{a} - \sigma, \bar{a}]\)           |
| Low risk                                  |
| \([\bar{a}, \bar{a} + \sigma]\)           |
| Risk-free                                 |
| \([\bar{a} + \sigma, a_{max}]\)           |
2.3. Predictive risk grade
Crock Ford proposes that the measurement of risk value can be expressed by the product size of the possibility of risk and the degree of loss caused by the risk, we added the successful bid ratio as a new evaluation factor. The risk grade can be shown as:

$$\text{Risk} = P \times L \times R$$ (1)

In the equation, Risk represents risk grade, P represents possibility, L represents loss caused by the risk and R represents successful bid ratio. Considering the particularity of the power industry, the supplier's performance risk will affect the normal construction of the power grid. It is not enough to measure the risk loss only with the economic loss, therefore, the grid stability is introduced. We set the weight of grid stability as 0.6 and economic loss as 0.4. So we have this equation:

$$L = 0.6S1 + 0.4S2$$ (2)

S1 represents the influence degree by grid stability and S2 represents economic loss. According to experts’ opinions, we can quantify P by using historical data which has the frequency of actual risk in the last three years, the data is updated annually. The quantization of P is shown in table 3.

**Table 3. Quantization of P**

| Frequency of actual risk | Score | Not more than once | Twice | Three times | More than three times |
|-------------------------|-------|-------------------|-------|-------------|----------------------|
|                         |       | 0.5               | 1     | 2           | 4                    |

S1 and S2 can also be quantized as shown in table 4.

**Table 4. Quantization of S1 and S2**

| Description | Score |
|-------------|-------|
| Grid Stability | |
| Grid construction be postponed for less than 10 days or power supply be affected slightly in small scale | 1 |
| 10-30 days delay or be affected obviously in small scale | 2 |
| 1-3 months delay or be affected slightly in large scale | 3 |
| More than 3 months delay or be affected obviously in large scale | 4 |
| Economic Loss | |
| The direct economic loss is less than 1 million yuan | 1 |
| 1 million – 5 million direct economic loss | 2 |
| 5 million – 10 million direct economic loss | 3 |
| More than 10 million direct economic loss | 4 |

Get P scores according to historical data, get L scores from grid stability and the degree of economic loss according to expert advice, Get R scores by calculating successful bid ratio of the supplier from one batch bidding, so the risk value can be got finally, it range from 0 to 16. According to the distribution of the score, the threshold is divided shown in table 5.

**Table 5. Grade of Predictive Risk**

| Range | [0, 1] | [1, 2] | [2, 4] | [4, 16] |
|-------|--------|--------|--------|---------|
| Grade | Risk-free (F) | Low risk (L) | Medium risk (M) | High risk (H) |
It is worth mentioning that the predictive risk grade represents the extent to which the risk may be affected if a performance risk occurs, rather than the risk actually exist.

2.4. Ultimate risk grade
Risk grades from 9 indexes are combined based on the short board effect, and then adjust the risk grade according to the predictive risk grade, so the ultimate risk grade is obtained. It’s shown in table 6.

| Individual Risk Grade | Predictive Risk Grade | Ultimate Risk Grade |
|-----------------------|-----------------------|---------------------|
| Based on the highest risk grade in 9 indexes | | |
| High risk (H) | Raise 2 grades on the basis of individual risk grade | |
| Medium risk (M) | Raise 1 grade on the basis of individual risk grade | |
| Low risk (L) | The same as individual risk grade | |
| Risk-free (F) | Reduce 1 grade on the basis of individual risk grade | |

Table 6. Setting Rules for Ultimate Risk Grade

Fig. 1 Structure of the Risk Early Warning Model

3. Empirical analysis of supplier performance risk early warning
Taking 10kV transformer equipment suppliers as example, the empirical analysis is carried out. Calculate the individual risk grades and predictive risk grades of one hundred suppliers and get the ultimate risk grade. We select a typical supplier’s data from 10 different batches range from year 2010 to year 2014. The different risk grade is shown in table 7, table 8 and figure 2.

| Batch | Year | A1 | A2 | A3 | A4 | A5 | A6 | A7 | A8 | A9 |
|-------|------|----|----|----|----|----|----|----|----|----|
| 1     | 2010 | N  | N  | M  | H  | M  | N  | N  | N  | N  |
| 2     | 2010 | N  | N  | M  | M  | N  | L  | N  | N  | H  |
| 3     | 2011 | L  | N  | N  | N  | M  | L  | L  | N  | N  |
| 4     | 2011 | L  | N  | N  | L  | L  | N  | N  | N  | N  |
| 5     | 2012 | N  | N  | N  | N  | N  | N  | N  | N  | N  |
| 6     | 2012 | N  | N  | N  | L  | N  | N  | L  | N  | N  |
| 7     | 2013 | N  | N  | N  | N  | L  | N  | N  | N  | N  |
| 8     | 2013 | N  | N  | N  | L  | N  | N  | N  | N  | N  |
| 9     | 2014 | N  | N  | N  | N  | N  | L  | L  | N  | N  |
| 10    | 2014 | N  | N  | N  | N  | N  | N  | N  | N  | N  |
Table 8. Predictive Risk Grade of Different Batches

| Batch | P  | S1 | S2 | R  | Risk | Grade |
|-------|----|----|----|----|------|-------|
| 1     | 2  | 2  | 3  | 0.87| 4.18 | H     |
| 2     | 2  | 2  | 2  | 0.85| 3.40 | M     |
| 3     | 1  | 1  | 2  | 0.53| 0.74 | N     |
| 4     | 1  | 1  | 1  | 0.11| 0.16 | N     |
| 5     | 1  | 1  | 4  | 0.63| 1.39 | L     |
| 6     | 1  | 2  | 1  | 0.42| 0.67 | N     |
| 7     | 0.5| 2  | 1  | 0.55| 0.44 | N     |
| 8     | 0.5| 3  | 1  | 0.44| 0.48 | N     |
| 9     | 0.5| 1  | 3  | 0.70| 0.63 | N     |
| 10    | 0.5| 2  | 4  | 0.20| 0.28 | N     |

Fig. 2 Ultimate Risk Grade of Different Batches

From the ultimate risk grade, we can see that the performance of this supplier in the 2010-2014 years has shown an optimize trend. In the first two batches of supply in 2010, there exist problems such as untimely delivery and equipment breakdown during operation, which lead to high risk. As for the predictive risk grade, the P value decreases year by year, and the risk grade also decreases, which has a favorable impact on the evaluation of the ultimate risk grade.

4. Conclusion and Suggestion

4.1. Conclusion
Considering the perspective of power industry, a set of risk early warning index for material supplier is established in this paper. The risk early warning model is combined with the concept of economic losses and the bid ratio of supplier. Firstly, we calculated one hundred suppliers evaluation data, and analyzes the early warning result of one typical supplier. The analysis results can better match the change trend of suppliers and can make early warn of possible risk points.

4.2. Suggestion
According to the analysis results, the following suggestions are made for supplier management of grid corps:

1. Establish and perfect the risk management mechanism. Supplier risk early warning management system should follow the "correct early warning, timely reporting, and effective pre-control" principle. In order to ensure the effective implementation and operation of the risk management mechanism, it is necessary to have a special risk management team, and adapt to the organizational structure of the
company to form a risk management chain from top to bottom for the purpose of effective risk management.

2. Manage suppliers classified. According to the distribution characteristics of different risk points of dissimilar suppliers, different solutions should be adopted, so as to make more efficient risk prevention.

3. Establish the supplier risk management database. In order to be more accurate for supplier risk warning, it is necessary to ensure the accuracy and completeness of the supplier performance data. The establishment of a supplier risk management database avoids the inconvenience that it is often necessary to capture relevant data from different locations. It is beneficial to extract relevant data efficiently and accurately, and improving risk management.

4. Simplify the process of early warning. In order to simplify the quantify process of early warning index, may consider the direct adoption of qualification licensing, special product certification, technological authentication and other qualification results, as the basis for the corresponding evaluation indicators. For instance, the suppliers who have dedicated certification can simplify the quality control process, applying 90 points as the default quality module score, thereby reducing the workload of qualified suppliers to perform the evaluation, thus reducing the performance evaluation workload of excellent suppliers.

5. Dynamic regulation. If all important suppliers and all supply links need to be supervised, not only to spend a lot of human resources, material resources, but also make it difficult to find problems. Therefore, it is feasible that using the evaluation results focuses on monitor of the supply chain, which has been problems or has been signs of a problem, and adjusts the supervision according to the good or not of the evaluation results. Therefore, we can give special supervision to the suppliers and supply link according to the evaluation results, and adjust the supervision and supervision methods according to the evaluation results.

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