Stability Warning Method for the Supply Chain in the Electrical Equipment Industry

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Abstract. To better ensure the supply chain's effective operation in the electrical equipment industry, considering the significant fluctuations in raw material prices, this paper aims to optimize the risk warning mechanism for the electrical equipment supply chain. Firstly, under the assumption of other costs remaining constant, the focus is placed on the fluctuation of raw material prices for electrical equipment. A warning detection process based on profit margin is designed. Subsequently, considering the actual situation of the enterprise and the enterprise's flexible profit strategy, the paper draws inspiration from VaR theory to design a model for assessing the supplier's resilience to raw material price changes based on a vast number of fulfilled orders as an auxiliary warning method. Finally, management recommendations are provided for electrical equipment suppliers and power grid construction enterprises, facilitating better assurance of the stable operation of the supply chain in the electrical equipment industry in the future.

Keywords: supply chain management; value-at-risk; power grid enterprises; agreement inventory

1 Introduction

In recent years, the dynamic shifts in the global trade landscape have posed unprecedented challenges to the stability of the supply chain in the electrical equipment industry. The escalating volatility in commodity prices has resulted in fluctuating raw material prices for power equipment, emerging as a crucial factor influencing fulfillment rates[1]. This phenomenon has had profound implications for the effective functioning of the power equipment industry supply chain, impacting both production enterprises and procurement entities. A key issue arises from the potential disparity between the prices of raw materials at the time of signing procurement contracts and their prices at the time of delivery. This difference poses significant risks to production enterprises, resulting in a substantial decline in profits or even operational losses. The inability to deliver equipment further exacerbates this challenge. Unfulfilled orders have repercussions throughout the procurement departments of the entire power equipment industry, magnifying the overall impact on the supply chain.

MSIEID 2023, December 08-10, Guangzhou, People's Republic of China

DOI 10.4108/eai.8-12-2023.2344804

Recognizing the urgency of establishing an early warning mechanism to assess future risks, this paper proposes two innovative supply chain warning methods. The primary aim is to evaluate the influence of anticipated fluctuations in raw material prices on the stability of the supply chain. The two methods, namely the profit margin-based warning method and a warning method based on supplier raw material price endurance, collectively address the multifaceted challenges posed by raw material price fluctuations within the electrical equipment industry.

In Section 2, the profit margin-based warning method is developed, emphasizing the direct influence of raw material costs on supplier profitability. This approach assumes fixed logistics, labor, and other non-raw material costs[2], providing a focused monitoring framework for the impact of raw material cost fluctuations on supplier profits and enabling effective risk management in fulfillment. However, recognizing the practical scenario where suppliers often adjust non-raw material costs to mitigate the impact of rising raw material prices, Section 3 introduces a supplementary warning method. Drawing inspiration from Value at Risk (VaR) theory, this method leverages a model based on extensive historical performance data from supplier contracts. It assesses suppliers' ability to withstand fluctuations in raw material prices by determining an acceptable range of raw material price changes. This allows for a more direct and comprehensive evaluation of suppliers' performance capabilities in the context of fluctuating raw material prices.

The following sections of the paper will delve into the detailed design and practical implementation of these warning methods, providing a comprehensive framework for application in the electrical equipment industry. This study aims to equip managers with valuable tools to navigate the complexities of raw material price fluctuations, ensuring a resilient and adaptable supply chain.

2 Profit Margin-Based Early Warning Method

Profitability is a core indicator of a company's operations, directly reflecting its profit-making capacity and sustainability in the market. Using profit as a measurement standard is advantageous, as it is directly expressed in monetary units, making it easy to understand and operate. This indicator serves as a crucial source of financial information for decision-makers, enabling them to respond quickly. Against the backdrop of fluctuating prices for raw materials in the electrical equipment industry, this section introduces a profit-based early warning method. The primary objective is to predict potential risks in supplier performance by monitoring the profit level.

The boundary conditions set for this method assume that the supplier's non-raw material costs, such as logistics and labor, remain constant. Only the impact of raw material cost fluctuations on profit is considered. This focus on raw material price volatility as an external shock aims to establish a more targeted early warning mechanism, providing the enterprise with more accurate early warning and decision-making information. By centering on profit margins, this method offers a direct and operational approach to predict and mitigate potential risks associated with changes in supplier raw material prices. Subsequent sections will delve into the detailed design and practical implementation of this profit-based early warning method, providing a comprehensive framework for application in the electrical equipment industry.

$$P = B - R_i - R_{fix} \tag{1}$$

$$R_i = \sum_i p_i \times k_i, i \in \{1,2,...,n\} \tag{2}$$

$$PM = {}^{P}\!/_{B} \times 100\% \tag{3}$$

The variable definitions for this model are as follows: P represents the profit for a supplier in manufacturing one unit of electrical equipment. B denotes the winning bid price. R_i signifies the total cost of raw materials within the monitored scope, representing the type of raw material. It is assumed that the production of specific electrical equipment requires n different types of raw materials. R_{fix} stands for fixed costs such as logistics and labor that do not fluctuate. p_i corresponds to the forecasted price for raw material i in a given month. k_i indicates the quantity of raw material i required to manufacture one unit of electrical equipment. PM represents the profit margin.

equation (1) computes profit by subtracting raw material costs and other fixed expenses from the winning bid price; equation (2) calculates raw material costs based on the forecasted values of each raw material's price multiplied by the material coefficient; equation (3) computes the profit margin.

Based on extensive research on power equipment suppliers, this section adopts 0% and 5% as alert threshold values, dividing the alert range into three intervals: red, blue, and green, as illustrated in Figure 1. A detailed exploration of specific strategies that electrical equipment procurement enterprises can implement within each alert interval is crucial. The red alert interval signifies profits below 0, indicating a loss state for the supplier. In this scenario, the company should closely monitor the supplier's financial condition and promptly take intervention measures to rectify the situation. Potential measures may include renegotiating contract terms, exploring alternative suppliers, or even implementing price linkage initiatives to support struggling suppliers.

Moving into the blue alert interval, characterized by the supplier operating at a standard profit level, attention should be directed toward refining cost control measures and elevating managerial efficiency. This phase offers electrical equipment procurement entities an opening to collaboratively work with suppliers, streamlining procedures, pinpointing opportunities for cost reduction, and enhancing overall operational efficiency. The implementation of performance improvement initiatives and the establishment of open communication channels can significantly enhance the resilience and mutual benefits of the partnership.

Within the green alert interval, where the supplier is operating at a higher profit level with stable business operations, the electrical equipment procurement enterprises can explore measures to further optimize costs without compromising quality. This may involve negotiating for volume discounts, exploring bulk purchasing options, or jointly investing in innovation and technology to enhance overall efficiency. Additionally, the enterprise can leverage this period to foster long-term strategic partnerships with high-performing suppliers, ensuring a stable and sustainable supply chain.

In summary, the profit-based early warning method serves not only as a tool for risk identification but also provides a roadmap for strategic interventions at different alert intervals.

By tailoring specific actions to each stage, the company can effectively navigate challenges and foster collaborative and mutually beneficial relationships with suppliers, contributing to the overall stability and sustainability of the industrial supply chain.

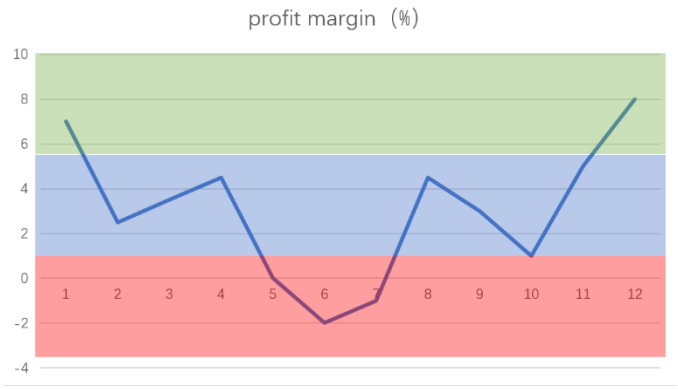

Fig. 1. Different Profit Margin Classification Warning Diagram.

3 Warning Method Based on Supplier Raw Material Price Endurance

In the face of short-term increases in raw material costs, companies adopt various measures, sometimes even at the expense of costs, to maintain customers and markets. In this scenario, the warning method based on profit margin in the previous section struggles to accurately assess the supplier's performance. To address this issue, this section draws inspiration from the VaR concept, making extensive use of a vast amount of fulfilled order information to construct a model that evaluates a supplier's capacity to withstand fluctuations in raw material prices. Based on this model, a warning method is designed.

VaR, or Value at Risk, is a method used to measure and manage financial risk. It represents the maximum potential loss of a specific investment portfolio or asset at a given confidence level[3]. VaR can be estimated by analyzing historical data on price changes to assess the maximum potential loss that may be faced in a future period. Inspired by the VaR approach and considering the supplier's ability to quickly adjust other non-raw material costs in the short term, this section, based on a vast number of successfully fulfilled orders, captures the raw material price changes within each order period. This allows for the calculation of the supplier's actual capacity to withstand fluctuations in raw material prices.

In the information concerning the supplier's performance in historical orders, particular attention is given to two variables: the contract signing time and the planned delivery time. Based on actual production, the latest procurement time can be defined as the planned delivery time minus the product's maximum production time. The period from the contract signing time to the latest procurement time represents the time range during which the manufacturing enterprise can procure raw materials. Let the price of the i-th type of raw material of the t-th month be denoted as $p_i^t, t \in \{1,2,\cdots,T\}, i \in \{1,2,\ldots,n\}$, The contract signing time corresponds

to the first month, at which point the price of the i-th type of raw material is p_i^1. The planned delivery time is set for the T-th month, at which point the price of the i-th type of raw material is p_i^T. The production of this type of equipment requires *n* different types of raw materials.

$$R^t = \sum_i p_i^t \times k_i,\ \ i \in \{1,2,\dots,n\}. \tag{4}$$

$$RC^t = \frac{R^t - R^1}{R^1},\ \ t \in \{2,\cdots,T\}. \tag{5}$$

$$RC = \min\{RC^t\},\ \ t \in \{2,\cdots,T\}. \tag{6}$$

Firstly, based on the raw material cost coefficient k_i, calculate the total cost R^t required for purchasing raw materials when producing such electrical equipment in the t-th month, as shown in equation (4). Subsequently, to determine the maximum range of raw material cost fluctuations that the manufacturing enterprise can afford, calculate the monthly variation rate of raw material costs compared to the contract signing period within the procurement period RC^t, according to equation (5). Finally, if the supplier possesses basic market identification capabilities and can select the point with the lowest (or relatively lower) cost within the feasible procurement period, choose the minimum value among all RC^t values, as expressed in equation (6), to represent the material cost bearing capacity for this order.

By analyzing a vast amount of historical order information for a specific type of electrical equipment, calculate the RC value for each order, thereby obtaining the range of raw material price fluctuations that a supplier can bear when producing this type of electrical equipment, denoted as $rank\ (RC)$. Taking the $max\ (RC)$ establishes the warning line. When the total cost R^t required for purchasing raw materials for producing this type of electrical equipment during the forecast period exceeds $max\ (RC)$, an alert is issued. This indicates that the supplier has not successfully fulfilled orders at this level of raw material prices, implying a default risk arising from fluctuations in raw material prices.For example, from historical iron tower orders that have been fulfilled, it is found that when the price of angle iron rises to 7%, which means the industry profit is negative, some suppliers can still fulfill the contract normally, indicating that tower suppliers have the ability to cope with short-term price increases of angle iron, produce by reducing logistics and other costs, or maintain operations at a loss to seize market share.In this example, if ues the warning method based profit margin, there is a possibility of overestimating risk. By considering the supplier's tolerance for raw material price fluctuations into the warning model can effectively avoid this issue.

4 Conclusions

This paper extensively addresses the challenge posed by the volatility of raw material prices within the supply chain. It proposes two interconnected warning methods designed to enhance the stability of the electrical equipment industry's supply chain. The first method, centered on profit margins, provides a succinct and direct approach to alerting stakeholders about fluctuations in various raw material prices. This method is particularly applicable to industries with well-defined profit margins and fixed non-material costs. On the other hand, the second warning method, which evaluates a supplier's resilience to changes in raw material prices, introduces a more comprehensive and realistic assessment of supplier performance. This

approach becomes especially valuable in industries where profit margins are unclear, and non-material costs can vary.

The profit margin-based method, being focused and precise, facilitates quick responses to changes in the market. It allows for targeted risk management, especially when dealing with industries where non-material costs remain relatively stable. In contrast, the supplier raw material price endurance method offers a broader perspective, considering the dynamic nature of industries with uncertain profit margins and variable non-material costs. This method enables a more holistic evaluation of supplier performance by assessing their ability to navigate through various raw material price changes effectively.

By integrating these two warning methods, this paper aims to provide a robust framework that addresses the diverse challenges arising from raw material price fluctuations. Through this comprehensive approach, the paper endeavors to equip stakeholders in the electrical equipment industry with effective tools for risk management and decision-making in the face of dynamic and uncertain market conditions.

Based on the above research findings, the following recommendations are provided for managers:

Firstly, enhance the application of predictive technologies, closely monitor the major trends in raw material prices affecting electrical equipment, and achieve proactive risk management. When enhancing the application of predictive technologies, managers may consider exploring advanced data analytics and machine learning tools to develop sophisticated models for predicting trends in raw material prices. Collaborating with data science experts and leveraging cutting-edge technologies can provide a competitive advantage in anticipating market shifts.

Secondly, the implementation of the risk prevention and control plan should involve the entire supply chain. Electrical equipment procurement enterprises should promptly share information on raw material price assessments with suppliers, guiding them in arranging production reasonably to ensure the quality of performance [4], [5]. Procurement enterprises in the electrical equipment industry can thoroughly audit suppliers' risk management practices, ensuring that suppliers not only receive timely information on raw material price assessments but also possess robust risk mitigation strategies. Additionally, establishing a collaborative platform for ongoing communication between electrical equipment procurement enterprises and suppliers can facilitate dynamic and adaptive risk prevention methods.

Thirdly, when examining the influencing factors and trends of bulk commodities in the economic landscape, managers should consider geopolitical factors, regulatory changes, and environmental impacts. This broader perspective ensures a holistic understanding of the external environment, enabling more informed decision-making. Moreover, in dynamically adjusting price linkage schemes, managers could explore innovative financial instruments or partnerships that provide flexibility in responding to rapid changes in raw material prices, thereby enhancing the adaptability of the supply chain.[6].

Acknowledgments. This work is supported by Technical Service Project of State Grid Corporation of China(Technical Support for Analyzing the Disturbance of Raw Material Price Fluctuations on Material Procurement and Supply,No.SGNY0000GXWT2300255).

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