

Research on Supplier Selection of Elevator Manufacturing Enterprises

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Abstract: With the increasingly fierce international and domestic competition, the construction elevator industry is facing huge risks and challenges, in order to enhance their competitiveness, each enterprise also needs to strengthen their own supply chain management capabilities, the selection of suppliers as the first link of supply chain management at this time plays a pivotal role, if the enterprise can smoothly achieve docking with the right supplier, it will provide great help for the follow-up operation of the enterprise. Based on the theory of supply chain management, this paper uses the combination of quantitative and qualitative methods to construct the supplier selection index system of DH company, determines the evaluation criteria of the index based on the relevant literature and the actual situation of the company, uses the entropy weight analytic hierarchy process to obtain the weight of the corresponding evaluation index, establishes the evaluation model through the TOPSIS method, takes the hydraulic pump supplier of DH company as the data sample, and helps DH company select the best supplier partner through data calculation, evaluation and decision-making.

Keywords: Supplier Selection; Entropy-Weighted Analytic Hierarchy Process; TOPSIS Method

1. Introduction

Based on the actual needs of supplier selection in the elevator industry, this paper summarizes the consensus of experts in the field on supplier selection indicators, and conducts questionnaire surveys on the internal personnel of elevator manufacturing enterprises and experts in the same industry, and obtains the most suitable supplier selection evaluation index for elevator companies through

multi-party negotiation, and then determines the specific weight of each evaluation index through entropy weight analytic hierarchy process, and uses TOPSIS method to rank the advantages and disadvantages, so that enterprises can have a dynamic grasp of the entire supplier selection work. The process and results of supplier selection are optimized, and this paper provides a certain reference value for the future research on supplier selection in the heavy machinery industry. In terms of research methods, domestic and foreign experts usually combine AHP with other methods, such as Büyüközkan et al. [1] to discuss the application of AHP-GP methods in supplier selection, especially when dealing with data uncertainty and ambiguity; Ma [2] and Zang & Lv [3] used a combination of AHP and TOPSIS to evaluate and select suppliers. In terms of the selection of research indicators, Dickson [4], Weber et al. [5] and Zhang et al. [6] all paid attention to price, quality, delivery time, production equipment and capacity, and technical capabilities. With the continuous development of the economy, scholars have innovated the supplier selection index, Tan & Wang [7] constructed a comprehensive evaluation index system for high-quality suppliers, including five aspects: business performance, business ability, quality system, enterprise environment and cooperation potential. to adapt to the ever-changing internal and external environment and corporate strategic needs; Li [8] included supply chain resilience, sustainable development, and social responsibility into the evaluation indicators, and conducted a comprehensive evaluation of auto parts suppliers.

2. Research Methods

2.1 Analytic Hierarchy Process

Analytic hierarchy process is a systematic and

hierarchical analysis method that combines qualitative and quantitative analysis. [9] The characteristic of this method is that on the basis of in-depth research on the nature, influencing factors and internal relationships of complex decision-making problems, the thinking process of decision-making is mathematized with less quantitative information, so as to provide a simple decision-making method for complex decision-making problems with multiple objectives, multiple criteria or no structural characteristics, and is a model and method for making decisions on complex systems that are difficult to fully quantify. According to the nature of the problem and the overall goal to be achieved, the analytic hierarchy process decomposes the problem into different constituent factors, and gathers and combines the factors at different levels according to the interrelated influence and affiliation between the factors to form a multi-level analysis structure model, so that the problem is finally reduced to the determination of the relative importance of the lowest level (for decision-making, measures, etc.) relative to the highest level (overall goal) or the arrangement of relative advantages and disadvantages.

2.2 Entropy-Weighted Analytic Hierarchy Process

The entropy method is a method that starts from objective data, reflects the importance of indicators according to the difference between the observed values of indicators, obtains the weight of indicators, and then evaluates the evaluated objects in the index system. [10] Entropy and analytic hierarchy process have their own advantages and limitations in weight determination. The entropy method is based on the objective nature of the data, which can reduce the influence of subjective factors on the determination of weights, but over-reliance on data may lead to the neglect of some key information. The analytic hierarchy process can fully consider the complexity and diversity of decision-making problems through the subjective judgment and experience of experts, but too strong subjectivity may lead to deviation of results. Therefore, by combining the two, you can make full use of their advantages and make up for their shortcomings.

2.3 TOPSIS Method

The TOPSIS method is a multi-attribute decision analysis method used to select the best option from a set of alternatives. The basic principle of TOPSIS is to rank and select alternatives by comparing their distance from the ideal solution (optimal solution) and the negative ideal solution (worst solution). [11]

3. Findings

3.1 Entropy Weight Analytic Hierarchy Process to Construct Index Weights

After combing the existing literature and combining the feedback from procurement and other relevant personnel, the index system of supplier selection of elevator manufacturing enterprises was determined, including 21 secondary indicators, and then 25 relevant authoritative figures were invited to score, and then the entropy weight hierarchy process was used to obtain the weight of the secondary indicators as shown in **Table 1**:

Table 1. Supplier Evaluation Indicator System Table

Index	Entropy weight analytic hierarchy process weights
Product qualification rate	20.61%
Quality system certification	9.46%
Quality Improvement Program	4.32%
On-time delivery rate	2.23%
Ability to accept urgent orders	6.29%
Downline accidents	8.67%
Price competitiveness	14.50%
Cost control rate	4.94%
R&D investment ratio	2.26%
R&D of new products and technologies	2.67%
Flexible production	2.29%
Financials	2.58%
Corporate reputation	1.35%
Enterprise risk control capabilities	0.52%
Energy saving and emission reduction capabilities	1.89%
Resource recovery processing capacity	1.73%
Environmental certifications	0.66%
Service capability	2.90%
Timeliness of problem resolution	4.20%
Customer satisfaction	1.06%
Level of informatization	4.89%

3.2 The TOPSIS method determines the ranking of suppliers

The relative proximity C value is calculated as

shown in **Table 2** below:

Table 2. Relative Proximity C Values

Relative proximity C-value	Sort	
Supplier 1	0.5308	4
Supplier 2	0.5372	3
Supplier 3	0.6748	1
Supplier 4	0.6198	2

4. Analytical Discussion

Supplier 3 has the best score in the TOPSIS evaluation, which is enough to show that its comprehensive strength is the strongest among the five alternative suppliers, such as the product qualification rate, new product and new technology research and development, informatization level, quality system certification, and the positive index data of supplier 3 are higher than those of other suppliers, which makes supplier 3 the best evaluation results.

Supplier 4 scored second in the comprehensive evaluation, although he did not have the significantly best indicators among the four suppliers, but it ranked second in many indicators, such as quality system certification, on-time delivery rate, ability to accept urgent orders, new product and new technology research and development, financial status, corporate reputation, enterprise risk control ability, environmental protection certification, problem solving timeliness and information level. That's why Vendor 4 is ranked second in the absence of the best metrics.

Although Supplier 2 is more prominent in terms of its ability to accept urgent orders, price competitiveness, production flexibility, and enterprise risk control capabilities, it ranks last in a relatively large proportion of indicators such as quality and delivery indicators, resulting in a poor ranking even though it seems to perform well in some aspects.

The main problem of Supplier 1 is its poor performance in terms of its ability to accept urgent orders, R&D and service, and ignoring the responsiveness of urgent orders and the possibility of serious consequences for R&D and service. First of all, this will have a direct impact on customer satisfaction, as the inability to meet customer demand quickly can lead to production delays, which in turn can damage customer trust. Second, this neglect undermines the supplier's competitiveness in the market, as quick response is a key

advantage in the modern market. In addition, frequent and urgent order mishandling can disrupt the stability of the supply chain and add additional costs such as overtime and fast logistics expenses. In the long run, neglecting R&D will lead to technological backwardness and inability to meet market demand for innovative products, which will affect the long-term development and profitability of enterprises. Ultimately, these factors can lead to extremely negative consequences for DH, affecting cooperation with suppliers.

Through the analysis of the evaluation results of the four suppliers, DH can consider cooperating with suppliers 3 and 4.

Focus on the evaluation indicators of product qualification rate and quality system certification ability, strictly control the product quality of parts suppliers, and establish and improve the quality evaluation system.

On the one hand, DH needs to focus on the investigation and implementation of the qualification rate of the batch of parts suppliers, and require the suppliers to provide immediate product inspection certificates, shipment inspection reports of the batch and corresponding samples; On the other hand, DH needs to clarify the responsibilities of the quality control department, improve the company's internal product quality inspection system, the quality control department needs to provide samples for alternative parts suppliers to conduct comprehensive quality inspection, monthly sampling inspection of the quality of parts and components that have been put into production, daily statistics and testing of defective products in the production line, extract the supply quality problems and feedback the corresponding suppliers.

For the quality system certification capability index, DH company needs to confirm the ISO9001 quality system certification of the parts supplier, check the supplier's quality certification body and certification time on the official website of the quality management system certification, and pay attention to whether the supplier conducts annual review and renewal of the quality system certification. Focus on the evaluation indicators of product price and logistics cost to ensure maximum cost-effectiveness and directly reduce the company's procurement costs.

For product price indicators, on the one hand, DH needs to negotiate the product price with

the parts supplier for many times, combine the historical transaction price, supply and demand, product cost, market environment and other factors to negotiate the price to a standard acceptable to both parties, and it is necessary to sign a price protection agreement to reduce the risk of cost imbalance; On the other hand, when conducting price negotiations, if DH establishes a long-term cooperative relationship with suppliers, and pre-purchases goods, bulk orders, and regular purchases from suppliers, it is sure to obtain relatively large discounts, so that the average price of parts and components can reach the lowest.

For the logistics cost index, due to the particularity of DH's parts, the transportation cost and storage cost of overseas suppliers are relatively high, so on the one hand, the company needs to examine the route distance between each alternative supplier and the company, and try to choose the supplier with lower route transportation costs; On the other hand, it is necessary to inspect the import and export warehousing costs of the supplier's nearby ports or factory cooperation ports, control logistics costs, and reduce overall procurement costs.

Focus on the on-time delivery rate and delivery lead time of the supplier, avoid the recurrence of bad events that seriously affect the project progress of DH due to the supplier's late delivery, and reduce the risk of overtime delivery.

First of all, when calculating the on-time delivery rate, DH needs to check the total number of deliveries and on-time delivery times of the alternative parts suppliers involved in detail to ensure the accuracy of the calculation. Secondly, when DH signs a procurement contract with a supplier, it needs to sign a supplementary agreement with the supplier on product delivery, focusing on the on-time delivery rate of the supplier's products, so that the supplier can make a guarantee in terms of on-time delivery; Finally, DH should focus on the assessment and supervision of on-time delivery of the suppliers that have cooperated, record their on-time delivery rate during the cooperation period, and establish a reward and punishment mechanism with suppliers to motivate suppliers to deliver on time or in advance, and cultivate the ability of suppliers to accept urgent orders.

The delivery lead time is the time from the

dispatch of the order to the acceptance of the goods for DH Company, and the time from the time of acceptance of DH's purchase order to the arrival of the parts and goods at the Company for the parts supplier. The shortest lead time for delivery is when the supplier has stock. One of the ways to ensure timely delivery from suppliers is to compress delivery lead times. In order to shorten the lead time for supplier delivery, DH should pay attention to the following points when evaluating parts suppliers. First, we will investigate the inventory of parts and components of our suppliers and prioritize suppliers with sufficient parts inventory. Second, when calculating the supplier's delivery lead time, DH should examine the supplier's production time, loading time, transportation cycle, sorting time and estimated production time of existing parts to ensure the accuracy of the calculation. Thirdly, the order management ability and execution ability of the component supplier after receiving the order are examined, and the response time to the purchase order is evaluated. Fourth, it examines the market demand forecasting and analysis capabilities of parts suppliers, including the judgment of market demand and product competitiveness. Fifth, for the suppliers who have reached cooperation, the two sides should strengthen communication, pay attention to the changes in DH's demand on a regular basis, and ensure that the production capacity of the supplier is adjusted in a timely manner, which will help the supplier to provide goods in a stable and timely manner.

The timeliness of supplier information feedback and problem solving has important reference significance for the company to evaluate parts suppliers. The company must ensure the service level of suppliers to solve the related problems arising from the production and use of parts and components, and improve the production efficiency of DH company.

First of all, DH can investigate the supplier's other cooperative enterprises to understand the supplier's information feedback efficiency, response speed and ability to truly solve problems when there are unexpected problems in ordering, coordination and communication, purchase acceptance, payment and after-sales of their purchased goods. Secondly, DH needs to examine whether the supplier has a perfect

service mechanism in terms of service, whether the service business is outsourced to other companies, and the timeliness of the supplier's supplier information feedback and problem solving is very relevant to whether it has a professional after-sales team. Thirdly, you can organize a regular meeting of supplier representatives, require the person in charge of each supplier to participate in the company's regular meeting regularly, and the two sides give feedback to each other, emphasize the importance of information feedback and timeliness of problem solving in the meeting, and require suppliers to provide better services. Finally, the company can put forward requirements for the degree of information feedback from suppliers and the timeliness of solving problems in the procurement contract, and give certain quantitative standards. When the company suffers losses due to untimely information feedback and problem solving, punitive measures such as reducing the proportion of goods purchased, financial penalties and delayed settlement can be taken to impose sanctions on suppliers, increase the cost of breach of contract by suppliers, and improve the degree of information feedback and the timeliness of solving problems.

5. Conclusion

Excellent procurement management can reduce the total cost of procurement, improve procurement efficiency, and promote enterprises to reduce product prices to enhance market competitiveness and improve the ultimate profitability of the entire supply chain, and the speed, efficiency, and implementation of orders will directly improve the customer service level of enterprises. Through the construction of supplier selection and evaluation system, this paper improves the optimal selection of suppliers by elevator manufacturing enterprises, effectively improves the evaluation efficiency of enterprises, saves time and labor costs for elevator manufacturing enterprises, promotes the common progress of elevator manufacturing enterprises and its suppliers, and provides a reference for supplier selection for other companies in the same industry. According to the comprehensive weight of each index in the evaluation index system established in this paper and the problems existing in the supplier evaluation of DH

company, from the four evaluation indicators with relatively high comprehensive weights of product quality, cost, delivery and service, the countermeasures and suggestions for DH company in selecting parts suppliers are put forward, and suggestions for improving the procurement business process are put forward. Among them, in terms of product quality, it is suggested that DH should focus on product qualification rate and quality system certification ability when evaluating parts suppliers, and should focus on product price in terms of procurement cost; In terms of delivery, the focus should be on the ability to accept urgent orders; In terms of services, we focus on the informatization level of suppliers.

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