Research on Purchasing Strategy of Manufacturing Enterprises Based on the Level of Definite Supply Risk

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Abstract: Based on the previous research on the supply risk of manufacturing enterprises, combined with the theoretical basis of supply chain management and risk management, this paper analyzes the supply risk level of manufacturing enterprises from the perspectives of various links of supply chain and business processes, establishes a decision-making model combining with the procurement strategy of enterprises, and puts forward procurement management suggestions for enterprises with different risk preferences.

1. Introduction

With the rapid development of the economy, manufacturing enterprises have gradually evolved from simple parts production and assembly to a supply chain mode that relies on suppliers, producers, distributors and consumers. Due to natural disasters, human factors, political and economic fluctuations and other inevitable factors, the supply of spare parts of manufacturing enterprises brings greater supply risk, resulting in shutdown loss, goodwill loss and other operational losses. Therefore, it is necessary to study the purchasing strategy of manufacturing enterprises with supply risk.

2. Literature review

It is found that there are few scholars who study the supply risk of manufacturing enterprises, and the corresponding research results are also less. IM Ariful et al. (2006) Introduced and described the developed theoretical framework of risk management and the working principle of its system, and explained how interference is related to various sources, including strategy (planning and leadership activities), operation (operation, technology and quality) and Technology (applied technical knowledge). Ariful Islam and Des Tedford (2012) presented a set of typical internal and external risk determinants, which need special attention to be dealt with to minimize operational risks of an SME.

For the research on the relationship between supply risk and procurement strategy, most scholars focus on the selection of procurement strategy under supply interruption, but lack of research on risk probability. Yu et al. (2008) studied the selection of single source procurement and dual source procurement under the background of supply interruption risk. The model assumes that the main supplier loses all supply capacity when the supply is interrupted, while the supplementary supplier can supplement the supply indefinitely, which is far from the actual situation. Tadeusz Sawik (2014) divides the supply disruption risk faced by manufacturers into three types: single supplier disruption, common supplier disruption in the same region, and all suppliers disruption. It studies the coordination between supplier selection and customer order allocation under single source and multi-source procurement strategies based on supply disruption risk, so as to achieve the overall optimization of cost and customer service level.

3. Risk assessment model of manufacturing enterprises

3.1 Supply risk identification system of manufacturing enterprises

The risk identification of manufacturing enterprises is mainly to analyze the risks of manufacturing enterprises in the supply chain. This paper analyzes and identifies the risks faced by manufacturing enterprises from three perspectives: the social environment, the upstream and downstream of the supply chain and the inside of the enterprises, combined with the production process analysis method.

(1) Social and environmental risks

The social and environmental risks faced by manufacturing enterprises are basically the same, mainly including Political environment risk C1 (referring to the impact of relevant government policies on the industry and the chain reaction to manufacturing enterprises), Legal environment risk C2 (referring to the difference between the enterprise's expectation and the actual results in the future, which causes the enterprise to bear legal responsibility, and the enterprise must bear legal liability due to This may cause losses to enterprises), Economic environmental risk C3 (the possibility of economic cycle fluctuations to the members of the industry supply chain), Natural disaster risk C4 (the impact of earthquakes, tsunamis and other natural disasters on the supply chain), Competitor risk C5 (the impact of other enterprises' vicious competition on enterprises).

(2) Supply chain risk

The production and operation of manufacturing enterprises are closely related to the upstream and downstream enterprises of the supply chain. Each enterprise in the supply chain and its related links have an important impact on the sustainable operation of manufacturing enterprises.

Supply chain risk of manufacturing enterprises mainly includes Production capacity risk C6 (refers to the influence of upstream supply chain enterprises on enterprises due to production disqualification or small batch), Supply interruption risk C7 (refers to supply interruption caused by member enterprises in upstream supply chain due to misprediction, etc.), Supply price risk C8 (refers to the increase of production and operation costs of manufacturing enterprises caused by the inconsistency between the price growth of parts and components of upstream enterprises and the market price of final products), Personnel risk C9 (refers to production interruption caused by insufficient employees), Capital fracture risk C10 (refers to the capital fracture risk caused by downstream capital delay to upstream enterprises), Information risk C11 (refers to the risk of resource waste caused by information asymmetry) and Logistics service risk C12 (refers to the possibility of loss caused by high logistics service cost and low logistics service level of third-party logistics enterprises).

(3) Risk of internal factors of manufacturing enterprises

Manufacturing enterprises are mostly complex processes involving multiple technological processes, which will produce various risks in the production process. According to the work flow analysis of manufacturing enterprises, the risk of internal factors of automobile manufacturing enterprises mainly includes Order risk C13 (the loss caused by misjudgment of manufacturing enterprises on market environment prediction, etc.), Research and Development risk C14 (refers to the problems such as the lack of spare parts and the shortage of new parts supply caused by the mistakes in scientific research and innovation of manufacturing enterprises), Financial risk C15 (refers to the risk of supply interruption caused by the financial crisis of the manufacturing enterprise, such as the rupture of operating funds, excessive liabilities, etc.).

Through the above analysis, it is concluded that the risk categories of manufacturing enterprises are subdivided into 15 items. Because there are too many risk assessment indicators and there may be repeatability between the three angles, it is necessary to test the correlation of the indicator system. Considering the correlation of risk types, combining capital fracture risk C10 and financial risk C15 into financial risk, the supply risk identification system of manufacturing enterprises includes three secondary indicators and 14 tertiary indicators.

From the above analysis, an indicator system can be formed, which takes the supply risk identification system of manufacturing enterprises as the first level, three secondary indicators such

as external environment risk as the second level, and 14 three-level shifts such as political environment risk as the third level.

3.2 Supply risk evaluation model

As can be seen from the previous section, the supply risk identification system of manufacturing enterprises includes many risk factors, and these risks are difficult to quantify. Therefore, it is necessary to use a multi index comprehensive evaluation method to evaluate the supply risk of manufacturing enterprises objectively and accurately.

In this paper, the fuzzy analytic hierarchy process is used to determine the weight of supply risk factors of manufacturing enterprises. The expert scoring method is used to score the correlation of risk factors, which can be scored by the specific manufacturing enterprise management and scientific research experts combined with the business strategy, core competitiveness, facing problems, geographical location and political and economic environment of different enterprises.

The steps are as follows:

1) Compare scores to determine relative importance.

By collecting the scores of multiple experts, the fuzzy judgment matrix of each level of indicators is established. Combined with the actual situation of manufacturing enterprises in this paper, the influence importance of the second level factors on the first level factors is recorded as matrix A, and the influence degree of the third level factors on the second level factors is recorded as matrix B1, B2 and B3 (take matrix A and matrix B1 as examples below).

$$\mathrm{A} = a_{\mathrm{ij}} = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix} \qquad B_1 = \begin{bmatrix} b_{11} & b_{12} & b_{13} & b_{14} & b_{15} \\ b_{21} & b_{22} & b_{23} & b_{24} & b_{25} \\ b_{31} & b_{32} & b_{33} & b_{34} & b_{35} \\ b_{41} & b_{42} & b_{43} & b_{44} & b_{45} \\ b_{51} & b_{52} & b_{53} & b_{54} & b_{55} \end{bmatrix}$$

a_{ij} represents the importance of the i-th element relative to the j-th element. The essence of this step is that experts compare different elements at the same level and quantify their importance in the form of numbers. In order to express quantitatively the importance degree of any two elements about a certain target, 0.1-0.9 scale method can be used for quantitative scale.

2) Sum the risk fuzzy judgment matrix according to the row, and get the fuzzy consistent matrix.

Note $a_i = \sum_{k=1}^{n} a_{ik} (i = 1,2,\dots,n)$, implement the following transformation $f_{ij} = \frac{r_i - r_j}{2n} + 0.5$, convert the fuzzy judgment matrix to the fuzzy consistent matrix, and record it as $F = f_{ij}$. In this paper, we can get the fuzzy consistent matrices $F_a,\ F_b,\ F_c,\ F_d$.

$$F_a = \begin{bmatrix} f_{a_{11}} & f_{a_{12}} & f_{a_{13}} \\ f_{a_{21}} & f_{a_{22}} & f_{a_{23}} \\ f_{a_{31}} & f_{a_{32}} & f_{a_{33}} \end{bmatrix} \qquad F_b = \begin{bmatrix} f_{b_{11}} & f_{b_{12}} & f_{b_{13}} & f_{b_{14}} & f_{b_{15}} \\ f_{b_{21}} & f_{b_{22}} & f_{b_{23}} & f_{b_{24}} & f_{b_{25}} \\ f_{b_{31}} & f_{b_{32}} & f_{b_{33}} & f_{b_{34}} & f_{b_{35}} \\ f_{b_{41}} & f_{b_{42}} & f_{b_{43}} & f_{b_{44}} & f_{b_{45}} \\ f_{b_{51}} & f_{b_{52}} & f_{b_{53}} & f_{b_{54}} & f_{b_{55}} \end{bmatrix}$$

3) Make clear the index weight of each index layer, and make a single ranking of each index layer.

According to $w_i = \frac{1}{n} - \frac{1}{2a} + \frac{1}{na}\sum_{j=1}^{n} f_{ij}\ (i = 1,2,\dots,n; a \geq \frac{n-1}{2})$, where $W = (w_1, w_2, \dots, w_n)^T$ is the weight matrix of A. According to this formula, the importance degree of each level of risk factors for the upper level factors is calculated. The weight matrix involved in this paper includes the weight matrix of the second level for the first level of importance which is $W_a = (w_{a_1}, w_{a_2}, w_{a_3})^T$, and the weight matrix of the third level for the second level includes $W_b = (w_{b_1}, w_{b_2}, w_{b_3}, w_{b_4}, w_{b_5})^T$, $W_c = (w_{c_1}, w_{c_2}, w_{c_3}, w_{c_4}, w_{c_5}, w_{c_6})^T$, $W_d = (w_{d_1}, w_{d_2}, w_{d_3})^T$.

4) Total index weight of each layer.

According to $W_n^{(1)} = \prod_{k=2}^{n} w_k^{k-1} = w_n^{(n-1)} \times w_n^{(n-2)} \ldots \times w_3^{(2)} \times w_2^{(1)}$, the weight of each level is multiplied to get the comprehensive weight of each subdivision factor of the lowest level relative to the evaluation target.

Combined with the actual situation of automobile manufacturing enterprises and the supply risk identification system, the weight matrix of manufacturing enterprises includes W_a, W_b, W_c, W_d.

According to the above formula, the importance matrix of the second layer of risk factors B1-B3 can be obtained as $W_a = (w_{a_1}, w_{a_2}, w_{a_3})^T$, which can be sorted according to specific values by combining with examples; according to step 4, the importance of the third layer of risk factors C1-C14 can be calculated as $W_B = (w_{B_1}, \ldots, w_{B_6}, \ldots, w_{B_{14}})^T$.

3.3 Probability equation of supply risk

Because the occurrence of risk factors of manufacturing enterprises in different time nodes and different enterprise environments is not consistent, the risk factors can be regarded as variables. Among them, some risk factors can be converted into qualitative indicators for calculation, and quantitative indicators that cannot be converted can be scored by the internal responsible part of the company. During the calculation, all index values are normalized. This paper takes each year as the time limit, and lists the relevant indicators as shown in the table below.

Table.1. Index transformation of supply risk factors

Risk Factor	Transformation Index	Risk Factor	Transformation Index
Political environment risk C1	Number of restrictions issued per year x_1	Legal environment risk C2	Number of legal disputes of industrial enterprises per year x_2
Economic environmental risk C3	Annual economic volatility x_3	Natural disaster risk C4	Number of natural disasters that affect the enterprise every year x_4
Competitor risk C5	Number of malignant competition events per year x_5	Production capacity risk C6	Times of supply interruption caused by insufficient production capacity of the supplier x_6
Supply interruption risk C7	Number of supply interruptions caused by supplier's mispredictions, etc. x_7	Supply price risk C8	Number of supply problems caused by price between manufacturer and supplier x_8
Personnel risk C9	Number of production chain breaks caused by insufficient personnel x_9	Information risk C10	Number of supply problems caused by poor information transmission x_{10}
Logistics service risk C11	Number of supply problems due to logistics problems x_{11}	Order risk C12	The number and variety of orders are wrong due to the forecast failure of the enterprise, which is far beyond the actual demand times x_{12}
Development risk C13	Number of supply problems caused by R & D and design mistakes of enterprises x_{13}	Financial risk C14	Times of supply problems caused by financial problems of enterprises x_{14}

Through the fuzzy analytic hierarchy process, we can get the weight of each risk factor. Therefore, we can take the supply risk level of manufacturing enterprises as the goal, the weight as the coefficient, and the risk factors as the variables to establish the supply risk probability equation of manufacturing enterprises. The formula is as follows:

$$L(x) = w_{B_1} \times x_1 + w_{B_2} \times x_2 + \cdots + w_{B_{14}} \times x_{14} \quad (1)$$

Combined with the supply risk identification system of manufacturing enterprises, the supply risk of enterprises mainly comes from three aspects. However, it is difficult to prevent risks from the external environment through procurement management. Therefore, enterprises need to pay close attention to the changes of social environment in order to reflect the changes of external environment quickly and reduce the losses of enterprises. The procurement management of this paper mainly focuses on the supply chain environment and the internal environment of manufacturing enterprises.

4. Procurement management under supply risk

In this paper, based on the supply risk factors of manufacturing enterprises, combined with the current procurement strategy of manufacturing enterprises, the decision-making models of different procurement strategies are established. This paper mainly studies two procurement strategies: single source procurement and dual source procurement.

4.1. Purchase strategy model construction

This paper assumes that manufacturing enterprises are in a two-level supply chain with single manufacturer and two suppliers, in which there is supply risk. Supplier 1 and supplier 2 have differences in production capacity, technical quality, supply price and personnel. Among them, the supply price of supplier 1 is lower, but the risk of production capacity, technical quality and personnel is higher than that of supplier 2. Supplier 2 is stable and reliable, but the supply price is higher. Among them, the manufacturing enterprise can choose to purchase goods from a single supplier 1 or supplier 2, or it can choose to supply goods jointly by two suppliers. Supplier 1 is the main supplier and supplier 2 is the standby supplier.

In order to get more orders, the promised supply price of main supplier 1 will decrease with the increase of order share. If the supply of supplier 1 is interrupted, the manufacturer will increase the purchase volume from supplier 2. This part of the order belongs to the additional order, and supplier 2 will increase the supply price of the additional order. Manufacturers need to weigh supply risk and sales profit to make purchase strategy decisions.

(1) Model assumptions

1) It is assumed that the supplier's supply capacity is unlimited, but in the event of supply risk, there are three situations in the supply of supplier 1: ① all supply is interrupted or delayed; ② shortage is caused by insufficient supply; ③ poor quality of supply products. The actual result is that the shortage of parts and raw materials in manufacturing enterprises leads to production stagnation. At this time, the manufacturer's stock out is M.

2) According to the scenario, the price of supplier 1 C_1^D is smaller than that of supplier 2 C_1^S in single source purchase. After supplier 1 generates supply risk, the price of the part of supplier 2 C_2^2 that increases the order will increase again. Then the price sequence is: $C_2^2 > C_2^1 > C_1^S > C_1^D$.

(2) Symbol description

Table.2. Symbol description

D: Raw material demand	M: In case of supply risk, the out of stock quantity of manufacturing enterprise, M≤D
x: Proportion of purchases from 2 suppliers	p: Sales price
C_1^D: Under the single source purchase strategy, the price of supplier 1	C_1^S: The price of supplier 1 under the dual sourcing strategy
C_2^1: The price of supplier 2 under the dual sourcing strategy	C_2^2: When supply risk occurs, supplier 2 increases the price of the order part
s: Unit out of stock loss of products	$L(x)$: Supply risk probability equation of manufacturing enterprises

(3) Model establishment

1) Single source purchase strategy

Under the single source purchase strategy, the manufacturer only selects supplier 1 for supply. When supplier 1 has supply risk, all or part of the raw materials of the manufacturing enterprise are out of stock. At this time, in order to resume production, the manufacturer turns to supplier 2 for purchase. At this time, the price of supplier 2 is C_2^2.

That is, under normal supply, the manufacturer's profit is $S_1^D = (p - C_1^D)D$; When supply risk occurs, the manufacturer's profit is $S_2^D = (p - C_1^D)(D - M) + (p - C_2^2)M - sM$.

Then the expected revenue model of manufacturing enterprises under the single source purchase strategy is $P^D = \big(1 - L(x)\big)S_1^D + L(x)S_2^D$.

2) Dual sourcing strategy

Under the dual source procurement strategy, the manufacturer selects supplier 1 as the main supplier, the procurement ratio is (1-x), supplier 2 as the alternative supplier, and the procurement ratio is x. When supplier 1 has supply risk, expand the purchase volume of supplier 2, and the price is C_2^2.

That is, under normal supply, the manufacturer's profit is $S_1^S = (p - C_1^S)(1 - x)D + (p - C_2^1)xD$; When supply risk occurs, the manufacturer's profit is

$$S_2^S = (p - C_1^S)[(1 - x)D - M)] + (p - C_2^1)xD + (p - C_2^2)M - sM.$$

The expected revenue model of manufacturing enterprises under the strategy of dual source procurement is $P^S = \big(1 - L(x)\big)S_1^S + L(x)S_2^S$.

4.2. Purchase strategy model application

The purchase strategy model can be used for the purchase decision before purchase and the improvement of the purchase management after the risk.

On the basis of defining the scope of supply risk level of manufacturing enterprises, the supply risk of manufacturing enterprises can be divided into five deterministic supply risk levels V1-V5, and the division is shown in Table 3. Among them, the critical value of risk level can be set according to the different risk preferences of decision makers.

Table.3. Supply risk level of manufacturing enterprises

Risk level	High risk V1	Higher risk V2	Medium risk V3	Lower risk V4	Low risk V5
Critical value of risk probability	m1	m2	m3	m4	m5

Because different decision-makers have different attitudes towards risk, some people pursue high investment and high return while ignore risk or accept greater risk, while others pursue sustainable and stable development. According to the decision-maker's preference for risk, it can be divided into risk avoider, risk pursuer and risk neutral person. Combining the characteristics of different risk preferences of decision makers with the supply risk level of manufacturing enterprises, we can substitute the risk probability critical value (m1-m5) which is in line with the risk preferences of decision makers into the expected return function (replacing the supply risk probability equation L (x)) under the two kinds of purchase strategies, so as to compare the returns, and then select the purchase strategy suitable for the risk type of the enterprise.

In addition, the actual income of the enterprise in the previous period can be compared with the expected income. When there is a deviation in the comparison result, the value of each item can be determined through the supply risk probability equation of the manufacturing enterprise, the cause of the risk can be found, and then the business strategy of the enterprise can be adjusted; or the focus of the supplier selection can be determined according to the risk factors, and the supplier can be reselected.

5. Conclusion

The purpose of this paper is to deal with the complex manufacturing process and high level of supply risk of manufacturing enterprises. Based on the supply risk of manufacturing enterprises, through the construction of index system and evaluation model to identify and evaluate the supply risk of manufacturing enterprises, the supply risk evaluation equation is obtained. In order to maximize the benefits, the profit model of each procurement strategy is established, and the applicability of the profit model is explained in combination with the risk preference of the enterprise, so as to provide suggestions for the procurement management of the enterprise.

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