

# Research on Application of Polychromatic Set Theory in Supplier Management

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**Keywords:** strategic procurement; multicolor set; supplier; supply chain

**Abstract:** Taking an assembly manufacturing enterprise as the research object, under the strategic purchasing mode of the enterprise, combined with the supplier management process of the enterprise, firstly, the supplier is selected by using the polychromatic set theory, secondly, the performance of the supplier is evaluated, and finally, the supplier's grade and supply ratio are adjusted based on the supplier's evaluation results. This empirical analysis has made a useful exploration in the application of multicolor set theory in practice, and has provided an effective method for enterprises to implement strategic procurement.

## 1. Introduction

In today's mass customization automotive enterprises, the quality of suppliers plays an important role in the overall competitiveness of enterprises. Therefore, the selection and evaluation of suppliers has become an important issue in enterprise procurement management. In this way, new requirements are put forward for the procurement of the automobile industry: not only to ensure timely and accurate, but also to meet the individualization, and to consider the core issue -- to reduce the procurement cost.

Ammer at first proposes that procurement should be included in the scope of enterprise strategic management. M. E. Porter puts forward a five-force model to drive industrial competition, advocating that both suppliers and customers are the driving forces of industrial competition, and that suppliers' bargaining power has an impact on the profit level of the industry. Since then, Corney, a famous consulting company, began to use the term "strategic procurement" and produced a large number of valuable research results. Subsequently, the strategic thinking of procurement began to spread around the world. The fundamental purpose of strategic procurement is to reduce the total cost and maximize the overall benefits. Strategic procurement is a systematic guiding ideology and a method of formulating procurement strategies, which cannot be misinterpreted as a practical procurement skill. Carr compares the differences between strategic procurement and procurement strategies in detail.

### 1.1 The Concept of Strategic Procurement

Overview of domestic and foreign scholars' research, the connotation of strategic procurement includes the following points: ①the procurement function must be included in the strategic planning of enterprises and be subject to the overall strategy of enterprises; ② the foothold of strategic procurement is the optimal total cost; ③ the cooperation between enterprises and suppliers can enhance the core competitiveness and innovation ability of supply chain.

### 1.2 Differences between Strategic Procurement and Traditional Procurement

(1) Traditional procurement is multi-purchasing based on the quantity and cost of procurement, and the number of suppliers is relatively large, usually made by the procurement department independently for its choices; while strategic procurement is based on the overall evaluation of the performance of the enterprise, the enterprise will determine the most suitable supplier according to the important needs of its core business functions, and the number of suppliers is relatively small. Therefore, the procurement department needs to unite other departments to make a comprehensive evaluation and selection on suppliers according to the quotient.

(2) Under the strategic procurement model, enterprises form long-term cooperative relationship

with suppliers who provide the most important goods and services through supplier integration in order to gain benefits.

(3) Strategic procurement emphasizes the ultimate goal of the lowest total procurement cost, so its evaluation index is not the lowest procurement price.

To sum up, strategic procurement is a purchasing activity based on the optimal total cost to formulate a purchasing strategy in line with the enterprise's business strategy, and establish a long-term partnership with suppliers to achieve sustainable enterprise competitiveness. Supplier research focuses on index evaluation and selection methods. There is no research on how to integrate strategic procurement management ideas with supplier selection into information management.

This paper intends to use the theory of multi-color set mathematical modeling, the idea of system theory and the theory of strategic procurement management in supply chain management to establish a complete set of supplier selection scheme suitable for enterprise application.

## **2. Polychromatic Set Theory**

Professor V.V. Pavlov of Russia put forward the concept of polychromatic graph in 1988, the concept of polychromatic set in 1995 and the structure of polychromatic set theory in 2002. Its core idea is to use the same model to simulate different objects to describe the hierarchical structure and complex relations among elements, organize and process information at the set level and logical level, and solve the problem of low-level quantity at the quantity level.

The theory of polychromatic sets is also applied to supply chain research. Feng Taiwen has used polychromatic graph to establish the supply chain member relationship model [14]. Jiang Lili has used the theory of polychromatic sets for suppliers to select. Liu Dongmei has studied a method of partner combination decision-making in supply chain network based on polychromatic set theory and genetic algorithm. But all of them are aimed at the traditional supplier selection research, and the research on supplier selection combined with strategic procurement has not yet been done.

## **3. The Background and Problems of Supplier Selection in S Enterprise**

(1) There are many suppliers with uneven quality and low qualified rate, which have a great impact on production and product quality. The existence of a large number of weak suppliers increases the difficulty of management and quality control, which makes it impossible for the enterprise to guarantee the quality and supply of spare parts during the peak period of sales. The long supply radius not only increases the logistics cost, but also lengthens the supply cycle. Strategic suppliers are few, cooperation and information sharing are insufficient, and supply is difficult to guarantee.

In 2017, 200 suppliers with purchasing volume less than 1 million yuan accounted for 45% of the total number of suppliers. Small purchasing vendors, accounting for 45%, make vendor management more complex and costly.

① At present, 69% of S enterprises' domestic suppliers come from outside the region. The supply radius is more than 180 kilometers or even 1000 kilometers, which greatly increases the logistics cost. ② From the point of view of the purchase amount, 65% of the current domestic purchase amount of the enterprise comes from areas beyond the supply radius of 180 kilometers. ③ The lack of strategy and preferred suppliers makes the supply of components not guaranteed in the peak season of the market.

(2) There are adverse effects of supply and harvest on production and sales. Firstly, the low qualified rate of batches of external suppliers increases the total cost of the system, affects the sales and brand, and increases the after-sales cost. Secondly, the cost rationality cannot be verified, and the cost reduction lacks goals and methods, which affects the profitability of the company.

The above problems are mainly caused by the absence of the establishment mechanism of cooperative relations. Firstly, there is no effective supplier classification; secondly, there is no

effective cultivation and utilization of supplier's R&D capabilities to support product improvement and R&D.

Among the Non-Subsidiary suppliers whose purchasing amount was more than 40 million Yuan in 2016, the cooperation degree between the enterprise and most suppliers is weak, and the cooperation degree between the enterprise and large suppliers is low. It is as shown in Table 1:

Table 1 The degree of cooperation between S enterprises and large suppliers

Supplier	Purchase volume (10k Yuan)	Cooperation with suppliers	Supply enterprise
A	190,438	21%	Three
B	42,562	9%	Five
C	18,567	3%	Seven
D	14,765	1%	Six
E	10,387	23%	Two
F	7,843	12%	Four
G	7,396	2%	Many
H	6,731	3%	Many
I	4,693	17%	Four

Due to the low accuracy and timeliness of parts and components, although there are a large number of parts in stock, nearly 8% of the products of the enterprise were found to be missing in production in October 2016. The quality problems caused by purchased parts from the procurement and supply department accounted for 61% of the total quality problems of the enterprise. The uneven suppliers and low qualified rate of quality have a great impact on the production and product quality.

In order to solve the above problems, from the perspective of supply chain, we should focus on the measures that need to be taken: establishing strategic procurement process and organizational assurance; establishing supplier development process and standards, as well as establishing supplier evaluation template and supplier classification methods and standards.

#### 4. Solutions

The existing supplier team of S enterprise is the key to the work of acquisition and supply system. At present, the reform of supplier management should form a virtuous circle of supplier access, daily management, evaluation, development and elimination, and do a solid job in each link, so as to gradually upgrade the supply chain.

①The purpose of supplier access is to introduce new and better suppliers continuously and establish scientific and reasonable access standards and procedures;

②The purpose of supplier daily management is to accumulate basic management data and communicate problems and rewards and punishments information in time;

③Supplier evaluation should be based on daily transaction data, and the evaluation results should be reflected in matching, development and relationship determination.

④Selection of suppliers: first, to eliminate the worse suppliers, put them on the waiting list and re-evaluate them; then for the general suppliers, we should reduce the purchasing volume and focus on counseling; finally, to the excellent suppliers, we should increase the purchasing volume.

##### 4.1 Supplier Access Standard Model Based on Polychromatic Sets

Because there are many criteria used by enterprises to evaluate suppliers, and most of them are difficult to quantify, it is necessary to adopt a more objective qualitative analysis method. Firstly, these criteria are given in the form of a hierarchical structure. Fig. 1 shows the selection criteria of the two-tier structure, which are refined from top to bottom and formulated according to the specific preferences of enterprises for the criteria. Figure 2 describes the criteria for supplier access and the

selection method for supplier access.

## 4.2 Supplier evaluation criteria

The indicators and weights of supplier evaluation are shown in Table 2.

Table 2 Supplier Evaluation Indicators

Level 1 index	Level 2 index
Cost 25%	Price cuts of 65% in the past year $H_{11}$ Cost price 35% $H_{12}$
Delivery 20%	Delay of delivery 75% $H_{21}$ Assessment of Logistics Handover 25% $H_{22}$
Quality 30%	Qualification rate of quality 50% $H_{31}$ Quantity of Quality Information 25% $H_{32}$ Quantity of rectification information 25% $H_{33}$
Service 15%	Assessment of Production Services 50% $H_{41}$ Assessment of after-sales service 50% $H_{42}$
Tech 10%	New Product Development Support 65% $H_{51}$ Temporary product production 35% $H_{52}$

The supplier evaluation matrix:

$x =$

83.0850	1.0000
49.4900	2.0000
90.2500	3.0000
80.2750	4.0000
66.6050	5.0000

$px =$

90.2500	3.0000
83.0850	1.0000
80.2750	4.0000
66.6050	5.0000
49.4900	2.0000

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As a result, supplier V6 ranks first with 90.25 points, supplier V1 ranks second with 83.085 points, supplier V7 ranks third, supplier V10 ranks fourth and supplier V4 ranks fifth.

## 4.3 Supplier Classification Model

S enterprise implements strategic purchasing, and after admitting and evaluating its suppliers, it takes corresponding measures according to the evaluation results. Specifically, as shown in Figure 3, it can be seen from this chart that when the supplier evaluation reaches 90-100 points, the supplier will be regarded as the priority supplier; if the score is 70-89, it will be listed in the better level; in turn, as shown in the figure.

Therefore, the best supplier  $V6 > 90$  points is the priority, followed by that V1 and V7 more than 70 points are better, V10 more than 50 points is common, V4 less than 50 points is eliminated.

## 5. Conclusion

Aiming at the supplier selection of an automobile manufacturer and its supply chain, this paper analyses the existing problems of acquisition and supply. Based on the research of multi-color set reasoning and partner selection, this paper establishes the contour matrix of supplier access by using multi-color set reasoning, and infers the supplier who gets access. The theory of multi-color set is further applied in practice. Finally, by scoring the admitted suppliers, the suppliers are evaluated by fuzzy evaluation, and the suppliers are classified, eliminated and proportioned according to the

evaluation results. Thus, it provides a set of feasible schemes to realize enterprise information management.

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