Study on Consumer Product Supplier Evaluation Method Based on Actor Analysis Thinking

Song Heliang1, a, Lu Xiaowei1, Wu Qian1, b*, Xu Yingcheng1 and Li Ya1

1China National Institute of Standardization, Beijing 100191, China

Corresponding author: a*53940134@qq.com; b*ustbwuqian@163.com

Abstract. This paper, based on the existing results of studying supplier evaluation indexes and Actor Analysis Thinking, and by combining the characteristics of consumer product suppliers, first establishes a consumer product supplier evaluation index system covering 10 indexes including product price, product quality, product performance, product series, timeliness of delivery, response capability, collaborative capacity, technical support capability and service attitude; then, refines the traditional Actor Analysis Method, reasonably converts some non-economic factors into economic factors, and improves the scientificity of the non-economic factor evaluation method by using comprehensive weighted average method; and finally proves the feasibility of the method proposed herein with practical application cases. The consumer product supplier evaluation method based on Actor Analysis Thinking proposed herein is scientific, rational, simple and easy to operate, and can provide technical support for enterprises and research institutions to carry out supplier evaluation, supply chain management, etc.

1. Introduction

With the worldwide economic development in modern society, the competition among enterprises has become diversified, and the comprehensive strength an enterprise increasingly depends on the management of its supply chain [1]. Consumer product suppliers are exporters of supply chain accessories. Their competitiveness in delivering accessories and service capability [2] are directly related to the operation of downstream consumer product manufacturers. Therefore, in the environment where the competition in the modern market economy is so fierce, consumer product manufacturers need to invest more energy and resources to evaluate and select optimal suppliers through scientific and reasonable methods, in order to effectively reduce their cost of enterprises and obtain more incomings [3].

Whether the qualitative analysis or quantitative evaluation is used for the study on supplier selection and evaluation, establishing the supplier evaluation index system is the basic premise. You Jianxin (2019) [4], Ding Bin (2018) [5], et al. established the supplier evaluation index system of enterprises from the aspects of quality, delivery, cost, service, etc. by analyzing the entire supply chain management. Wang Xiaojing (2012) [6] evaluated the suppliers of fast moving consumer goods (FMCG) from the aspects of operation capability, price level, quality service, agile capability, etc. according to the characteristics of FMCG. Cai Wenjia (2019) [7], et al. evaluated the suppliers of intelligent ammeter from performance index and business index. Xu Yanli (2019) [8] and Yu Jun (2019) [9] divided supplier evaluation indexes into quality index, supply index, economic index, service index, etc.
Generally speaking, most scholars establish supplier evaluation index system from five aspects: quality, cost, efficiency, service and operation. According to the characteristics of the consumer products supply chain, this paper, based on the existing study results, aims at establishing a consumer product supplier evaluation index system covering 10 indexes, including product price, product quality, product performance, product series, timeliness of delivery, response capability, collaborative capacity, technical support capability and service attitude. By improving the limitations of the traditional Actor Analysis Method, this paper tries to develop a more scientific, rational and operable consumer product supplier evaluation and selection method.

2. Consumer Product Supplier Evaluation Index System

Establishing a consumer product supplier evaluation index system for is a precondition for consumer product supplier evaluation and selection. According to the characteristics of consumer products, this paper, based on the principles of comprehensiveness, flexibility, feasibility and supplier strategy [10] and the study achievements of Li Jianming (2019) [1], Wang Hao (2019) [2], You Jianxin (2019) [4], Ding Bin (2018) [5], Wang Xiaojing (2012) [6], et al., divides consumer product supplier evaluation indexes into product competitiveness indexes and supplier service capability indexes, as shown in Figure 1:

![Figure 1. Consumer Product Supplier Evaluation Index System](image)

2.1. Product competitiveness indexes

The product competitiveness index includes product price, product quality, product performance and product series, among which the product price is a cost index, the smaller the better, and product quality, product performance and product series are benefit indexes, the larger the better.

2.1.1. Product price. Product price means the purchase cost required by a consumer product manufacturer to purchase products from the supplier. The lower the purchase price is, the lower the purchase cost will be. Thus, for this index, the smaller the better.

2.1.2. Product quality. Product quality means the quality safety level of products provided by suppliers, which can be expressed by product quality qualification rate. For this index, the larger the better.
2.1.3. **Product performance.** Product performance means the degree to which the products provided by suppliers meet the performance requirements of consumer product manufacturers, which can be expressed by product performance qualification rate. For this index, the larger the better.

2.1.4. **Product series.** Product series means the types of products provided by suppliers. More types available are more favorable to meeting the requirements of consumer product manufacturers. For this index, the larger the better.

2.2. **Supplier service capability indexes**

Supplier service capability indexes include timeliness of delivery, response capability, collaborative capacity, technical support capability, and service attitude. All of them are benefit indexes, the larger the better.

2.2.1. **Timeliness of delivery.** Timeliness of delivery means the capability of a supplier to deliver products to consumer product manufacturers ahead of time or as scheduled according to contract requirements. The higher the timeliness of delivery is, the less the cost generated due to time delay will be. For this index, the larger the better.

2.2.2. **Response capability.** Response capability means the capability of a supplier to meet the requirements for change of orders, demands, etc. in a timely manner where market demands fluctuate. The higher the response capability is, the lower the cost generated due to change of orders, demands, etc. will be. For this index, the larger the better.

2.2.3. **Collaborative capacity.** Collaborative capacity means the compatibility and collaborative capacity between the products produced and operated by suppliers and other accessories required by consumer product manufacturers. The higher the compatibility and collaborative capacity are, the lower the rejection rate of finished products arising from the compatibility inspection of accessories will be, and the lower the production cost will be. For this index, the larger the better.

2.2.4. **Technical support capability.** Technical support capability means the capability of a supplier to meet the requirements of consumer product manufacturers for subsequent technical consultation and technical training. For this index, the larger the better.

2.2.5. **Service attitude.** Service attitude means the attitude of a supplier to provide pre-sales consultation, after-sales training and other services for consumer product manufacturers. The higher the satisfaction degree towards service attitude, the better. For this index, the larger the better.

3. **Traditional Understanding of Actor Analysis Thinking**

Actor Analysis Method, originating from the field of logistics engineering, is widely used in facility location selection, efficiency evaluation, effectiveness evaluation, etc. [11], [12] because of its comprehensive evaluation characteristics, enabling both qualitative analysis and quantitative evaluation. Traditionally, parameters of Actor Analysis Method are divided into economic factors and non-economic factors, which limits the economic factors to be cost factors that must be measured by cost. As a result, the importance of some quantifiable non-economic factors and non-quantifiable economic factors can only be measured by forced choice method. This greatly narrows the application scope of factor analysis method on the one hand, and limits the scientificity of the Actor Analysis Method to some extent on the other hand.

Based on the understanding of traditional Actor Analysis Method, in the consumer product supplier evaluation index system, only product price is the economic factor, and the remaining 8 indexes including product quality and product performance are all non-economic factors. The index expression method is shown in the following table 1:
Table 1. Supplier Evaluation Indexes Divided Based on Actor Analysis Thinking

| Level-1 index | Level-2 index | Index evaluation expression method |
|---------------|---------------|------------------------------------|
| Economic factors | Product price | To be expressed by the cost necessary for purchasing the product |
| Non-economic factors | Product quality | To be expressed by product qualification rate: low, average, high, very high |
| | Product performance | To be expressed by product performance qualification rate: low, average, high, very high |
| | Product series | To be expressed by types of series of products: a few, average, many, a great many |
| | Timeliness of delivery | To be expressed by the timeliness ratio of product delivery: low, average, high, very high |
| | Response capability | To be expressed by the capability to respond to buyers' demands in a timely manner: low, average, high, very high |
| | Collaborative capacity | To be expressed by compatibility and collaborative capacity between the products purchased and other accessories: low, average, high and very high |
| | Technical support capability | To be expressed by technical support capability before and after sales: low, average, high, very high |
| | Service attitude | To be expressed by the satisfaction of buyers with the supplier's service attitude before and after sales: dissatisfied, average, satisfied, very satisfied |

4. Improvement of Actor Analysis Method

4.1. Converting part of non-economic factors into economic factors

The direct economic factor index of consumer product supplier evaluation is product price, but the indexes of product quality, product performance, timeliness of delivery, response capability and collaborative capacity can also indirectly affect the cost of manufacturers even though they have no direct relationship with cost.

The lower the quality and performance qualification rate of the products provided by suppliers is, the higher the possibility of existence of defective products will be. This may cause the supply of parts to be purchased by consumer product manufacturers in the subsequent production process insufficient, delay the production period and increase the production cost. The higher the timeliness of delivery is, the shorter the lead time will be, and the earlier the consumer product manufacturers can put these parts into production. On the contrary, the lower the timeliness of delivery is, the longer the construction period and the higher the production cost will be. The response capability can reflect the supplier's capability to respond to the dynamic requirements of consumer product manufacturers. The faster the dynamic response is, the shorter the delay time will be. Conversely, the slower the response is, the longer the construction period and the higher the production cost will be. Similarly, the collaborative capacity also affects the length of subsequent production cycle of consumer product manufacturers.

Therefore, this paper includes the delay cost into economic factors, and comprehensively considers such indexes as qualification rate, timeliness and collaboration together with the construction period delay and daily cost accounting. On this basis, it develops the cost accounting coefficient of such indexes as product quality and product performance, and converts some non-economic evaluation indexes that may cause construction period delay into economic indexes. The consumer product supplier evaluation indexes after conversion are shown in the table 2:
Table 2. Improved Consumer Product Supplier Evaluation Indexes

| Level-1 index | Level-2 index | Index evaluation expression method |
|---------------|---------------|-----------------------------------|
| Economic factors | Product price | To be expressed by the cost necessary for purchasing the product |
| | Product quality | To be expressed by the product of construction period delayed due to low qualification rate of product quality * daily delay cost * cost accounting coefficient |
| | Product performance | To be expressed by the product of construction period delayed due to low qualification rate of product performance * daily delay cost * cost accounting coefficient |
| | Timeliness of delivery | To be expressed by the product of construction period delayed due to low timeliness of delivery * daily delay cost * cost accounting coefficient |
| | Response capability | To be expressed by the product of construction period delayed due to low response capability * daily delay cost * cost accounting coefficient |
| | Collaborative capacity | To be expressed by the product of construction period delayed due to low collaborative capability * daily delay cost * cost accounting coefficient |
| Non-economic factors | Product series | To be expressed by types of series of products: a few, average, many, a great many |
| | Technical support capability | To be expressed by technical support capability before and after sales: low, average, high, very high |
| | Service attitude | To be expressed by the satisfaction of buyers with the supplier's service attitude before and after sales: dissatisfied, average, satisfied, very satisfied |

4.2. Improving the non-economic factor evaluation method

The traditional method to deal with non-economic factors by Actor Analysis Method is forced selection method, i.e. comparing two indexes and marking the better one as 1 and the other one 0. Some absoluteness exists in this method. Therefore, expert evaluation and comprehensive weighted average method are used in this paper to evaluate non-economic factors.

4.2.1. Importance index. According to the traditional understanding, the importance index is determined by forced selection method. In this paper, the non-economic factors are divided into average, important, more important and very important according to their degrees of importance, corresponding to the scores of 1, 2, 3 and 4 respectively. Experts grading method is used to determine the importance of each index, which will be recorded as $I_k$.

4.2.2. Non-economic factor rating value. The non-economic factor rating value is also determined by forced selection method. In this paper, non-economic factors are dealt with similarly and the evaluation of suppliers by this index is divided into 5 grades: unsatisfied, average, satisfied, quite satisfied and very satisfied, corresponding to the integer rating values of (0, 2], (2, 4], (4, 6], (6, 8] and (8,10] respectively. The rating value of each index is determined by experts grading method and recorded as $S_{ki}$.

4.2.3. Measures of non-economic factors. According to the above contents, the measure of a non-economic factor can be expressed by the product of the importance index and the rating value of that factor, i.e. $I_k \times S_{ki}$.
The improved method to calculate non-economic measures can not only make up the one-sidedness of the forced selection method, but also facilitate the evaluation of new suppliers, i.e. it is not necessary to recalculate the measures of all non-economic factors when new suppliers appear.

5. Case Application

5.1. Case background
A household electric appliance manufacturer has four electronic component suppliers, different in product price, product quality, timeliness of delivery and response capability. It is necessary to comprehensively evaluate all indexes of these suppliers. This paper helps this manufacturer to select the best electronic component suppliers through the improved Actor Analysis Method. The basic information of these suppliers is shown in the following table 3 and table 4:

Table 3. Economic Factors of Suppliers

| Alternative supplier | Product price | Product quality | Product performance | Timeliness of delivery | Response capability | Collaborative capacity |
|----------------------|---------------|-----------------|---------------------|------------------------|---------------------|------------------------|
| Supplier 1           | 25000         | 97%             | 95%                 | 98%                    | 96%                 | 93%                    |
| Supplier 2           | 23000         | 94%             | 93%                 | 94%                    | 95%                 | 98%                    |
| Supplier 3           | 24800         | 98%             | 97%                 | 97%                    | 94%                 | 97%                    |
| Supplier 4           | 26100         | 99%             | 95%                 | 96%                    | 97%                 | 95%                    |

Table 4. Non-economic Factors of Suppliers

| Alternative supplier | Product series | Technical support capability | Service attitude |
|----------------------|----------------|------------------------------|------------------|
| Supplier 1           | Average        | Very high                    | Average          |
| Supplier 2           | Many           | High                         | Satisfied        |
| Supplier 3           | A great many   | Average                      | Average          |
| Supplier 4           | Average        | High                         | Very satisfied   |

5.2 Case calculation

5.2.1. Data processing. It is understood that the product quality qualification rate, product performance qualification rate, timeliness ratio of product delivery, response efficiency and collaboration efficiency allowed by the household electric appliance manufacturer are all 95%. The past experience shows that the decrease of every one percentage point may delay the construction period by one day and the daily delay cost is RMB 8,000. If these indexes are higher than 95%, the delay cost will be calculated based on the allowable delay of 3 days. If the cost accounting coefficients of the above indexes are all calculated at 0.7, the raw data of economic factors of each supplier can be processed as shown in the following table 5:

Table 5. Economic Factors of Suppliers after Processing

| Alternative supplier | Product price | Product quality | Product performance | Timeliness of delivery | Response capability | Collaborative capacity |
|----------------------|---------------|-----------------|---------------------|------------------------|---------------------|------------------------|
| Supplier 1           | 2.5           | 2.8             | 1.68                | 3.36                   | 2.24                | 0.56                   |
| Supplier 2           | 2.3           | 1.1             | 0.56                | 1.12                   | 1.68                | 3.36                   |
| Supplier 3           | 2.48          | 3.36            | 2.8                 | 2.8                    | 1.12                | 2.8                    |
| Supplier 4           | 2.61          | 3.92            | 1.68                | 2.24                   | 2.8                 | 1.68                   |

Unit: RMB 10,000
5.2.2. Calculation of economic factor measures. The calculation formula of economic factor measures of the Actor Analysis Method is as follows:

\[
OM_i = \left[ C_i \sum_{i=1}^{4} \frac{1}{C_i} \right]^{-1} = \left[ \sum_{j=1}^{6} C_{ij} \sum_{i=1}^{4} \frac{1}{\sum_{j=1}^{6} C_{ij}} \right]^{-1}
\]

where,
- \(i\) represents the \(i\)th supplier, \(i = 1, 2, 3, 4\);
- \(j\) represents the \(j\)th economic factor, \(j = 1, 2, 3, \ldots, 6\);
- \(C_{ij}\) represents the cost of the \(j\)th economic factor of the \(i\)th supplier;
- \(OM_i\) represents the economic factor measure of the \(i\)th supplier, and the sum of the economic factor measures of all suppliers is \(1\), i.e. \(\sum_{i=1}^{4} OM_i = 1\), \(OM_i \in [0,1]\).

According to Formula (1) and Table 5, the economic factor measures of the four suppliers can be calculated respectively as follows: \(OM_1 = 0.2479, OM_2 = 0.3219, OM_3 = 0.2121, OM_4 = 0.2182\).

5.2.3. Calculation of non-economic factor measures. According to the actual requirements of that household electric appliance manufacture, 10 experts from its Purchase Department, Quality Department and other relevant departments were invited to score the importance index and rating value of non-economic indexes, and then calculated the average value of the scoring results. The calculation formula of non-economic factors can be obtained as follows:

\[
\bar{I}_k = \frac{\sum_{k=1}^{10} I_k}{10}
\]

\[
\bar{S}_{ik} = \frac{\sum_{i=1,k=1}^{4,3} S_{ik}}{\sum_{i=1,k=1}^{4,3} \bar{I}_k S_{ik}}
\]

\[
SM_i = \frac{\sum_{i=1,k=1}^{4,3} \frac{1}{S_{ik}} \sum_{k=1}^{10} I_k}{\sum_{i=1,k=1}^{4,3} \sum_{k=1}^{10} \frac{1}{S_{ik}}}
\]

where,
- \(i\) represents the \(i\)th supplier, \(i = 1, 2, 3, 4\);
- \(k\) represents the \(k\)th non-economic factor, \(k = 1, 2, 3, \ldots, 6\);
- \(\bar{I}_k\) represents the average importance index of the \(k\)th non-economic factor;
- \(\bar{S}_{ik}\) represents the average rating value of the \(k\)th non-economic factor of the \(i\)th supplier;
- \(SM_i\) represents the non-economic factor measure of the \(i\)th supplier, and the sum of the economic factor measures of all suppliers is \(1\), i.e. \(\sum_{i=1}^{4} SM_i = 1\), \(SM_i \in [0,1]\).

According to the scoring results given by 10 experts on the rating values of non-economic factors: product series, technical support capability and service attitude and Formula (2), the followings can be obtained: \(\bar{I}_1 = 2.2, \bar{I}_2 = 2.8, \bar{I}_3 = 1.8\).

According to the scoring results given by 10 experts on the importance of three non-economic factors: product series, technical support capability and service attitude and Formula (3), the followings can be obtained:

\[
\bar{S}_{11} = 7.4, \bar{S}_{12} = 6.7, \bar{S}_{13} = 4.8
\]

\[
\bar{S}_{21} = 6.6, \bar{S}_{22} = 7.1, \bar{S}_{23} = 7.9
\]

\[
\bar{S}_{31} = 8.0, \bar{S}_{32} = 6.6, \bar{S}_{33} = 6.4
\]

\[
\bar{S}_{41} = 6.8, \bar{S}_{42} = 5.8, \bar{S}_{43} = 5.0
\]

According to Formula (4), the non-economic factor measures of the four suppliers can be calculated as follows: \(SM_1 = 0.2425, SM_2 = 0.2700, SM_3 = 0.2643, SM_4 = 0.2232\).

5.2.4. Determination of location measure. The location measure \(LM_i\) is the overall evaluation value of the alternative suppliers, and its calculation formula is:

\[
LM_i = X \times SM_i + (1 - X) OM_i
\]

where,
- \(X\) represents the weight value of economic factors;
(1-X) represents the weight value of non-economic factors;
SM<sub>i</sub> represents the economic factor measure of the ith alternative supplier;
OM<sub>i</sub> represents the non-economic factor measure of the ith alternative supplier.

This household electric appliance manufacture attaches the same importance to both economic factors and non-economic factors, so X=0.5, and the location measure of each supplier can be calculated as follows according to Formula (5): \( LM_1 = 0.2452, LM_2 = 0.2959, LM_3 = 0.2382, LM_4 = 0.2207 \).

5.2.5. Decision on the best plan. The larger the location measure is, the better the comprehensive evaluation result of the alternative supplier will be, to be represented by \( LM_i^* \). The calculation method of \( LM_i^* \) is as follows:

\[
LM_i^* = \max \{ LM_i | i = 1, 2, 3, 4 \}
\]

According to Formula (6), \( LM_2^* = \max \{ LM_i | i = 1, 2, 3 \} = LM_2 \).

The location measure of alternative supplier 2 is the largest, which indicates the comprehensive evaluation result of that supplier is the best, therefore the best supplier for that household electric appliance manufacture is supplier 2.

6. Summary
Dynamic evaluation of the comprehensive service capability of suppliers by using effective methods can help enterprises to select qualified and suitable suppliers in a better way and can also reduce the risks caused due to suppliers' problems. The Actor Analysis Method can be used for qualitative and quantitative evaluation by integrating subjective and objective evaluation indexes, but the traditional Actor Analysis Method strictly distinguishes economic indexes and non-economic indexes, and the evaluation method of non-economic indexes is too absolute. Therefore, considering the characteristics of consumer product supplier evaluation, this paper improves the traditional Actor Analysis Method, reasonably converts some non-economic factors into economic factors, and improves the scientificity of non-economic factor evaluation method through comprehensive weighted average method. The application case of a household electric appliance manufacturer shows the method proposed in this paper can effectively evaluate the comprehensive service capability of different suppliers, thus supporting enterprises to formulate the strategies related to supply chain management.

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