

SUPPLIER SELECTION AND PLANNING MODEL USING AHP

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Abstract: *Supplier selection is a multi-criteria decision making problem which includes evaluation factors. In order to select the best suppliers it is crucial to considering the both qualitative and quantitative factors simultaneously. In the supplier selection process, manager also has to consider multi- criteria factors related. Thus the integration of all the multi-criteria analysis and those analysis results by multi-analysis teams has an important meaning in supply chain design. In this paper we suggest a supplier selection analysis problem considering both by AHP method and integration method of analysis results. The proposed first analysis model using AHP which is a three-step decision analysis model which converts the qualitative factors of suppliers transferred into the quantitative measure reliability. Then, the integration model integrates the results of multi-analysis and selects the best supplier. We develop a computer program for both the AHP model and for integration model.*

Key words: Supplier selection, AHP, MCDM, Fuzzy set ranking

1. Introduction

The purpose of this study is to develop a supplier's performance evaluation model for a third party logistics (TPL) in supply chain management (SCM). Recently, with the increasing trends of the study in the third party logistics system (TPL) that some of production of supply chain works are outsource to the other companies, the supplier performance evaluation model for TPL becomes one of the important research areas. The supplier performance analysis problem is one of the multi-criteria decision making (MCDM) problem considering a lot of factors in a hierarchical structure of decision analysis system. Thus in this study we used a MCDM method for supplier selection problem.

Recently, the outsourcing problem in supply center and its practices have evolved significantly in the last 20 years for the

purchasing managers. These researches have shown that suppliers are becoming increasingly critical for the competitive success cost reduction. This research is concerned with supplier selection problem under the condition of high service level for customers, total logistics cost saving, and supply efficiency increasing. The major researches on suppliers selection problem are as follows: Boer (2001) reviewed the methods of supplier selection problems, Ghodsypour and O'Brien (1998) used an integrated analytic hierarchy process to overcome the multi-criteria decision problem, Dulmin and Mininno (2003) used multi-criteria decision analysis method in supplier selection problem, and Wang and Huang (2004) used a product-driven method for supply chain selection using integrated multi-criteria decision making methodology. A great deal of studies have examined evaluation problems for the suppliers selection, but the results of these

studies do not provide a basis upon which to construct comprehensive evaluation criteria in terms of suppliers performance evaluation or to identify relative weights of these criteria. We propose a method to select supplier for the third party logistics (TPL) using multi-attribute decision analysis method. First, we use the solution methodology of analytic hierarchy process (AHP) to select the supplier with lots of factors, second, we apply the fuzzy set ranking methodologies to integrate the special decision problems, and then we develop computer programs and demonstrate a methodology for the supplier evaluation based decision support system using this computer programs. These programs can transform several individual multi-criteria rank-ordered lists of decision alternatives into one aggregated and prioritized rank-ordered list. We apply this model in supplier evaluation problem of third party logistics and compared with the results with that of other methods and show the sample outputs.

2. Conventional Suppliers Performance Evaluation and Third Party Logistics

Third party logistics is originated by the council of logistics management (CLM) of United State. For the purpose of the improvement of customer service, the logistics cost saving, and logistics management improvement, a part of supply chain works is transferred to outsourcing. Recently, there are many researches on the supplier selection problems using AHP, and mathematical programming methods.

This kind of third party logistics has several advantages and disadvantages instead of working by their own companies or sub-companies. We can summarize as following;

Advantages:

- Economical advantages by outsourcing to a specialized company,
- The risk can be reduced.

Disadvantages:

- Uncertainty of services,
- The beliefs will be worse by the customers,

- Internal company information security problem,
- Labor problem by reducing the workers for outsourcing part of work,
- Difficulties of fast reply to customer claims,
- Difficulties of knowledge accumulation for outsourcing area.

Because of these disadvantages, it is very important to evaluate the supplier selection problems considering the most of important factors of supplier evaluation indicators.

The objectives of the outsourcing policy in TPL is concerned with customers to service with a customer centric new logistics service level with a good supplier selection, thus it has been an important evaluation in logistics decision area. The conventional approach of supplier selection process is given by Figure 1.

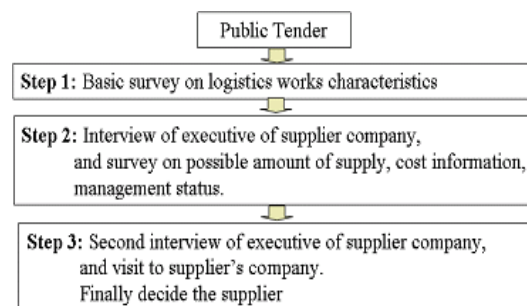


Figure 1. Conventional process of supplier selection

This supplier selection problem has to be evaluated considering all the related supplier performance indicators and evaluated by a hierarchical decision structure, but the conventional process for supplier selection didn't considered these major analysis factors. There are many difficulties in analyzing to select suppliers such as:

- The increasing of factors to be considered,
- Difficulties for holding in common the SCM information between related industries,
- Difficulties of evaluation for the supplier's performance,
- Strategic priority of objects and weighted values.

In this study, we propose a systematic approach and evaluation method using AHP and fuzzy-AHP methods to consider the hierarchical decision structure considering all the related factors and we develop computer softwares for the proposed method. Figure 2 shows the schematic diagram of proposed model.

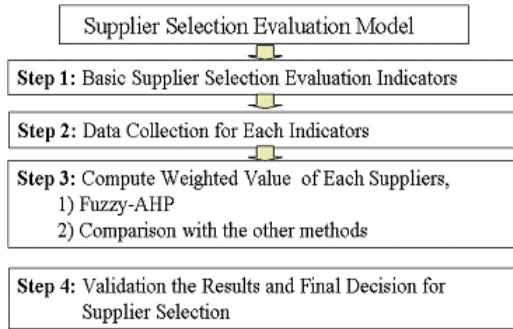


Figure 2. Supplier selection

3. A Decision Analysis Model for Supplier Selection

3.1 Fuzzy-AHP Method

The theory of fuzzy sets has extended traditional mathematical decision theories so that they can cope well with any vagueness problems which cannot adequately be treated by probability distributions. The impacts and the relationships among the characteristics in any decision problems can sometimes be described only by vague verbal descriptions. The concepts and rules of fuzzy decision making provide us with the necessary tools for structuring a decision from a kind of information. The model used in this study had a limited capability in studying the fuzzy set priority that could be obtained from the summed frequency matrix of Shannon (1986) method. The fuzzy priority is computed and compared with the rank order of Shannon method. The fundamental concept of fuzzy set priority relation R was derived from the result obtained by Shannon method.

From the Shannon's summed frequency matrix for complementary cells, A_{ij} and A_{ji} , an

additional fuzzy set matrix was made by considering $A_{ji} = 1 - A_{ij}$ for all cells. The fuzzy matrix complement cell values sum to 1 and fuzzy set difference matrix is defined as follows:

$$R - R^T = \begin{cases} U(A,B) - U(B,A), & \text{if } U(A,B) > U(B,A), \\ 0, & \text{otherwise} \end{cases}$$

where, for $U(A,B)$ quantifies, A is preferable to B .

To obtain fuzzy preferences, the following five steps were considered:

Step 1 Find the summed frequency matrix (using Shannon method)

Step 2 Find the fuzzy set matrix R which is the

summed frequency matrix divided by the total number of evaluators

Step 3 : Find the difference matrix

$$R - R^T = \begin{cases} U(A,B) - U(B,A), & \text{if } U(A,B) > U(B,A) \\ 0, & \text{otherwise} \end{cases}$$

where, for $U(A,B)$ quantifies, A is preferable to B .

Step 4 : Determine the portion of each project that is not dominated as follows :

$$A_{ColA}^{ND} = 1 - \max(X_{1.ColA}, X_{2.ColA}, \dots, X_{n.ColA})$$

Step 5: The priority of the fuzzy set is then the rank order of XND values with a decreasing order.

An example is shown as follows:

$$R = \begin{bmatrix} 0.0 & 0.8 & 0.6 & 0.6 \\ 0.2 & 0.0 & 0.0 & 0.4 \\ 0.4 & 0.1 & 0.0 & 0.4 \\ 0.4 & 0.6 & 0.6 & 0.0 \end{bmatrix}$$

$$R^T = \begin{bmatrix} 0.0 & 0.2 & 0.4 & 0.4 \\ 0.8 & 0.0 & 0.1 & 0.6 \\ 0.6 & 0.0 & 0.0 & 0.6 \\ 0.6 & 0.4 & 0.4 & 0.0 \end{bmatrix}$$

$$R - R^T = \begin{bmatrix} 0.0 & 0.6 & 0.2 & 0.2 \\ 0.0 & 0.0 & 0.0 & 0.0 \\ 0.0 & 0.1 & 0.0 & 0.0 \\ 0.0 & 0.2 & 0.2 & 0.0 \end{bmatrix}$$

$$X_A^{ND} = 1 - \max(0.0) = 1 - 0.0 = 1.0,$$

$$X_B^{ND} = 1 - \max(1.0) = 1 - 0.6 = 0.4$$

$$X_c^{ND} = 1 - \text{Max}(0.2) = 1 - 0.2 = 0.8,$$

$$X_d^{ND} = 1 - \text{Max}(0.2) = 1 - 0.2 = 0.8$$

Thus, the fuzzy set priority score is given by $1.0 > 0.8 > 0.8 > 0.4$ and the alternative priority is given by $A > C > D > B$.

3.2 Evaluation for Supplier Selection (Example)

Step 1: Basic Supplier Selection Indicators and AHP Structure To construct the hierarchy structure of AHP decision process, we use the integrated decision analysis model (Hwang, 2004) which can drive out the indicators by web-based brainstorming. For example the results of brainstorming ranking of the 3 major indicators and 11 most important sub-indicators are shown in Table 1. Four supplier

Major indicators	Sub-indicators
1. Serviceability	Meet the lead time
	Inventor rotation rate
	Lead time
	Customer satisfaction
	Market share
2. Supply Capability	Production flexibility
	Multi-item production capability
	New item development/production capability
	Quality assurance
3. Quality	Return penalty
	After service level
	A/S

candidates are considered in this example.

Table 1. Supplier Selection Indicators

These indicators can be transferred to AHP structure as Figure 3 and 4 which show the sample output of alternative generated by brainstorming process and construct the decision structure of the example of supplier selection problem by the integrated decision analysis model (Hwang, 2004).

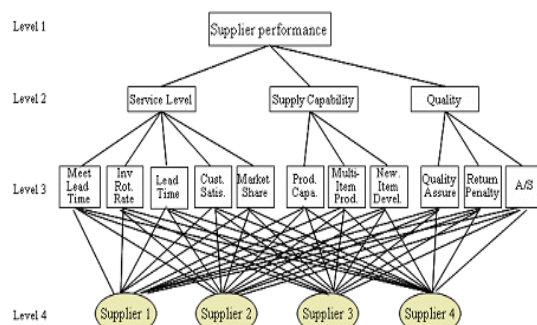


Figure 3. AHP structure of example problem

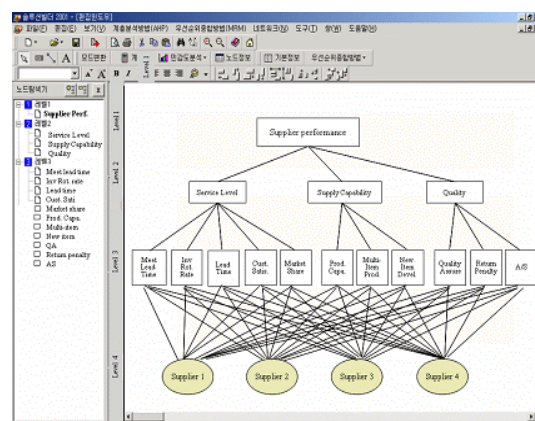


Figure 4. AHP structure of example problem by web-program

Step 2: Data collection by basic evaluation indicators

First we collect the detail data related with supplier selection problem, and then we used these data in evaluating the selection of supplier performance. Following data are collected for the sample problem.

comparison purpose, we summarized the sample results of this problem both by AHP

Table 2. Suppliers for evaluation indicators

Indicator	Supplier 1	Supplier 2	Supplier 3	Supplier 4
Meet the lead time	91%	80%	85%	90%
Inventory rotation rate	15 times	12 times	16 times	13 times
Lead time	15 days	17 days	16 days	143 days
Customer satisfaction	42	48	52	55
Market share	12%	18%	19%	15%
Production flexibility	20 days	27 days	16 days	18 days
Multi-item Prod. Capa.	2 ea	4 ea	3 ea	1 ea
New item dev./ prod.	1 ea	2 ea	1 ea	1 ea
Quality assurance	ISO9001	ISO9001	ISO9001	none
Return penalty	12%	3%	1%	4%
A/S	3 days	6 days	2 days	5 days

Table 3. Results of integrated

Evaluation factors		Weighted value	
1.Serviceability, 0.48	Meet the lead time	0.190	0.091
	Inventory rotation rate	0.315	0.151
	Lead time	0.120	0.058
	Customer satisfaction	0.301	0.145
	Market share	0.074	0.035
2.Supply capability, 0.25	Production flexibility	0.160	0.040
	Multi-item Prod. Capa.	0.499	0.125
	New item dev./ prod.	0.341	0.085
3. Quality, 0.27	Quality assurance	0.591	0.160
	Return penalty	0.211	0.057
	A/S	0.198	0.053

Step 3: Compute the weighted values of each suppliers using fuzzy-AHP

Using fuzzy-AHP method, we find the weighted value of each evaluation factors as in Table 3. Table 4 shows the weighted values of each evaluation indicators by four supplier candidates. In Table 4 we can see that supplier candidate #1 (Supplier 1) is the best candidate. For the detail out sourcing policy it has to be more analyzed to maximize the weighted values of suppliers selection factors and lower cost of logistics operations. For the

and fuzzy AHP as Table 5. To validate the final results of supplier selection problem, we have to collect real data more and analyze the supplier selection problems with various areas of industries and compared with several methods. This work will be done in further study.

known to be supplier 1, while by the result of AHP we can decide the supplier 3 to be the best one.

Table 4. The weighted value for each suppliers candidates for sub-factors

Indicator	Weighted value	Supplier 1	Supplier 2	Supplier 3	Supplier 4
P ₁ : Meet the lead time	0.091	0.26, 0.024	0.23, 0.021	0.25, 0.023	0.26, 0.024
P ₂ : Inventory rotation rate	0.151	0.36, 0.054	0.21, 0.031	0.29, 0.044	0.14, 0.021
P ₃ : Lead time	0.058	0.58, 0.034	0.09, 0.005	0.08, 0.005	0.25, 0.015
P ₄ : Customer satisfaction	0.145	0.32, 0.046	0.25, 0.036	0.27, 0.039	0.18, 0.026
P ₅ : Market share	0.035	0.19, 0.007	0.28, 0.010	0.30, 0.011	0.23, 0.008
P ₆ : Production flexibility	0.040	0.25, 0.010	0.33, 0.013	0.20, 0.009	0.22, 0.009
P ₇ : Multi-item Prod. Capa.	0.125	0.20, 0.050	0.40, 0.05	0.30, 0.038	0.10, 0.013
P ₈ : New item dev./ prod.	0.085	0.20, 0.017	0.40, 0.034	0.20, 0.017	0.20, 0.017
P ₉ : Quality assurance	0.160	0.48, 0.077	0.11, 0.018	0.30, 0.048	0.11, 0.018
P ₁₀ : Return penalty	0.057	0.60, 0.034	0.15, 0.009	0.05, 0.003	0.20, 0.011
P ₁₁ : A/S	0.053	0.19, 0.018	0.38, 0.020	0.12, 0.006	0.31, 0.017
Total	1.000	0.368	0.180	0.243	0.179

Table 5. Results of Sample problem by both AHP and fuzzy set ranking method

Evaluation method	Priority of Suppliers and Weighted Values of factors	Selected Supplier
1. Fuzzy Set Ranking Method	S ₁ (0.368), S ₃ (0.243), S ₂ (0.180), S ₄ (0.179) P ₉ (0.160), P ₂ (0.151), P ₄ (0.145), P ₇ (0.125), P ₁ (0.091), P ₈ (0.085), P ₃ (0.058), P ₁₀ (0.057), P ₁₁ (0.053), P ₆ (0.040), P ₅ (0.035),	S ₁ : Supplier #1
2. AHP Method	S ₃ (0.342), S ₁ (0.330), S ₂ (0.180), S ₄ (0.148) P ₂ (0.170), P ₉ (0.141), P ₁ (0.140), P ₅ (0.125), P ₄ (0.101), P ₃ (0.090), P ₁₀ (0.062), P ₈ (0.060), P ₉ (0.041), P ₇ (0.040), P ₅ (0.030),	S ₃ : Supplier #3

For this example, we used two evaluation methods, fuzzy set ranking and AHP method for the comparison purpose. We compared the results of both AHP and fuzzy set ranking method. These both methods are theoretically similar except the fuzzy relation functions. We developed the computer programs and applied it in the given example problem. Table 5 summarizes these results for the comparative purpose. By the results of fuzzy set ranking method, the reasonable supplier is

Some of the other methods and more example problems can be considered to validate this problem. However, the AHP method gives a multi-criteria decision making structure considering all the related factors in a hierarchical decision structure.

4. Conclusion

In this paper, we proposed supplier selection methods using a multi-criteria decision making methods which include multipurpose and hierarchical analysis and also its programs. We used AHP and fuzzy-AHP method for purpose of multi-attribute characteristics of supplier selection problems. In the third party logistics system, some of works are done by outsourcing, thus the supplier selection problem is one of the most important works which can save logistics cost. In this study, we used a three-step approach based on web-based decision model for multi-structured decision support systems (Hwang, 2004, 2002) in the view of multi-attribute evaluation. These steps are: 1) brainstorming to define the alternatives and performance evaluation factors, 2) individual evaluation the alternatives using fuzzy-AHP, heuristic and fuzzy set reasoning methods, and 3) integration the individual evaluations using majority rule method.

For the computational purpose, we developed a GUI-type computer program for supplier selection model. We applied this method in a supplier selection problem in Taoyuan area of Taiwan for a third party logistics considering the 11 evaluation factors and 4 supplier candidates. By the sample results of both AHP and fuzzy set reasoning method, it is known that the proposed model is a good method for the performance evaluation of multi-attribute and multiple goals. For the academic users, we would provide this software and user manual. For the problems of data collecting and its analysis in hierarchical decision structures, the DHP (Delphic Hierarchy Process) method can be used in future study.

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