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Liner Supplier Selection Using Analytic Hierarchy Process

Mohd Kamal Mohd Nawawi[1,2,*], Vignesh Devar Kumar[1], Suliadi Firdaus Sufahani[3], Kamarul Azhar Abdullah[4]

[1]School of Quantitative Sciences, Universiti Utara Malaysia, 06010 UUM Sintok, Kedah, Malaysia
[2]Institute of Strategic Industrial Decision Modelling (ISIDM), Universiti Utara Malaysia, 06010 UUM Sintok, Kedah, Malaysia
[3]Faculty of Applied Sciences and Technology, Universiti Tun Hussein Onn Malaysia, Pagoh Campus, 84600 Pagoh, Johor, Malaysia
[4]Perunding KAZA, 40-1, Jalan Pekaka 8/3, Seksyen 8, Kota Damansara, 47810 Petaling Jaya, Selangor, Malaysia

[*] Corresponding author: mdkamal@uum.edu.my

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ABSTRACT

This study is conducted at one of the largest nitrile glove manufacturers in Malaysia. The company is facing some problems with delayed containers. This problem directly affects the company's profit. The objectives of this study are to identify the company requirement that is expected to get to be fulfilled by the liner, to determine the priority for possible solutions and efficient decisions using Analytic Hierarchy Process (AHP), and to rank the suppliers who fulfilled the requirement and choose the best supplier. By choosing the best solution to pick the best liner supplier, the company can evaluate how to implement a correct solution due to some criteria such as responsiveness, features, price, quality, estimate-time of departure (ETD), and detention to ease the operations. Using AHP methodology, a liner supplier known as MA was found to be the best with the five criteria: responsiveness, features, price, quality, and ETD. This solution can reduce the operational cost for the container and can deliver the goods on time to customers. Furthermore, it can increase the satisfaction level of customers and it also builds a good reputation for the company.

Keywords: Analytic hierarchy process, liner supplier selection, multi-criteria decision making.

1 INTRODUCTION

Logistics management is a supply chain management element that assists to fulfil client demands through the preparation, control, and execution of the effective movement and storage of related information, goods, and services from origin to destination. Logistics management improves the company's efficiency and effectiveness by managing the cost of the company and fulfilling customer demands. Logistics management of a logistic company can be divided into numerous components to manage the flow. i.e., customer service, inventory management, storage, warehouse and material handling, packaging, transportation, information processing, production planning, demand forecasting, purchasing, facility location, and other activities. The warehouse is one of the main components of logistics management. It can be defined as a location to receive goods from sources, store goods till they are requested, pick the goods when they are required, and ship the goods to users.

In this era of globalization and high exposure to hi-technology in organizational learning, knowledge creation, and innovating ability have been the prevailed factors of the competition [1]. Selection of the right liner could be saving companies to meet or exceed the regulatory standards, drive customer demand on accurate time, and build a strong reputation of quality in work [2]. Therefore, choosing a suitable liner is very important as this contributes a major part in the shipping department to ensure products deliveries are on time, without delay, which leads to increased profit.

The objectives of this study are to identify the requirement that is expected to get to be fulfilled by the liner, to determine the priority for possible solutions, and efficient decisions using multi-criteria decision making (MCDM) analysis and to rank the suppliers who fulfilled the requirement and choose the best supplier. Analytical hierarchy process (AHP), analytical network process (ANP), data envelopment analysis (DEA), simple additive weighting (SAW), technique for order of preference by similarity to ideal solution (TOPSIS), and many more are typical MCDM approaches [3].

Due to simplicity and accuracy, AHP is the method we employed in this study. Consistency and cross-checking between several pairwise comparisons are made possible by AHP. The three main stages of AHP are hierarchy structure, priority analysis, and consistency validation [4]. This study has been carried out in choosing the best liner for the shipping department of the company.

2 RELATED WORKS

AHP method is a mathematical modelling method which to determine the best solution to solve a problem. Thus, it can reduce the cost and time for the betterment of the company. Malindzakova and Puskas [5] used AHP to study the criteria for choosing the data frame into a production company, while Miciuła and Nowakowska-Grunt [6] used the AHP method to select an energy supplier for household in Poland.

In supply chain problems, AHP has been used to select suppliers for aerospace and defense industry [7], assist small and medium enterprises (SMEs) to select effective suppliers [8], and select green supplier in steel door industry [9]. Other works on AHP in supplier selection problems include a combination with Taguchi loss function and technique for order performance by similarity to ideal solution (TOPSIS) [10], a combination of fuzzy AHP and fuzzy TOPSIS in an automotive manufacturing company in Malaysia [11], and a combination of mixed balanced scorecard and fuzzy AHP in automobile industry [12].

AHP has also been applied in other area such as evaluation of sustainability certification methods [13], optimization of investment selection in the transportation sector [14], identification of athletes' talents [15], prioritization of the assembly line process [16], and flooding risk assessment of metro system [17].

3 METHODOLOGY

3.1 Data Collection

The data collection started with an interview session. An interview is the right method to gather data from individuals through discussions. Interviews also can be a tool that can get involved in the participants to talk about specific topics. Moreover, the interviewer can also discuss their view with the respondent. By conducting the interview, the researcher will know what method to use for the study and the researcher will identify what is important information contained in this interview. In addition, the interviewer has been properly trained to ask proper and good questions and avoid preferences stemming from social desirability, conventionality, or constructs of disinterest.

An interview has been conducted with the manager of the shipping department. The data obtained from the interview were used as the input and the weight for all pairwise comparison matrices were computed. The interview was carried out to collect data about the factors of liner supplier needed and criteria that it fulfilled. Through this interview the researcher gained data about the liner suppliers and what are the actions that will be implemented to choose the liner. On the other hand, the situation at the shipping department regarding the delayed containers has been observed. The delay makes the company bear extra charges and challenges the competency of the workers. An analysis to pick the best liner supplier is needed to reduce this problem.

3.2 AHP Method

Analytic Hierarchy Process (AHP) was used to achieve the objectives in obtaining the solution to the supplier selection problem. AHP has been widely used in complex decision-making problems. Despite that, AHP is viewed as a flexible model that allows individuals or groups to shape the ideas and define the problem by making their assumption and to derive the solution from it [18]. It can provide a quantitative computational method to generate priorities based on the judgment of the criteria by using the multi-level hierarchical structure of objectives, criteria, sub-criteria, and alternatives [19].

In this study, five liners had been proposed which are EG, YM, MS, OO, and MA. Among these liners, we need to choose the best liner. The preference level scale of pairwise comparison as recommended by Saaty [20] is used for the comparison accordingly as shown in Table 1.

Table 1 : Preference level scale

Scale	Description
1	Equally preferred
3	Moderately preferred
5	Strongly preferred
7	Very strongly preferred
9	Extremely preferred
2, 4, 6 and 8	Intermediate values

There are six major criteria that need to be considered in selecting the new suitable liners by the management. The criteria chosen are based on the interview with the shipping department manager. The criteria are responsiveness, features, price, quality, estimate time of departure and detention days.

Responsiveness is about the fast and determined liner's response and feedback whilst features are about the multiple size of the container such as 20GP, 40GP, 40HC, 40 HC (refrigerated). The price of the liner is reasonable according to the type of container which is stated at the features. The quality of the liner or container such as no rust, no oily surface, no dented, have four-arm stunner, and so on. Estimated time of departure (ETD) is the time of booking confirmation from the liner, and detention days are free periods of time to load and send the container for delivery.

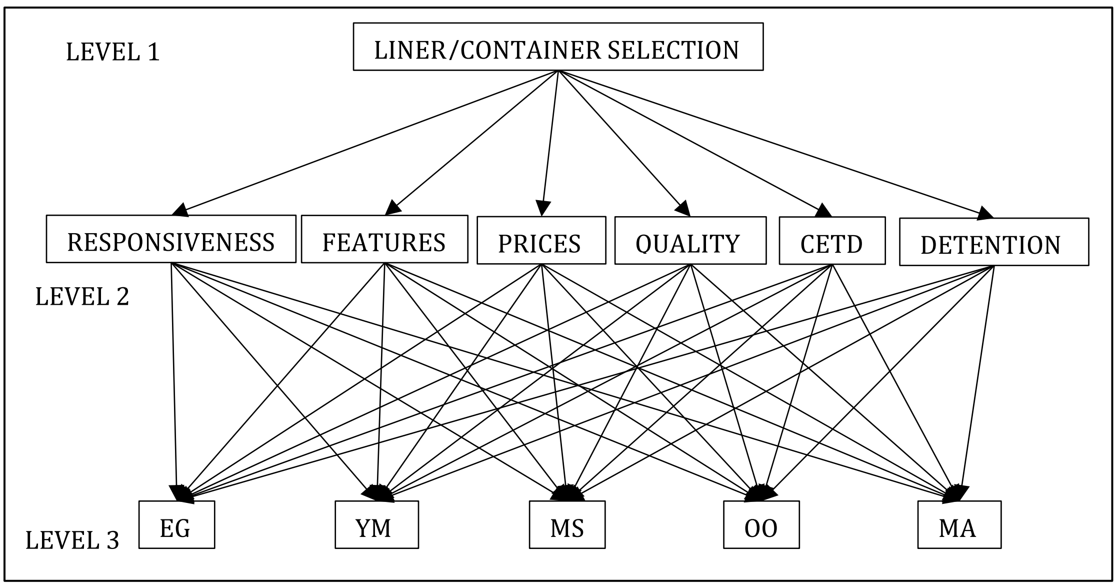

Figure 1 : Hierarchy system of the liner selection

Figure 1 shows the hierarchy problem of the liner selection with 6 criteria which are responsiveness, features, price, quality, ETD, and detention along with the collaboration of 5 liners. The hierarchy is divided into three levels; Overall Goal – liner selection (Level 1), criteria which contribute to the goal (Level 2), and applicants as alternatives contribute to each criterion (Level 3).

Other than that, to find the consistent ratio by equation (1):

$$CR = CI/RI \tag{1}$$

where *CI* is the consistency index, computed from the matrix and *RI* is the random index, as shown in Table 2 derived from Saaty [18]. If the value of *CR* is less than 0.1, then the decision-maker can take a decision that the degree of consistency is satisfactory and therefore acceptable. Meanwhile if *CR* is greater than 0.1, then it results that there are inconsistencies in the pairwise comparison.

Table 2 : Random index (RI)

Random index, RI														
n	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57	1.59

4 RESULTS AND DISCUSSIONS

4.1 AHP Results

The data obtained from the interview were used as the input of the pairwise comparison matrix, as shown in Table 3.

Table 3 : Pairwise comparison of the criteria

Alternatives	**Responsiveness**	**Features**	**Price**	**Quality**	**ETD**	**Detention**
Responsiveness	1	1	2	2	1	1/3
Features	1	1	½	1	1	½
Price	½	2	1	½	2	1
Quality	½	1	2	1	½	½
ETD	1	1	½	2	1	1
Detention	3	2	1	2	1	1
Total	**7**	**8**	**7**	**8½**	**6½**	**4 1/3**

Each value in each column is then divided by the sum of values in the column which yields a normalized matrix with the sum of the values in each column is 1. Table 4 shows the normalized matrix. The weight of each criterion is calculated using equation (2):

$$w_i = \frac{1}{n}\sum_{j=1}^{n} c_{ij}\ , i = 1,2,3,\dots,n. \quad (2)$$

As an example, for responsiveness criterion, the weight:

$$w_1 = \frac{0.1429 + 0.1250 + 0.2857 + 0.2353 + 0.1538 + 0.0769}{6} = 0.1699$$

Table 4: Normalized matrix of the pairwise comparison

Alternatives	**Responsiveness**	**Features**	**Price**	**Quality**	**ETD**	**Detention**	**Weight, w_i**	**Rank**
Responsiveness	0.1429	0.1250	0.2857	0.2353	0.1538	0.0769	0.1699	3
Features	0.1429	0.1250	0.0714	0.1176	0.1538	0.1154	0.1210	6
Price	0.0714	0.2500	0.1429	0.0588	0.3077	0.2308	0.1769	2
Quality	0.0714	0.1250	0.2857	0.1176	0.0769	0.1154	0.1320	5
ETD	0.1429	0.1250	0.0714	0.2353	0.1538	0.2308	0.1599	4
Detention	0.4286	0.2500	0.1429	0.2353	0.1538	0.2308	0.2402	1
Total	**1.0000**	**1.0000**	**1.0000**	**1.0000**	**1.0000**	**1.0000**	**1.0000**	

The pairwise comparison of all criteria of the manager selection and result shows that detention is the best criterion required from the supplier with the weightage of 0.2402, followed by price with the weight of 0.1769 and responsiveness at third place with the weight of 0.1699. To validate that the judgement is consistent, the consistency ratio is calculated using equation (1).

There are three steps to determine the *CI*. First step, the average weight of each criterion is calculated by multiplying matrix from Table 3 and the weight matrix as follows.

$$\begin{vmatrix} 1 & 1 & 2 & 2 & 1 & 1/3 \\ 1 & 1 & ½ & 1 & 1 & ½ \\ ½ & 2 & 1 & ½ & 2 & 1 \\ ½ & 1 & 2 & 1 & ½ & ½ \\ 1 & 1 & ½ & 2 & 1 & 1 \\ 3 & 2 & 1 & 2 & 1 & 1 \end{vmatrix} \text{X} \begin{vmatrix} 0.1699 \\ 0.1210 \\ 0.1769 \\ 0.1320 \\ 0.1599 \\ 0.2402 \end{vmatrix} = \begin{vmatrix} 1.1488 \\ 0.7914 \\ 1.1299 \\ 0.8919 \\ 1.0436 \\ 1.5929 \end{vmatrix}$$

Second step, the maximum eigenvalue, λ_{max} is calculated by summing each average weight value divided by each weight value, before dividing it with the number of criteria, *n*.

$$\lambda_{\max} = \frac{1}{6}\left(\frac{1.1488}{0.1699} + \frac{0.7914}{0.1210} + \frac{1.1299}{0.1769} + \frac{0.8919}{0.1320} + \frac{1.0436}{0.1599} + \frac{1.5929}{0.2402}\right) = 6.6001$$

Final step, *CI* is calculated using Equation (3)

$$CI = \frac{\lambda_{\max} - n}{n-1} \qquad (3)$$

$$CI = \frac{6.6001 - 6}{6-1} = 0.1200$$

Finally, CR is calculated using Equation (1)

$$\text{CR} = \frac{0.1200}{1.24} = 0.0967$$

Since the *CR* value is less than 0.1, the pairwise comparison is consistent and considered valid.

Table 5 illustrates the pairwise comparison with respect to responsiveness criterion. MA ranked first as the liner supplier whose response fast and clear with the weightage of 0.3104, followed by MS in second place with the weight of 0.2378 and YM hold third place in ranking with the weightage of 0.1745. This pairwise comparison was consistent with the CR value of 0.0847 as it is less than 0.1.

Table 5: Pairwise comparison with respect to responsiveness

Alternatives	**EG**	**YM**	**MS**	**OO**	**MA**	**Weight**	**Rank**
EG	1	½	¼	1	½	0.1102	5
YM	2	1	1	1	½	0.1745	3
MS	4	1	1	2	1/3	0.2378	2
OO	1	1	½	1	1	0.1671	4
MA	2	2	3	1	1	0.3104	1
Total	10	5 ½	5 ¾	6	3 1/3	1.0000	

Table 6 shows the pairwise comparison with respect to the second criterion, features. MA holds the first in the rank list as containing multiple shapes of the container such as 20GP, 40GP, 40HC, 40 HC (refrigerate) with the weightage of 0.6096, followed by OO in second place with the weight of 0.1498 and YM, third place in ranking with the weightage of 0.0880. This pairwise comparison was consistent with the *CR* value of 0.0748 as it is less than 0.1.

Table 6: Pairwise comparison with respect to features

Alternatives	**EG**	**YM**	**MS**	**OO**	**MA**	**Weight**	**Rank**
EG	1	½	2	¼	1/9	0.0721	5
YM	2	1	1	½	1/7	0.0880	3
MS	½	1	1	1	1/8	0.0805	4
OO	4	2	1	1	1/5	0.1498	2
MA	9	7	8	5	1	0.6096	1
Total	16½	11½	13	7¾	1 4/7	1.00000	

Table 7 shows the pairwise comparison with respect to the third criterion, price. MA is in the first list as the price of the liner is reasonable, affordable and relevant according to the type of container which stated at the features with the weightage of 0.4958, MS is second in the list with the weightage of

0.2146, OO in the third place in ranking with the weightage of 0.1609 and followed by EG and YM with fourth and fifth place in the ranking with the weightage of 0.0872 and 0.0415 respectively. This pairwise comparison was consistent with the CR value of 0.0543 as it is less than 0.1.

Table 7: Pairwise comparison with respect to price

Alternatives	**EG**	**YM**	**MS**	**OO**	**MA**	**Weight**	**Rank**
EG	1	2	1/3	1	1/9	0.0872	4
YM	½	1	1/8	1/5	1/7	0.0415	5
MS	3	8	1	1	1/3	0.2146	2
OO	1	5	1	1	1/3	0.1609	3
MA	9	7	3	3	1	0.4958	1
Total	14 ½	23	5 ½	6 1/5	2	1.00000	

Table 8 shows the pairwise comparison with respect to the quality criterion. MA was rated first in the list as it's quality of the container or liner such as no rust, no oily surface, not dented, with the weightage of 0.4219, OO is in the second rank of the list with the weightage of 0.3139 and followed by MS, as third in rank with the weight of 0.1303. This pairwise comparison was consistent with the CR value of 0.0173 as it is less than 0.1.

Table 8: Pairwise comparison with respect to quality

Alternatives	**EG**	**YM**	**MS**	**OO**	**MA**	**Weight**	**Rank**
EG	1	½	½	1/7	1/8	0.0499	5
YM	2	1	½	1/3	1/6	0.0840	4
MS	2	2	1	½	¼	0.1303	3
OO	7	3	2	1	1	0.3139	2
MA	8	6	4	1	1	0.4219	1
Total	20	12½	8	3	2½	1.00000	

Table 9 shows the pairwise comparison with respect to the ETD criterion. MA is in the first of list as the liner supplier get booking confirmation according to ETD with the weightage of 0.3298, OO is second in the list with the weightage of 0.2398, YM in the third place in ranking with the weightage of 0.1742 and followed by EG and MS with fourth and fifth place in the ranking with the weightage of 0.1473 and 0.1088 respectively. This pairwise comparison was consistent with the CR value of 0.0779 as it is less than 0.1.

Table 9: Pairwise comparison with respect to ETD

Alternatives	**EG**	**YM**	**MS**	**OO**	**MA**	**Weight**	**Rank**
EG	1	1	2	1/3	½	0.1473	4
YM	1	1	3	½	½	0.1742	3
MS	½	1/3	1	1	1/3	0.1088	5
OO	3	2	1	1	½	0.2398	2
MA	2	2	3	2	1	0.3298	1
Total	7 ½	6 1/3	10	4 5/6	2 5/6	1.000	

Table 10 shows the pairwise comparison with respect to the last criterion, detention. EG, is first in the list with the weightage of 0.3690, which means EG has provided more detention days or free periods of time to load and send the container for delivery that satisfies the supervisors more compared to others, followed by OO, second in the rank of the list with the weightage of 0.2728 and MA, as third in the rank with the weight of 0.1573. This pairwise comparison was consistent with the CR value of 0.0767 as it is lesser than 0.1.

Table 10: Pairwise comparison with respect to detention

Alternatives	**EG**	**YM**	**MS**	**OO**	**MA**	**Weight**	**Rank**
EG	1	3	2	2	4	0.3690	1
YM	1/3	1	1	1/2	1/2	0.1020	4
MS	1/2	1	1	1/4	1/3	0.0989	5
OO	1/2	2	4	1	3	0.2728	2
MA	1/4	2	3	1/3	1	0.1573	3
Total	2 4/7	9	11	4	8 5/6	1.000	

With the preference for each criterion from Tables 5 to 9, the weights for all alternatives are calculated. For example, the weight of EG is = (0.1102 x 0.1699) + (0.0721 x 0.1210) + (0.0872 x 0.1769) + (0.0499 x 0.1320) + (0.1473 x 0.1599) + (0.3690 x 0.2402) = 0.1616. Table 11 shows the rank of all liners, with the highest value of weightage is considered as the best liner.

Table 11: Rank table of liner suppliers

Alternatives	**Weight**	**Rank**
EG	0.1616	3
YM	0.1111	5
MS	0.1465	4
OO	0.2203	2
MA	0.3604	1
Total	1.000	

4.2 Discussions

Based on the AHP score, MA should be selected as the perfect supplier among the competitors that have fulfilled for most of the management of the company requirement. It is proven that the company does give importance to the liner supplier who provides containers with the best features and quality of the liner since indirectly, this will affect the performance and the ETD of the liner produced. MA is the first rank in the criteria of responsiveness, features, price, quality, and ETD, meaning that the liner supplier gives fast response and feedback, they provide multiple shapes of the container such as 20GP, 40GP, 40HC, 40 HC (refrigerated), the price of the liner is reasonable according to the type of container which stated at the features, the quality of the container mostly in good condition such as no rust, no oily surface, no dented, have four-arm stunner, and so on. Also, the liner supplier provides the container on time and ensure to deliver the good before the closing time respectively.

5 CONCLUSION

The first objective, to identify the company requirement was achieved through the interview session. Some information about the solution and implementation of the liner was also gathered. The second objective that is to determine the priority for possible solutions, and efficient decisions was achieved by using the AHP method. The researcher obtained six main criteria: responsiveness, features, price, quality, ETD, and detention. These six criteria are important to achieve the main effective implementation of this study. Using AHP method, MA found to be the best liner with top in responsiveness, features, price, quality, and ETD. The third objective of this study which is to rank the suppliers who fulfilled the requirement and choose the best supplier was achieved using AHP.

The findings of the study could be generalized as reference for any company in selecting liner supplier. AHP may not only be used for choosing the best liner supplier, but also can be used in the future for other departments in the company. Any company can use the AHP method in other fields if the decision should be derived from any multi-criteria such as selecting the best staff of the year, selecting the best candidate in the interview, and selecting the best worker for a month and so on.

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