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VENDOR SELECTION FOR AN AUTOBOT SYSTEM FOR VDK GLOVES MANUFACTURING COMPANY USING FUZZY ANALYTICAL HIERARCHY PROCESS

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ABSTRACT

Vendor selection of an autobot system is not a simple process as it typically involves multiple criteria, and it needs human judgement. Therefore, there is a requirement to have a better system for vendor selection due to ambiguity and vagueness that exist in dealing with multiple criteria decision making (MCDM) problems. In this study, there are two main objectives which is to identify the important criteria for vendor selection and to determine the most preferable

vendor based on selected criteria using Fuzzy Analytical Hierarchy Process (FAHP) for the VDK gloves manufacturing company. The finding shows seven criteria which are flexibility, reputation, service, price, quality, distance, and competitiveness chosen by the experts. Based on FAHP, Vendor 1 is selected as the most preferable vendor with the score of 0.4708 since it met all the criteria chosen by the VDK glove manufacturing company's expertise. As a recommendation this method can also be adopted by the company to manage other selection problems.

Keywords: Fuzzy AHP, Gloves Manufacturing, Vendor Criteria, Vendor Selection.

INTRODUCTION

In the current modernised world, hygiene is the most important role in everyone's daily life. Due to many unseen viruses which unable to be seen by naked eyes, a lot of diseases have been transmitted to humans even though they are hygienic. The viruses are spread by touching contaminated surfaces and most people are unaware that they have been infected. Gloves have been used for protection to control spread of viruses. It has been used in many sectors or professions such as health, food preparation, and production. In addition to the current pandemic situation, the demand for gloves has increased significantly worldwide.

VDK is a glove manufacturing company which produces gloves. In VDK gloves company they are using a manual system in collecting delivery orders (DO) at the main gate or guard house. This will be delay or exceed the cut off time of submitting the document to the third party such as shipping instruction (SI), imported security file (ISF), verified gross weight (VGM), commercial invoice, and packing list (CIPL) to the forwarders for custom declaration (k2) and will ended up with penalty charges, late SI charges, and SSR.

According to Trans-border Global Freight System (2021), the punishments caused for neglecting to present an ISF inside the required time span or submitting wrong ISF data can add up to $5,000.00 per infraction or potentially up to $10,000.00 per exchange. Therefore, to

avoid these circumstances, the VDK gloves manufacturing company had decided to implement an autobot system in the guard house. For the implementation of an autobot system, top management in the VDK glove manufacturing company had decided to assign an IT (Information Technology) vendor to do the system. Due to the overwhelming response from several vendors, the VDK gloves manufacturing company had faced a huge confusion on selecting the best vendor in implementing an autobot system.

There is an increasing number of literatures about selection in manufacturing such as raw material, worker promotion, supplier and vendor. One of the best methods in solving selection problems is known as Multiple Criteria Decision Making (MCDM). Some techniques from MCDM have been used in manufacturing by several researchers such as Analytical Hierarchy Process (AHP) and Technique for Order Performance by Similarity to Ideal Solution (TOPSIS) (Rashid et al., 2020; Noor et al., 2019; Jain et al., 2018). Recently, a derivative of the AHP, has been used by considering the fuzzy set theory into the principles of the AHP which is known as fuzzy AHP (FAHP). FAHP is the extension of traditional AHP. The advantage of FAHP is it can effectively model uncertainty and imprecision conditions. This method can be used to evaluate the criteria that are difficult to determine by human thinking.

Noor et al. (2019) used FAHP to identify the best cost selection during implementation of design for remanufacturing in economy indicators. The selection of the contractor for maintenance services in the manufacturing company also used FAHP (Rashid et al., 2020). Whilst, based on Tukimin et al. (2021), FAHP can be used to select supplier development practice. As referred to Galankashi et al. (2016), the criteria in vendor selection have been made by considering price, quality, service, flexibility, competitiveness, reputation, and distance. The yield of this stage was an initial state of measures appropriate to be utilized for vendor selection. As stated by Jain et al. (2018), quality, price, on time delivery (service), brand name of supplier (reputation) has been analyzed as the criteria to select the vendor. Moreover, as supporting above research criteria, Astanti et al. (2020) had done the vendor selection by using the similar criteria which is quality, price, transportation (distance), delivery time (service), vendor capacity (competitiveness). Generally, evaluating the criteria

of a vendor involves imprecise and uncertain data. Therefore, FAHP is used for vendor selection to install the autobot system at VDK gloves manufacturing company. The aim of this study is to identify the important criteria for vendor selection and to determine the most preferable vendor based on selected criteria using FAHP for VDK gloves manufacturing company.

Other than that, by implementing an autobot system at guardhouse, management is able to control errors and ensure there are less mistakes happening in the document. Moreover, by having this vendor selection process, management can select the best vendor which is able to provide a good service with the best price. This can reduce the unnecessary cost during implementation. Furthermore, the criteria would be decided by the top management of the company. This is due to top management having sufficient knowledge and experience in their respective field, which is known as an expertise to the system/ process in their company.

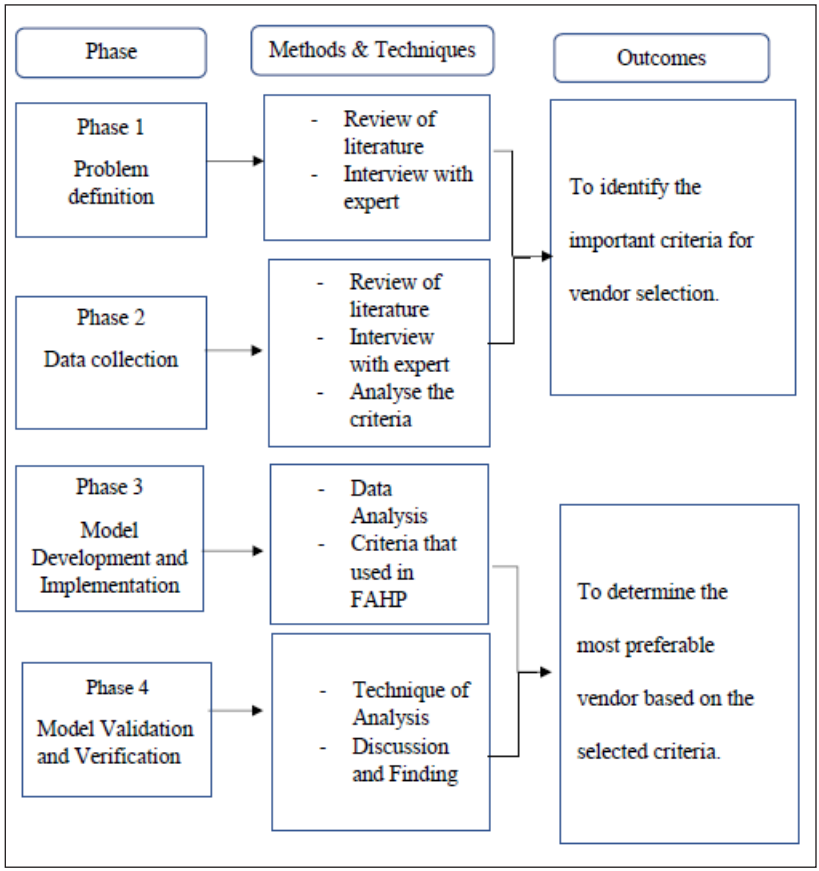
METHODOLOGY

This section describes the research design used, the data collection method of analysis, and criteria applied to find the most preferable vendor to install the autobot system at VDK glove manufacturing company using FAHP. This study is conducted through several phases of the research process as shown in Figure 1. Phase 1 and phase 2 contain a similar method such as reviewing several literatures to achieve the first objective. Next, phase 3 and phase 4 is about techniques used in order to succeed in the second objective.

The process of providing documents to liners at VDK gloves manufacturing company often gets delayed which makes the company bear extra charges and challenges to the competency of the outdated system. This may affect the trust and loyalty towards customers which will affect the business. Due to this problem, the study on vendor selection using FAHP is proposed. The literature on the vendor selection problem is reviewed to make a summary and extract some related information. The review is focused on identifying the important criteria for vendor selection and determining the most preferable vendor using FAHP.

Figure 1

Flowchart of Research Activity



Data collection in this research involved interviews with the experts, and question and observation to identify the criteria involved in vendor selection. This research is about a two-way conversation between the researcher and the top management from the assistant manager and manager from the related departments such as shipping department, purchasing department, supply chain management department and management information system department. Among thirty expertise from top management had been chosen as the respondent. This interview has been carried out at VDK gloves manufacturing company. The data obtained from the interview is used as input and the weight for all pairwise comparison matrices are

computed. Interviews also are the right method to gather data from individuals through discussions (Kajornboon, 2005). Interviews also can be a tool that can get involved in the participants to talk about specific topics. Moreover, the interviewer also can discuss their view with the respondent (O'Leary, 2004). In this study, semi-structured interviews have been carried out and the vendor selection criteria to be considered are revealed in a checklist form. The checklist helps the researcher to get the point of view from the experts.

The questionnaire plays a main role in this research in collecting data. A set of questionnaires with two sections had been created. Section A contains demographic information and Section B contains criteria scoring along the scale. The study used primary data which were gathered using a set of questionnaires. While, observations in data collection can develop knowledge about a specific topic, processes, knowledge, belief, and attitudes towards social interactions (Fry, 2017). This research is also conducted by observing the situation. The researcher observed the data received from expertise which does not get to be manipulated by others. This will ensure the data is in valid status and avoid bias.

Other than that, Fuzzy Analytic Hierarchy Process (FAHP) was used to achieve the objectives in obtaining the solution to the vendor selection problem as the most suitable method used in the decision-making technique. Five vendors had been proposed in this study. Among these IT vendors, researchers need to identify the most preferable vendor which is able to fulfil the criteria and bring benefits to the VDK gloves manufacturing company. The preference level scale of pairwise comparison was taken from the recommendation of Saaty (1980) and Zhou and Lu (2012), and used for the comparison accordingly as stated in the Table 1 below.

Table 1

Pairwise Comparison Table, Linguistic Terms and the Triangular Fuzzy Numbers

Scale	AHP Scale	FAHP Triangular Scale	Triangular Fuzzy Reciprocal Scale
Equally important	1	(1, 1, 1)	(1, 1, 1)
Intermediate 1	2	(1, 2, 3)	(1/3, 1/2, 1)

(continued)

Scale	AHP Scale	FAHP Triangular Scale	Triangular Fuzzy Reciprocal Scale
Moderately important	3	(2, 3, 4)	(1/4, 1/3, 1/2)
Intermediate 2	4	(3, 4, 5)	(1/5, 1/4, 1/3)
Important	5	(4, 5, 6)	(1/6, 1/5, 1/4)
Intermediate 3	6	(5, 6, 7)	(1/7, 1/6, 1/5)
Very important	7	(6, 7, 8)	(1/8, 1/7, 1/6)
Intermediate 4	8	(7, 8, 9)	(1/9, 1/8, 1/7)
Absolutely important	9	(9, 9, 9)	(1/9, 1/9, 1/9)

Table 1 is the important preference level scale as a guide to identify the most preferable vendor that will contribute a good performance to VDK gloves manufacturing company. In this study, there are seven (7) major criteria have been considered in selecting the new suitable vendor by the management. The criteria chosen are selected based on review of the literature involving vendor selection as well as advice from the management of VDK gloves manufacturing company. Descriptions of the criteria to be used in the selection of vendors and related researchers are listed in Table 2.

Table 2

Criteria, Description and List of Researchers

Criteria	Description	Authors
Flexibility	Vendors are flexible to adapt the situation and current usage system in the company.	Galankashi et al.(2016) Chatterjee & Stevic (2019) Tooranloo & Iranpour (2017)
Reputation	Vendors should have a good background and no blackmark.	Galankashi et al. (2016) Jain et al. (2016).
Service	Provide a good service which satisfies the company requirement.	Haq & Kannan (2006) Galankashi et al. (2016) Jain et al. (2016) Chatterjee & Stevic (2019) Tooranloo & Iranpour (2017) Astanti et al. (2020) Tahriri et al. (2014)

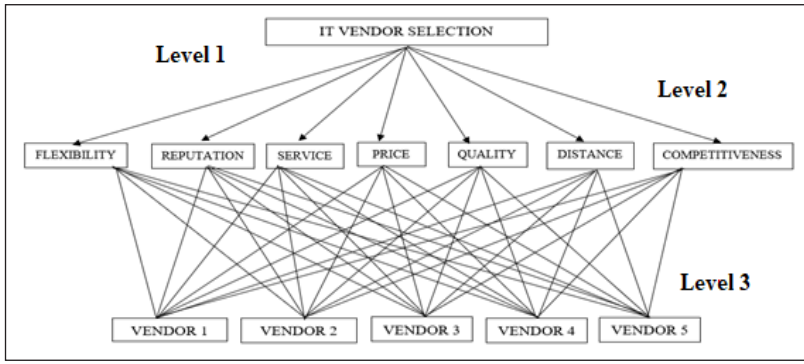
(continued)

Criteria	Description	Authors
Price	The price is reasonable and lower according to another competitor vendor.	Haq & Kannan (2006) Galankashi et al. (2016) Jain et al. (2016) Chatterjee & Stevic (2019) Astanti et al. (2020) Tahriri et al. (2014)
Quality	The quality of the autobot system should be good and friendly to the user.	Haq & Kannan (2006) Galankashi et al. (2016) Jain et al. (2016) Chatterjee & Stevic (2019) Tooranloo & Iranpour (2017) Astanti et al. (2020) Tahriri et al. (2014)
Distance	Distance of the vendor to the company should be nearer due to emergency purposes, able to contact and receive fast.	Galankashi et al. (2016) Chatterjee & Stevic (2019) Astanti et al. (2020).
Competitiveness	System interface is catchy and capable of providing more details in a precise way to compete with other vendors.	Galankashi et al. (2016) Astanti et al. (2020).

Figure 2 shows the structure of the vendor selection at VDK gloves manufacturing company and represented as a hierarchical decision model with seven (7) criteria which are flexibility, reputation, service, price, quality, distance, competitiveness along with five (5) vendors.

Figure 2

Hierarchy System of the Vendor Selection



The FAHP was used to achieve the objectives in obtaining a solution to the vendor selection. There are a few steps to proceed with FAHP as the performance evaluating tool (Jain et al., 2018).

STEP 1: Construct the hierarchical chart.

STEP 2: Identify fuzzy scales to conduct the pairwise comparisons.

STEP 3: Build pairwise comparison $(\widetilde{A})$ matrix referring fuzzy scale as below:

$$\tilde{A} = \begin{bmatrix} 1 & \widetilde{a_{12}} & \dots & \widetilde{a_{1n}} \\ \widetilde{a_{21}} & 1 & \dots & \widetilde{a_{2n}} \\ \vdots & \vdots & \ddots & \vdots \\ \widetilde{a_{n1}} & \widetilde{a_{n2}} & \dots & 1 \end{bmatrix} \quad (1)$$

In case there are a few specialists, components of a total pairwise comparison matrix utilized in the FAHP strategy is a triangular fuzzy scale where the main part is the least remarks, the subsequent part (m) is the mean of numbers, and the third part (u) is the most extreme number.

STEP 4: Analyse S_i intended for every single line of the pairwise comparison matrix as below:

$$S_i = \sum_{j=1}^{m} M_{gi}^{j} \times \left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{j} \right]^{-1} \quad (2)$$

Hence, i signifies the row value and j indicates the column value. In the method, M_{gi}^{j} is triangular

fuzzy digits of pairwise comparison matrices. The numbers of $\sum_{j=1}^{m} M_{gi}^{j}, \sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{i}$ and $\left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{i}\right]^{-1}$

be able to analyse by applying the following methods, individually:

$$\sum_{j=i}^{m} M_{gi}^{j} = \left(\sum_{j=1}^{m} l_j \, , \sum_{j=1}^{m} m_j \, , \sum_{j=1}^{m} u_j \right) \quad (3)$$

$$\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j} = \left(\sum_{i=1}^{n} l_i \ , \sum_{i=1}^{n} m_i \ , \sum_{i=1}^{n} u_i\right) \tag{4}$$

$$\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j}\right]^{-1} \left(\frac{1}{\sum_{i=1}^{n} u_i} , \frac{1}{\sum_{i=1}^{n} m_i} , \frac{1}{\sum_{i=1}^{n} l_i}\right) \tag{5}$$

The method above, l_i, m_i and u_i are the first, second, and third elements of the fuzzy digits, correspondingly.

STEP 5: Calculate the significance S_i of with sense of other

Other than that, if $M_1 = (l_1, m_1, u_1)$ and $M_2 = (l_2, m_2, u_2)$ are dual triangular fuzzy digits, according following figure, and the significance of M_1 to M_2 be able to specify as arises:

$$V(M_2 \geq M_1) = hgt(M_1 \cap M_2) = \mu_{M_2}(d) = \begin{cases} 1 \ if \ m_2 \geq m_1 \\ 0 \ if \ l_1 \geq u_2 \\ \dfrac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)} \end{cases} \tag{6}$$

Moreover, the extent of a triangular fuzzy digit from k as one more triangular fuzzy digit can be acquired by the accompanying equation:

$$\begin{aligned} V(M \geq M_1, M_2, \dots, M_k) &= V[(M \geq M_1) \ and \ (M \geq M_2) \ and \dots (M \geq M_{1k})] \\ &= Min \ \mathrm{V}(M \geq M_1) \quad i = 1,2,3, \dots, k \end{aligned} \tag{7}$$

STEP 6: Calculate the weight of the criteria and alternatives in the pairwise comparison matrix as below:

$$d'(A_i) = Min \ V \ (S_i \geq S_k) \qquad k = 1,2, \dots, n \ , k \neq i \tag{8}$$

Hence, the unnormalized weight vector as follows:

$$W' = \left(d'(A_1), d'(A_2), \dots, d'(A_n)\right)^T \quad A_i \ (i = 1, 2, \dots, n) \tag{9}$$

STEP 7: Compute the final weight vector

Before compute concluding weight vector, the determined weight vector in the earlier step must be normalized, then:

$$W = \left(d(A_1), d(A_2), \dots, d(A_n)\right)^T \tag{10}$$

This is one of the major steps or in other words we can say as the technique that needs to be done to carry out this research.
According to Cypress (2017), legitimacy during data generation is

assessed through the researcher's capacity to explain information of data collection, exhibit delayed commitment and relentless perception, verbal transcription, and accomplish information immersion. In FAHP, when making the pairwise comparison, some degrees of inconsistency normally occur. The consistency ratio can be computed using the formula CR = CI/RI, where the Consistency Index (CI) will be computed from the comparison matrix while the value of the Random Index (RI) is derived from Saaty (1980) as shown in Table 3.

Table 3

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

If the value of CR is less than 0.1, then the decision-maker can make 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 serious inconsistencies.

RESULTS

Descriptive analysis is a section where researcher explained about respondent's background. In this section, the researcher has explained on the respondent gender, age, marital status, education background, position, work experience and department. There is analysis of 30 respondents in this study. There were 19 male experts with 63.3% who answered the questionnaires and females were 11 experts with 36.7%. Whereas the majority of the experts were 10 or 33.3% from the age group of 35-44. Second highest with 8 (26.7%) experts are from age group is 25-34 and following as 6 (20.0%) experts from 45 – 54, 5 (16.7%) experts from 55 – 64 and the least of 1 (3.3%) expert from the age group of 65 & above. Moreover, there were three types of marital status involved in this study. Most of the experts were married with 15 respondents (50.0%). Meanwhile, 11 out 30 respondents (36.7%) were single, and another 4 respondents (13.3%) were others. Hence, analysis of an expert's education background who obtained a diploma with 3 (10.0%) respondents, degree with highest respondent of 15 (50.0%), Master degree with 10 (33.3%) respondent and the least respondent of 2 (6.7 %) obtained a PhD degree. In this company,

there are six positions that had been declared as upper management, 10 (33.3%) experts in assistant manager positions. Meanwhile, 6 experts (20.0%) as manager and each 4 experts (13.3%) for the position of senior manager, deputy general manager and general manager respectively. Finally, with least score of 2 experts (6.7%) as Director. Majority of the experts were 9 or 30.0% from 21-30 years of experience. 1-10 years and 11-20 years contain the same number of experts which is 8 respondents (26.7%). 30 years and above obtain the least number of experts with 5 respondents (16.7%). Other than that, most of the respondents were from shipping department which have 9 respondents (30.0%). Meanwhile, rest of 3 department which is MIS, purchasing, SCM contain of 7 experts (23.3%) each.

As per discussion in the methodology section, there are seven (7) criteria that have been selected which are flexibility, reputation, service, price, quality, distance, and competitiveness to conduct this research. These criteria had been selected by reviewing from literature and by getting consensus from the management of the company. The selected criteria and the description as per Table 2. These criteria are the important criteria for the vendor selection. Therefore, the first objective of this research has been achieved which is to identify the important criteria for vendor selection.

In addition, Table 4 shows the weightage of all criteria based on the expert's evaluation. The result shows that price is the best criteria with the weightage of 0.2850, followed by reputation with the weight of 0.2791 and quality at third place with the weight of 0.1329 and the last four place obtain by service, competitiveness, flexibility, and distance with weightage of 0.1268, 0.1143, 0.0400 and 0.0220, respectively. This pairwise comparison was consistent with the CR value of 0.0748 as it is less than 0.1.

Table 4

Weightage of Criteria

Criteria	Fuzzy Weight (FW)			Mean FW	Normalized
Flexibility	0.0289	0.0407	0.0559	0.0418	0.0400
Reputation	0.1930	0.2804	0.4027	0.2920	0.2791
Service	0.0843	0.1262	0.1875	0.1327	0.1268
Price	0.1970	0.2895	0.4080	0.2982	0.2850

(continued)

Criteria	Fuzzy Weight (FW)			Mean FW	Normalized
Quality	0.0857	0.1282	0.2032	0.1390	0.1329
Distance	0.0160	0.0216	0.0314	0.0230	0.0220
Competitiveness	0.0853	0.1133	0.1600	0.1196	0.1143

Table 5 shows the weightage of vendor criteria, flexibility. Vendor 1 ranked first as the vendor supplier who's flexible to adapt the situation and current usage system in company with the weightage of 0.5281, followed by Vendor 2 in second place with the weight of 0.1517 and Vendor 4 hold third place in ranking with the weightage of 0.1274. Vendor 3 and Vendor 5 obtain the last 2 places with weightage of 0.1108 and 0.0644, respectively. This pairwise comparison was consistent with the CR value of 0.0928 as it is less than 0.1.

Table 5

Weightage of Vendor for Criteria Flexibility

Alternative	Fuzzy Weight (FW)			Mean FW	Normalized	Rank
Vendor 1	0.4146	0.5477	0.6955	0.5526	0.5281	1
Vendor 2	0.1171	0.1488	0.2103	0.1587	0.1517	2
Vendor 3	0.0770	0.1121	0.1588	0.1160	0.1108	4
Vendor 4	0.0973	0.1328	0.1696	0.1333	0.1274	3
Vendor 5	0.0434	0.0585	0.1003	0.0674	0.0644	5

Table 6

Weightage of Vendor for Criteria Reputation

Alternative	Fuzzy Weight (FW)			Mean FW	Normalized	Rank
Vendor 1	0.4483	0.5721	0.7168	0.5790	0.5534	1
Vendor 2	0.1721	0.2278	0.3062	0.2354	0.2250	2
Vendor 3	0.0842	0.1191	0.1688	0.1241	0.1186	3
Vendor 4	0.0373	0.0491	0.0786	0.0550	0.0526	5
Vendor 5	0.0562	0.0833	0.1229	0.0874	0.0836	4

Table 7 shows the weightage of the vendor for the criteria service. Vendor 1 ranked first as the vendor who's provide a good service which satisfy the company requirement with the weightage of 0.4386, followed by Vendor 4 in second place with the weight of 0.1941 and

Vendor 2 hold third place in ranking with the weightage of 0.1895. Vendor 3 and Vendor 5 obtain the last 2 places with weightage of 0.1297 and 0.0586, respectively. This pairwise comparison was consistent with the CR value of 0.0868 as it is less than 0.1.

Table 7

Weightage of Vendor for Criteria Service

Alternative	Fuzzy Weight (FW)			Mean FW	Normalized	Rank
Vendor 1	0.2876	0.4391	0.6502	0.4589	0.4386	1
Vendor 2	0.1273	0.1849	0.2826	0.1983	0.1895	3
Vendor 3	0.07482	0.1274	0.2049	0.1357	0.1297	4
Vendor 4	0.1344	0.1928	0.2822	0.2031	0.1941	2
Vendor 5	0.0383	0.0559	0.0899	0.0614	0.0586	5

Table 8 shows the weightage of vendors for criteria price. Based on Table 8, Vendor 1, Vendor 4 and Vendor 2 obtain the top 3 ranking with weightage of 0.4692, 0.2674 and 0.1073, respectively. This shows the vendor price is reasonable and lower according to another competitor vendor. Vendor 3 and Vendor 5 obtain the fourth and fifth rank along with the weightage 0.0936 and 0.0472, respectively. This pairwise comparison was consistent with the CR value of 0.0128 as it is less than 0.1.

Table 8

Weightage of Vendor for Criteria Price

Alternative	Fuzzy Weight (FW)			Mean FW	Normalized	Rank
Vendor 1	0.3599	0.4852	0.6275	0.4909	0.4692	1
Vendor 2	0.0828	0.1110	0.1431	0.1123	0.1073	3
Vendor 3	0.0660	0.0888	0.1390	0.0980	0.0936	4
Vendor 4	0.1957	0.2705	0.3730	0.2800	0.2674	2
Vendor 5	0.0363	0.0445	0.0673	0.0494	0.0472	5

Table 9 below shows the weightage of vendor criteria for quality. Vendor 1 obtained the first rank with weightage of 0.3516 which shows that the quality of the autobot system is good and friendly to the user. Hence, Vendor 3, Vendor 2, Vendor 5 and Vendor 4 were placed from rank 2 till rank 5 respectively with the weightage of 0.3504,

0.1625, 0.0952 and 0.0435, respectively. This pairwise comparison was consistent with the CR value of 0.0356 as it is less than 0.1.

Table 9

Weightage of Vendor for Criteria Quality

Alternative	Fuzzy Weight (FW)			Mean FW	Normalized	Rank
Vendor 1	0.2559	0.3402	0.5076	0.3679	0.3516	1
Vendor 2	0.1126	0.1600	0.2377	0.1701	0.1625	3
Vendor 3	0.2207	0.3601	0.5191	0.3667	0.3504	2
Vendor 4	0.0317	0.0410	0.0638	0.0455	0.0435	5
Vendor 5	0.0604	0.0987	0.1398	0.0997	0.0952	4

Table 10 shows the weightage of vendors for the criteria distance. Vendor 1 is in the first of list as the distance of vendor to the company is nearer especially when while emergency purpose able to contact and received fast with the weightage of 0.3417, Vendor 3 is in second in the list with the weightage of 0.2579, Vendor 2 in the third place in ranking with the weightage 0.2364 and followed by Vendor 4 and Vendor 5 with fourth and fifth place in the ranking with the weightage of 0.0924 and 0.0633, respectively. This pairwise comparison was consistent with the CR value of 0.0538 as it is less than 0.1.

Table 10

Weightage of Vendor for Criteria Distance

Alternative	Fuzzy Weight (FW)			Mean FW	Normalized	Rank
Vendor 1	0.2632	0.3421	0.4673	0.3575	0.3417	1
Vendor 2	0.1649	0.2449	0.3322	0.2473	0.2364	3
Vendor 3	0.1830	0.2639	0.3629	0.2699	0.2579	2
Vendor 4	0.0599	0.0902	0.1399	0.0967	0.0924	4
Vendor 5	0.04476	0.0589	0.0951	0.0663	0.0633	5

Table 11 shows the weightage of vendors for criteria competitiveness. Vendor 1 is first in the list with the weightage of 0.4522, this means Vendor 1 system interface is catchy and capable to provide more details in precise way compete to other vendors, followed by Vendor 4, second in the rank of the list with the weightage of 0.2650 and Vendor

2, Vendor 3 and Vendor 5 as third till fifth in the rank with the weight of 0.1388, 0.0712 and 0.0610, respectively. This pairwise comparison was consistent with the CR value of 0.0367 as it is less than 0.1. Table 12 shows the consistency ratio for pairwise comparison matrix for five vendors of each criteria.

Table 11

Weightage of Vendor for Criteria Competitiveness

Alternative	Fuzzy Weight (FW)			Mean FW	Normalized	Rank
Vendor 1	0.3323	0.4579	0.6292	0.4731	0.4522	1
Vendor 2	0.1112	0.1363	0.1881	0.1452	0.1388	3
Vendor 3	0.04788	0.0734	0.1024	0.0746	0.0712	4
Vendor 4	0.1937	0.2760	0.3621	0.2773	0.2650	2
Vendor 5	0.0427	0.0565	0.0923	0.0638	0.0610	5

Table 12

Model Validation of each Criteria

Criteria	Consistency Ratio (CR)
Flexibility	0.0928
Reputation	0.0638
Service	0.0868
Price	0.0128
Quality	0.0356
Distance	0.0538
Competitiveness	0.0367

According to Table 13 below, researchers show the overall ranking of vendor selection based on criteria flexibility, reputation, service, price, quality, distance, and competitiveness. By this the researcher showed the most preferable vendor to be selected for the company. Therefore, the second objective of this study is achieved.

Table 13

Overall Ranking of Vendors

	Vendor 1	Vendor 2	Vendor 3	Vendor 4	Vendor 5
Flexibility	0.0211	0.0061	0.0044	0.0051	0.0026
Reputation	0.1545	0.0628	0.0331	0.0147	0.0233
Service	0.0556	0.0240	0.0164	0.0246	0.0074
Price	0.1337	0.0306	0.0267	0.0762	0.0134
Quality	0.0467	0.0216	0.0466	0.0058	0.0127
Distance	0.0075	0.0052	0.0057	0.0020	0.0014
Competitiveness	0.0517	0.0159	0.0081	0.0303	0.0070
SUM	0.4708	0.1661	0.1410	0.1587	0.0678
RANK	**1**	**2**	**4**	**3**	**5**

Based on the FAHP score, Vendor 1 should be selected as the most preferable vendor among the competitors as it fulfilled all the criteria which had been selected by the expertise of the VDK gloves manufacturing company. Whereas, Vendor 1 obtained the first rank in all the criteria and overall ranking as well. This shows that Vendor 1 is flexible to adapt the situation and current usage system in company, should have a good background and no blackmark, able to provide a good service which satisfy the company requirement, the price is reasonable and lower according to another competitor vendor, quality of the autobot system is good and friendly user, distance of vendor to the company nearer and when emergency purpose able to contact and received fast and finally, the system interface is catchy and capable to provide more details in precise way compete to other vendor. Whereas, Vendor 2 obtained the second rank, Vendor 4 obtained the third rank, Vendor 3 obtained the fourth rank, and Vendor 5 obtained the last rank.

Based on the analysis and finding, researchers have achieved the two objectives successfully. According to the first objective, researchers are able to identify the required criteria to select the vendor. Meanwhile, by using the FAHP method, a second objective was achieved, where Vendor 1 had been selected as the most preferable vendor whereas. However, not only in overall selection, Vendor 1 obtained the first rank in pairwise comparison with respect to the criteria such as, flexibility, reputation, service, price, quality, distance, and competitiveness.

CONCLUSION

Selecting the right vendor is the important process since it will give positive impacts to the VDK gloves manufacturing company. Vendor selection is a Multi-Criteria Decision Making (MCDM) problem as it involves evaluation of vendors based on multiple criteria.

The researchers in this study had discovered seven important criteria which are flexibility, reputation, service, price, quality, distance, and competitiveness for vendor selection. These criteria were chosen based on expert opinion as well as previous journal references. The first objective of this study was accomplished, which was to discover the glove manufacturing company's specifications that vendors are required to meet.

Other than that, Vendor 1 is chosen as the most preferable vendor among the vendors based on the FAHP score since it met all of the criteria. Vendor 1 takes first rank in all criteria, as well as the overall rank. This demonstrates that Vendor 1 is adaptable to changing circumstances and current system usage in the company, has a clean background with no blemishes, is able to provide a good service that meets the company's needs, the price is reasonable and lower than a competitor vendor, the quality of the autobot system is good and user-friendly, and the vendor's distance from the company is closer, making it easier to contact and receive information in an emergency. Finally, the system interface is appealing and capable of providing more information in a precise manner as compared to other vendors. Vendor 2 receives the second rank, Vendor 4 receives the third rank, Vendor 3 receives the fourth rank, and Vendor 5 receives the fifth rank. As a result, the second objective was met.

This research can be beneficial for VDK gloves manufacturing company to implement the best solution with low cost and the solution with high effectiveness. This can help the company to decrease the overcharges of the detention rate in an effective way and can avoid the delay of shipping or delivering products to the customers. Moreover, this research also could be a reference for the company with the knowledge and importance of the FAHP method. This method is not only used for choosing the best vendor, it also can be used for the other field or other departments in the company.

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REFERENCES

Astanti, R. D., Mbolla, S. E., & Ai, T. J. (2020). Raw material supplier selection in a glove manufacturing: Application of AHP and fuzzy AHP. *Decision Science Letters*, *9*(3), 291–312.

Chatterjee, P., & Stevic, Z. (2019). A two-phase fuzzy AHP - Fuzzy TOPSIS model for supplier evaluation in manufacturing environment. *Operational Research in Engineering Sciences: Theory and Applications*, *2*(1) 72 -90.

Cypress, B. S. (2017). Rigor or reliability and validity in qualitative research: Perspectives, strategies, reconceptualization, and recommendations. *Dimensions of Critical Care Nursing, 36*(4), 253 - 263.

Fry, M., Curtis, K., Considine, J., & Shaban, R. Z. (2017). Using observation to collect data in emergency research. *Australas Emerg Nursing Journal, 20*(1), 25-30.

Galankashi, M. R., Helmi, S. A., & Hashemzahi, P. (2016). Supplier selection in automobile industry: A mixed balanced scorecard–fuzzy AHP approach. *Alexandria Engineering Journal*, *55*(1), 93-100.

Haq, A. N., & Kannan, G. (2006). Fuzzy analytical hierarchy process for evaluating and selecting a vendor in a supply chain model. *The International Journal of Advanced Manufacturing Technology*, *29*(7–8), 826–835.

Jain, V., Sangaiah, A. K., Sakhuja, S., Thoduka, N., & Aggarwal, R. (2018). Supplier selection using fuzzy AHP and topsis: A case study in the Indian automotive industry. *Neural Computing and Applications*, *29*(7), 555–564.

Kajornboon, A. B. (2005). Using interviews as research instruments. *E-journal for Research Teachers*, *2*(1), 1-9.

Noor, A. Z. M., Fauadi, M. H., & Jafar, F. A. (2019). Fuzzy analytic hierarchy process (FAHP) for better selection during implementation of design for remanufacturing in economy indicator. *Journal of Mechanical Engineering* , 99-120.

O'leary, Z. (2004). *The essential guide to doing research.* Sage Publications, London.

Rashid, N. A., Amin, N. M., & Mahad, N. (2020). Application of fuzzy analytic hierarchy process for contractor selection problem. *Journal of Science and Technology, 3*(2)*,* 109-117.

Saaty, T. L. (1980). *The analytic hierarchy process: Planning, Priority Setting, Resource Allocation*. Mcgraw-Hill, New York.

Singh, P. K., & Sarkar, P. (2019). A framework based on fuzzy AHP-TOPSIS for prioritizing solutions to overcome the barriers in the implementation of ecodesign practices in SMEs. *International Journal Sustainable Development & World Ecology*, *26*(6), 506–521.

Tahriri, F., Dabbagh, M., & Ebrahim, N. A. (2014). Supplier assessment and selection using fuzzy analytic hierarchy process in a steel manufacturing company. *Journal of Scientific Research and Reports, 3*(10), 1319-1338.

Tooranloo, H. S., & Iranpour, A. (2017). Supplier selection and evaluation using interval-valued intuitionistic fuzzy AHP method. *International Journal of Procurement Management, 10*(5), 539-554.

Trans-Border Global Freight System (2021, December) CBP Enforcing Penalties for Late ISF Filings, https://Tbgfs.Com/Knowledgecenter-Articles/Cbp-Enforcing-Penalties-For-Late-Isf-Filings/

Tukimin, R., Mahmood, W. H. W., Nordin, M. M., Muhamad, M. R., & Ayuni, N. S. (2021). Application of AHP and FAHP algorithm for supplier development evaluation. *Malaysian Journal on Composites Science & Manufacturing*, *5*(1), 21–30.

Zhou, X., & Lu, M. (2012). Risk evaluation of dynamic alliance based on fuzzy analytic network process and fuzzy TOPSIS. *Journal of Service Science and Management*, *5*(3), 230-240.