

A Sector Wise Prioritization of Vendor Selection in Supply Chain using Multi-Criteria Decision-Making Method

Durga Patel

Research Scholar

Department of Industrial & Production Engineering
Shri G. S. Institute of Science & Technology,
Indore, M.P, India

Girish Thakar

PhD, Professor

Department of Industrial & Production Engineering
Shri G. S. Institute of Science & Technology,
Indore, M.P, India

ABSTRACT

Selecting vendors is one of the most important decision-making issues in the organization due to its strategic importance. The selection of vendors, which involves multiple parameters and multiple conflicting objectives, can be described as the process of finding the right vendors at the right cost, at the right time and in the right quantities with the right quality. The subjective issue of vendor selection is to minimize the risk and optimize the vendor's overall benefit. This article highlights the application of AHP, VIKOR, TOPSIS and FUZZY AHP across four sectors (i.e. manufacturing, pharmaceutical, service and healthcare) to determine the important criteria of vendor selection in different sectors. In addition, the steps of the MCDM methods are clearly and numerically described in this research. This study may be a strategy guide to be implemented for other multiple criteria decision-making problems. The main purpose of this document is to priorities the vendor selection criteria and MCDM techniques for individual sectors.

Keywords

Vendor Selection, Multi Criteria Decision Making Method (MCDM), Analytical Hierarchy Process (AHP), Multi-Criteria Optimization and Compromise Solution (VIKOR), Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), Fuzzy Analytical Hierarchy Process (F-AHP), Supply Chain Management (SCM).

1. INTRODUCTION

The issue of the vendor selection is based on the selection of the best vendor from a pre-established group of criteria, in terms of qualitative and quantitative characteristics, it is known as a multi-criteria decision-making tool (MCDM) and is of commensurate significance. Initially, to generate an initial feasible solution to the problem, multi-criteria decision-making (MCDM) is implemented. To increase flexibility in today's global marketplace, there is a need to remain competitive and respond to rapid market developments. These methods provide the framework to make effective decisions in complex decision situations (e.g., selection of vendors), makes it possible to simplify and speed up the natural decision-making process. Today, many organizations are facing rapid change as a result of technological innovations and changing customer demands [5].

2. LITERATURE REVIEW

Currently, there's intense competition within the supply chain of Indian firms. An outsized amount of collection has appeared on this topic, particularly within the problem of

choosing vendors using different MCDM methods. The subsequent may be a summary of a number of the important contributions during this paper.

These organizations envisage that the endeavor for getting products at proper cost in proper quantity having right quality at appropriate time from a reliable source is important for their better survival. So, in order to do this the efficient vendor selection process is our primary importance for smooth supply chain management. It starts by realizing a good vendor need which determines and formulate decision criteria from the shortlist of potential vendors from a large list. Assessing and selecting vendors is a typical multi-criteria decision-making (MCDM) issue that can be both tangible and intangible. The analysis of vendor selection and work measurement criteria was the focus of numerous researchers and procurement specialists to provide a specific overview of the fundamental criteria in the vendor selection decision. The vendor selection process requires a formal, systematic and efficient selection of model [12], [17]. Gupta, A, et al, (2013) has proposed the foremost recent survey on choosing the vendor, in an industry, he concluded that the organization should pay attention to the cost and quality to extend the productivity of the firm. Jayant, A, (2017) proposed a structured model to analyze the selection of vendors through the Analytical Hierarchy Process (AHP). The AHP hierarchy includes four assessment criteria and 13 sub-factors, whose materiality ratings were calculated which supports the customer requirements [5]. K.G. Rajasekaran, (2012) establishing a technique for evaluating the criteria for selection of vendor and ranking of selected supply chain partners against these criteria was proposed. This is also accomplished by the use of the Multi-Criteria Decision-Making Method (MCM) VIKOR, which can help procurement decision-makers to achieve improved product quality [36].

Athena et al, (2018) present a replacement approach to boost vendor selection in an exceedingly multi-item/multi-vendor environment, and supply the importance and reliability of the standards by treating the imperfection of the knowledge within the deciding process [22]. Anirban Ganguly (2019) provides a framework for the analysis and evaluation of supplier selection in the Indian pharmaceutical (IPS) sector using the MCDM technique of the fuzzy analytic hierarchy process. It intends to enhance managerial decision-making within the IPS in developing a vendor selections strategy supported multi-criteria evaluation technique [23]. Konstantinos Kirytopoulos, (2008) proposed a method in which the analytical network is customized highly especially for pharmaceutical industry because of its specific nature of

products. Its basic conceptualization assist in evaluating the complex problem in numerous regions and industries for selecting vendors offer [38]. Pourghahreman et al, (2015) categorizes the factors that influence the behavior of a drug manufacturer when its objective is to select which vendors to interact with in a drug agent's supply chain [28].

Mohanty, (2015) proposed model which addresses two problems related to vendor selection. Decisions made using the arranged model with those are obtained by using the pre-existing vendor selection process [31]. (Hadi, et al, (2017) proposes a structured and integrated decision model for evaluating sustainable vendors within the context of the telecommunications industry by combining the Analytical Hierarchy Process (AHP) and Enhanced Gray Relational Analysis (IGRA) approaches [10].

Stević et al, (2020), adopted a brand-new method of different measures and classification according to the compromise solution (MARCOS) for a sustainable selection of providers within the healthcare sector [11]. Leili et al, (2012) provides a good approach to the assessment and comparison of service quality in four hospitals. Service quality consists of a spread of attributes, many of which are intangible and difficult to measure. Ali et al, (2018) adopted the data envelopment analysis (DEA) and then using multi-attributed utility theory (MAUT) as a backup approach to repair errors, attempts to introduce the foremost important criteria and sub-criteria for choosing the most effective vendor of medical equipment among domestic and foreign vendors [28].

3. PROBLEM FORMULATION

Multi-criteria decision-making challenges are business as usual for the entire organization. The criteria and sub-criteria should be the most widely used and predominant for the selection of an appropriate vendor. Selecting the various selection criteria is a challenging task and includes selecting experts from contrasting industries. The important criteria and sub-criteria were selected on the basis of a literature review. A questionnaire based on these factors was developed for the survey. The questionnaire was distributed to various respondents and was selected at random from various industries. The criteria and sub-criteria for the selection of a suitable vendor were chosen based on the survey conducted. The purpose of this study is to recognize the important criteria and sub-criteria for the selection of vendors in various sectors. In this work, the four multi-criteria decision-making methods (MCDM) i.e., analytical AHP, VIKOR, TOPSIS and Fuzzy AHP are used for prioritization of alternatives. Identification

of sectors where multi-criteria decision making (MCDM) tools can be applied, such as Manufacturing sector, Pharmaceutical sector, Service sector and Health care sector. Sector wise prioritization of alternative criteria and their sub-criteria for the selection of vendors by using the four MCDM techniques.

Table 1. Criteria and Sub-criteria

Criteria	Sub- criteria
Quality (Q)	% of rejection (Q-1) Defects in process (Q-2) Customer complaint (Q-3)
Cost (C)	Product cost (C-1) Ordering cost (C-2) Transportation cost (C-3)
Service (S)	Urgent deliveries (S-1) Order size (S-2) Special request (S-3)
Technical Capability (TC)	Technical knowledge (TC-1) Experience (TC-2) Use of technology (TC-3)
On time delivery (OTD)	Lead time (OTD-1) Safety (OTD-2) Location (OTD-3)

Figure 1 includes four levels to select an appropriate vendor. Level 1 is the objective, which is to select the best vendor; Level 2 represents the five criteria of quality (Q), cost (C), service (S), technical capacity (TC), on-time delivery (OTD); Level 3 represents 15 sub-criteria.

According to the ratings provided in the questionnaire, a matrix is developed and criteria and sub-criteria are incorporated using the MCDM templates. Here are the steps to set up the template.

- Synthesis of priorities for the set of criteria and measurement of the consistency ratio (CR).
- Prioritization of criteria and sub-criteria for four sectors (manufacturing, pharmaceuticals, services and healthcare).
- Synthesis of overall priority matrix.

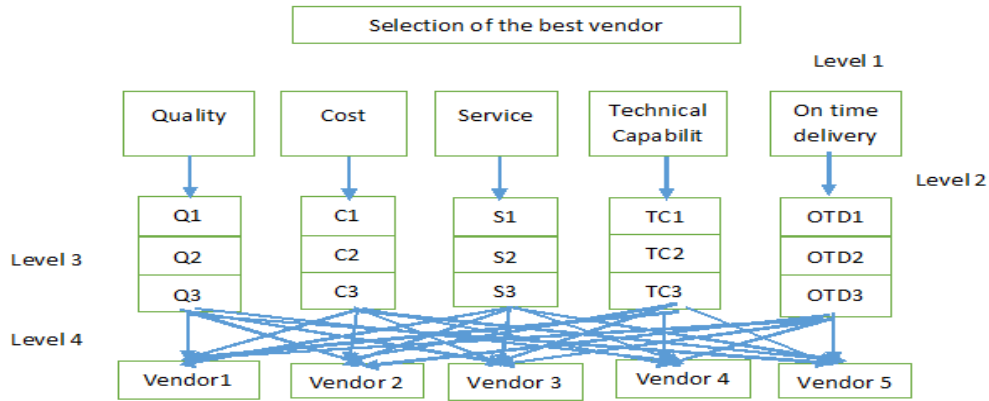


Fig 1: Proposed model for the selection of vendor

4. THE PROPOSED MODEL USING AHP, VIKOR, TOPSIS, FUZZY AHP

4.1. Analytical Hierarchy Process (AHP)

In the 1970s, Thomas Saaty developed the analytic hierarchy method. AHP is a highly outstanding management tool for complex multi-criteria decision problems and was developed as a methodology that can present flexible solution on qualitative and quantitative problems. Weighting of criteria by several experts to prevent bias in decision-making and impartiality of priority. In this study, the following steps of the AHP were used to help us measure the relative importance of the weighted values of a number of criteria.

1. Identify the problem and establish the criteria.
2. Structure the decision hierarchy in relation to the intensity of the decision.
3. Develop a comparison matrix in which the entire element is compared to itself using the baseline pair comparison scale.
4. Assign the reciprocal value in the respective position in the total number of matrix comparisons necessary to extend the matrix set in step 3.
5. The function of the phrases of the hierarchy is employed to the eigenvector by the weight of the criteria and the sum is taken on all weighted eigenvectors and therefore the entries equivalent to those of the following lower level of the hierarchy.
6. Once the pair comparison is complete, the consistency of the comparison is assessed using the eigen value, so as to calculate the consistency index.
7. The final consistency ratio (CR) is calculated as the ratio of the consistency (CI) to the random index (RI), as indicated- $CR = CI / RCI$

4.2. Multi-Criteria Optimization and Compromise Solution (VIKOR)

The VIKOR method has been developed for multi-criteria simulation of complex systems. When inconsistent parameters are present, this approach focuses on rating and choosing from a variety of alternatives. It displays the multi-criteria rating

index supported by the specific "proximity" measure to the "ideal" solution (Opricovic et al., 2004). The step-by-step approach is presented below:

Step 1. Decision Matrix Establishment: A team of evaluators, including the company's executives, formulates the decision matrix. On a scale of 1-5, the experts in the decision-making team will rate the characteristics of each alternative. The average of the expert's entire rating is employed to construct the assessment matrix.

Step 2. Normalization of the Decision Matrix: The different alternatives are denoted as x_i

$$r_{ij} = x_{ij} \sqrt{\sum_{i=1}^m x_{ij}^2} \quad i=1, 2, \dots, m \text{ and } j=1, 2, \dots, n.$$

Step 3. Evaluate attribute weights: In order to express their relative value, the weights of the attributes must be determined.

Step 4. Evaluate the best and worst values: The best value and the worst value for all the attribute functions, that is, for the attribute $j = 1-n$, we get equations:

$$f_j^* = \max f_{ij}, \quad i = 1, 2, \dots, m$$

$$f_j^- = \min f_{ij}, \quad i = 1, 2, \dots, m$$

Step 5. Measurement of the distance of alternatives to the optimal solution: This step is to calculate the distance between the ideal positive solution and the ideal negative solution of each alternative.

$$s_i = \sum_{j=1}^m w_j \frac{(f_j^* - f_{ij})}{(f_j^* - f_j^-)}$$

$$R_j = \max_j \left[w_j \frac{(f_j^* - f_{ij})}{(f_j^* - f_j^-)} \right]$$

Step 6. Determine VIKOR values: VIKOR values Q_i for $i=1, 2, m$ is determined using the equation shown below.

$$Q_i = \frac{v(s_i - s^*)}{(s^- - s^*)} + (1 - v) \frac{(R_i - R^*)}{(R^- - R^*)}$$

Step 7. Rank the alternatives by Q_i values: We may rank the alternatives according to the Q_i values determined by step (4) and thus formulate the decision matrix [23].

4.3. Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)

Hwang and Yoon (1981) first described the technique of order preference by similarity as the ideal solution to multi-criteria decision-making problems. It is based on the theory that the shortest Euclidean distance in relation to the positive ideal solution (PIS) and the longest distance away from the negative ideal solution must be the preference of an alternative (NIS). The positive ideal is an ideal that maximizes profit specifications and minimizes cost criteria, while the negative ideal maximizes cost criteria and minimizes profit requirements. In the traditional TOPSIS approach, weightings and other ratings are known net values that are used in the valuation process. The algorithm for this method is outlined below.

Step 1: Development of the Decision Matrix (A)

At the primary level, the TOPSIS (Technique for Order Preference by Similarity to the Ideal Solution) approach consists of computing the decision matrix A with attribute values and then constructing the standard decision matrix R based on matrix A. The matrix of R elements are calculated as.

$$f_{ij} = \frac{x_{ij}}{\sum_{i=1}^m x_{ij}^2}, i = 1, 2, \dots, m \ \& \ j = 1, 2, \dots, n$$

Step 2: Calculate the matrix of weighted decisions

Using the R normalized decision matrix and the weightings assigned to the parameters, the criteria weights decision matrix is derived.

Step 3: Compute the best ideal solution and the best negative solution. At the second stage, the ideal (fictitious best) solution S^+ and the negative-ideal (fictitious worst) solution S^- are determined, respectively, as follows -

$$S_i^+ = \sqrt{\sum_{j=1}^m (v_{ij} + v_j^*)^2}, f = 1, 2, \dots, m$$

$$S_i^- = \sqrt{\sum_{j=1}^m (v_{ij} - v_j^-)^2}, f = 1, 2, \dots, m$$

Step 4: Calculating the closeness index

The relative closeness of each alternative to the ideal solution is computed as shown below.

$$RC_i^* = \frac{S_i^-}{S_i^+ + S_i^-}, i = 1, 2, \dots, m$$

4.4. Fuzzy Analytic Hierarchy Process (F-AHP)

Fuzzy Analytic Hierarchy Process (F-AHP) embeds the fuzzy theory (FT) to basic Analytic Hierarchy Process (AHP). It is the most promising decision tool for the multi-criteria decision-making conditions. It basically compares pair wisely the different alternatives on the behalf of diverse criteria and sub-criteria which gives a decision aid tool for MCDM problems. In order to hierarchal representation target is at the first level, criteria and sub-criteria at second & third level and alternatives at the fourth level respectively. In F-AHP, pairwise comparisons between the two criteria and alternatives are made using variables, which are represented by triangular numbers [35]. VanLaarhoven and Pedrycz were responsible for one of the first fuzzy AHP applications [27]. They defined triangular matrix functions for pair comparisons. Buckley later contributed to the topic by identifying fuzzy priorities for comparison ratios with triangular belonging functions. A new methodology concerned the use of triangular

numbers in pair comparisons. Although there are other techniques integrated into F-AHP, in which methods are implemented to determine the relative weights of criteria and alternatives. The major steps for this method are:

Step 1: Decision Maker compares the criteria or alternatives via linguistic terms shown in the table.

Step 2: If more than one decision maker exists, each decision maker's preferences (d_{ijk}) are aggregated and (\tilde{d}_{ij}) are determined as shown below-

$$\tilde{d}_{ij} = \frac{\sum_{k=1}^k \tilde{d}_{ijk}}{k}$$

Step 3: In order to comply with average preferences, the pair wise contribution matrix is modified, as shown below.

$$A \sim = \begin{bmatrix} \tilde{d}_{11} & \dots & \tilde{d}_{1n} \\ \vdots & \ddots & \vdots \\ \tilde{d}_{n1} & \dots & \tilde{d}_{nn} \end{bmatrix}$$

Step 4: The standard deviation of the fuzzy comparison values of each criterion is calculated and the triangular values are also represented by $r_i \sim$.

$$r_i \sim = (\prod_{j=1}^n \tilde{d}_{ij})^{1/n}, i=1, 2, \dots, n$$

Step 5: To find the fuzzy weights of each criterion, by combining the next three sub-steps.

Step 5a: Find the summation of each $r_i \sim$ vector.

Step 5b: Locate the summation vector (-1) power. To make it in an increasing order, substitute the fuzzy triangular number.

Step 5c: multiply each $r_i \sim$ with this reverse vector to find the fuzzy weight of the criterion.

Table 2: Shows linguistic terms to make fuzzy matrix [12]

Saaty Scale	Definition	Fuzzy Triangular Scale
1	Equally important (Eq. Imp.)	(1,1,1)
3	Weakly Important (W. Imp.)	(2,3,4)
5	Fairly important (F. Imp.)	(4,5,6)
7	Strongly important (S. Imp.)	(6,7,8)
9	Absolutely important (A. Imp.)	(9,9,9)
2	The intermittent values between two adjacent scales	(1,2,3)
4		(3,4,5)
6		(5,6,7)
8		(7,8,9)

$$r_i \sim = r_i \sim \otimes (r_i \sim \oplus r_i \sim \oplus \dots \oplus r_n \sim)^{-1} \\ = (lw_t, mw_t, uw_t)$$

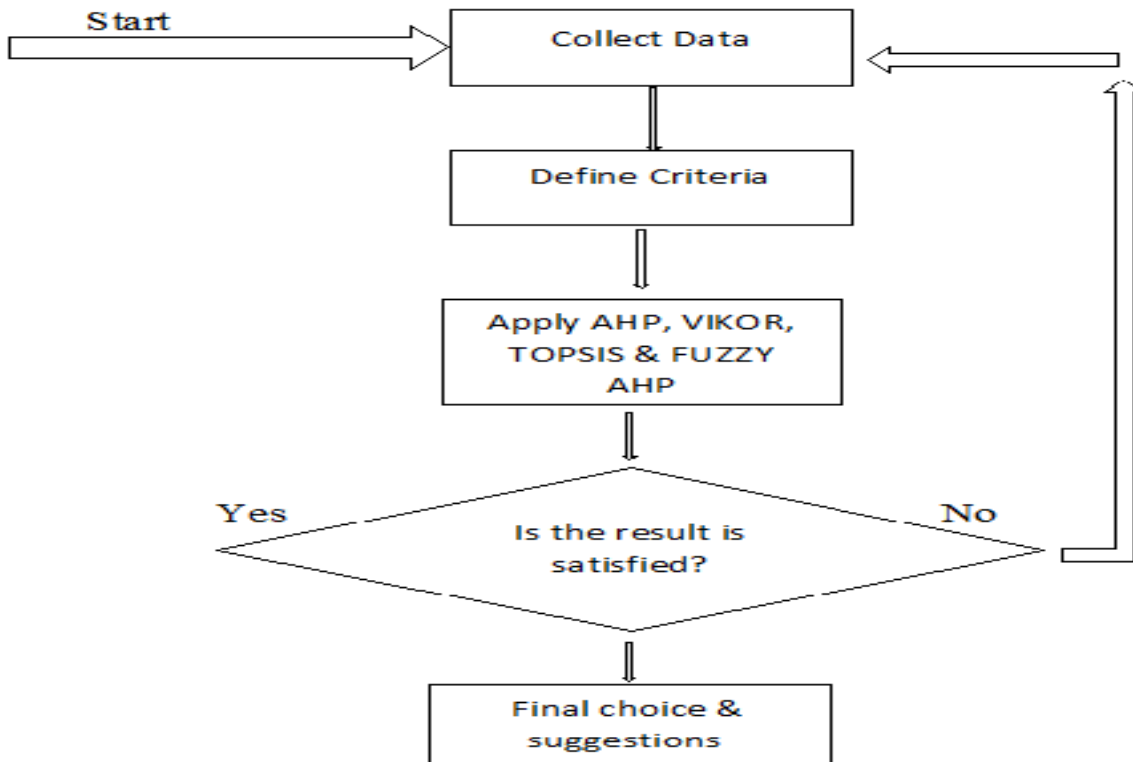


Fig 2: Represents the illustrative diagram of the proposed model of the research

Step 6: Since \tilde{w}_l are still fuzzy triangular numbers, the technique recommended by Chou and Chang [20] must be de-fuzzified by Centre of arc method [20] by applying equation 6.

$$M_i = \frac{(lw_t + mw_t + uw_i)}{3}$$

Step 7: M_i is a number which is non-fuzzy.

$$N_i = \frac{M_i}{\sum_{i=1}^n M_i}$$

5. IMPLEMENTING THE METHODOLOGY: AN DESCRIPTIVE PROBLEM

Data and sampling

The real data sets are segregated from the different sectors. The sectors have to choose the best vendor with respect to five criteria such as quality, cost, service, technical capability and on time delivery on the basis of four main sectors such as manufacturing sector, pharmaceutical sector, service sector and healthcare sector. In order to investigate the criteria, the sectors of the identical topics are simulated with each other having AHP measurement scale. A schematic diagram is represented in a hierarchal categorization in figure: 4.

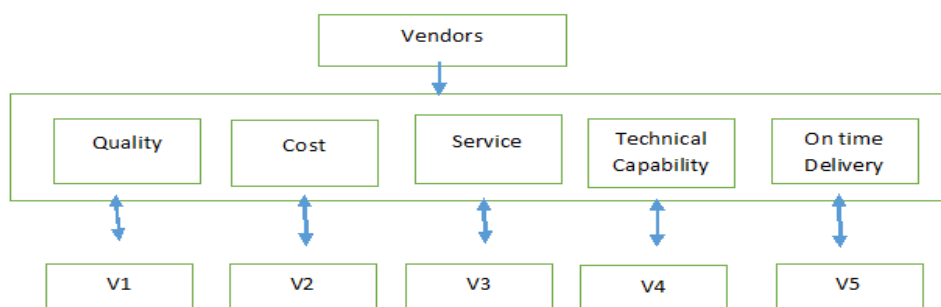


Fig 3: Represents the hierarchy of the problem

Manufacturing Sector

- Calculation with respect to AHP method

Table 3: Pair-wise comparison of matrix

Criteria	Quality	Cost	Service	Tech Capability	Delivery
Quality	1	3	5	7	5
Cost	1/3	1	6	3	2
Service	1/5	1/6	1	1/3	1/3
TC	1/7	1/3	3	1	1/3
Delivery	1/5	1/2	3	3	1
Total	1.8762	5	18	14.3333	8.6667

Table 4: Normalized matrix of criteria

Criteria	Quality	Cost	Service	Tech. C	On time d	Row avg	Weight
Quality	0.533	0.6	0.2778	0.4884	0.5769	0.49522	49.52
Cost	0.1777	0.2	0.3333	0.2093	0.2308	0.23022	23.02
Service	0.1066	0.0333	0.0556	0.0232	0.0385	0.05144	5.14
TC	0.0761	0.0667	0.1667	0.0698	0.0385	0.08356	8.35
Delivery	0.1066	0.1	0.1667	0.2093	0.1154	0.1396	13.96
Total	1	1	1	1	1	1	100

Table 5: Comparison of quality sub-criteria 1 on a pair-wise scale

Criteria	Quality	Cost	Service	Tech C	On time d	Row avg	Weight	∫ max
Quality	0.533	0.6	0.2778	0.4884	0.5769	0.49522	49.52	5.5043
Cost	0.1777	0.2	0.3333	0.2093	0.2308	0.23022	23.02	5.3591
Service	0.1066	0.0333	0.0556	0.0232	0.0385	0.05144	5.14	5.1171
TC	0.0761	0.0667	0.1667	0.0698	0.0385	0.08356	8.35	5.1696
Delivery	0.1066	0.1	0.1667	0.2093	0.1154	0.1396	13.96	5.4351
Total	1	1	1	1	1	1	100	
								∫ max = 5.5043

No of comparisons	5
Average Consistency (∫ Max)	5.317
Consistency Index (CI)	0.0793
Randomly Generated Consistency Index (RI)	1.12
Consistency Ratio (CR)	0.0708
Consistent	Yes

Since the consistency ratio (CR) values is less than 0.1, then the pair-wise comparison matrix is consistence & Judgements is true.

Table 6: Sub-criteria quality pairwise comparison matrix

Sub-criteria	% of Rejection	Defects in Process	Customer Complaints
% of Rejection	1	3	9
Defects in Process	1/3	1	6
Customer Complaints	1/9	1/6	1
Total	1.4444	4.1667	16

Table 7: Sub-criteria quality pair –wise comparison matrix normalized

Sub-criteria	% of Rejection	Defects in Process	Customer Complaints	Sum	Wi
% of Rejection	0.6923	0.7179	0.5625	1.9727	0.6586
Defects in Process	0.2307	0.2399	0.375	0.8456	0.2816
Customer Complaints	0.0769	0.0399	0.0625	0.1793	0.0597

Table 8: represents the criteria and their gross weights

Issues	Relative Weight	Sub-criteria	Relative wt of sub-criteria	Global Weight
Quality	0.6427	Q1	0.6586	0.4232
		Q2	0.2816	0.1809
		Q3	0.0597	0.0383
Cost	0.101	C1	0.5438	0.0549
		C2	0.1412	0.0142
		C3	0.2657	0.0268
Service	0.2082	S1	0.7482	0.1557
		S2	0.1803	0.0375
		S3	0.0714	0.0148
TC	0.0479	TC1	0.6333	0.0303
		TC2	0.2604	0.0124
		TC3	0.1061	0.005
Delivery	0.2567	D1	0.0364	0.0093
		D2	0.5354	0.1374
		D3	0.1287	0.0334

Table 9: Rank by ahp method

S.No.	Criteria	Priorities	Rank
1	Quality	0.6426	I
2	Cost	0.2237	II
3	Service	0.208	III
4	Technical Capability	0.0477	V
5	On time delivery	0.1801	IV

- Calculation with respect to VIKOR method

Table 10: Normalized matrix of criteria

	Beneficial	Beneficial	Non-Beneficial	Beneficial	Non-Beneficial
Weightage	0.276	0.276	0.16	0.16	0.1
Criteria	Quality	Cost	Service	Tech C	On time d
Quality	0.1866	0.5572	0.3102	0.275	0.2878
Cost	0.1354	0.0078	0.225	0.255	0.6214
Service	0.1563	0.5502	0.2599	0.532	0.2126
Tech C	0.1611	0.0103	0.4166	0.1577	0.1059
On time d	0.0944	0.0121	0.2441	0.2126	0.369

Table 11: Rank by vikor method

Criteria	Qi	Rank
Quality	0.9951	I
Cost	0.8022	II
Service	0.7132	III
Tech C	0.0484	V
On time d	0.4503	IV

- Calculation with respect to TOPSIS method

Table 12: Euclidean distance

Criteria	Quality	Cost	Service	Technical Capability	On Time Delivery	E+	E-
Quality	0.101	0.066	0.039	0.037	0.033	0.077	0.108
Cost	0.122	0.079	0.032	0.025	0.043	0.057	0.132
Service	0.081	0.059	0.024	0.029	0.03	0.104	0.082
Tech C	0.142	0.093	0.059	0.039	0.055	0.02	0.169
On time d	0.02	0.026	0.015	0.012	0.037	0.176	0.026
Vi+	0.162	0.093	0.059	0.042	0.058		
Vj-	0.02	0.019	0.012	0.012	0.017		

Table 13: Rank by topsis method

Criteria	H+	Rank
Quality	0.583	III
Cost	0.698	II
Service	0.441	IV
TC	0.894	I
OTD	0.128	V

- Calculation with respect to FAHP method

Table 14: Geometric means of fuzzy comparison values

Criteria	Ri			wi
Quality	0.2911	0.4024	0.5495	0.39821
Cost	0.1702	0.2448	0.3433	0.24288
Service	0.0935	0.1371	0.2053	0.13965
TC	0.0935	0.1371	0.2053	0.13965
Delivery	0.0571	0.0787	0.1128	0.07958

Table 15: Rank by f-AHP method

Criteria	Scores	Rank
Quality	1.849	I
Cost	1.83	IV
Service	1.47	V
TC	1.577	III
Delivery	1.579	II

Table 16: Comparison of rank for Manufacturing Sector

Criteria	Rank			
	Methods			
	AHP	VIKOR	TOPSIS	Fuzzy AHP
Quality	I	I	III	I
Cost	II	II	II	IV
Service	III	III	IV	V
TC	V	V	I	III
Delivery	IV	IV	V	II

The same procedure is carried out in other sectors respectively, the comparison of methods and ranking is calculated on the basis of the priorities criteria. Later used in this research.

6. RESULT & DISCUSSION

The detailed factor analysis is carried out with the applications of MCDM techniques to obtain the most precise results. The criteria and sub-criteria are assessed separately to generate the global rankings. The values are not accurate but

approximately calculated to get the prescribed rankings. The most widely used MCDM tools that are used - AHP, VIKOR, TOPSIS and FUZZY AHP. The main purpose is to compare the four methods to obtain more precise classifications with respect to the priorities criteria. Here, if in the case different classifications obtained from the methods having the common values are considered the best. The methods are solved and the overall classification is presented in the relevant tables below.

Table 17: Sector wise method priorities

Alternatives method priorities	Sectors A – Manufacturing Sector			
	Method Used			
	AHP	VIKOR	TOPSIS	F-AHP
AHP	IV	IV	I	III
VIKOR	II	II	IV	IV
TOPSIS	III	III	II	II
F-AHP	I	I	III	I

Alternatives method priorities	Sectors B – Pharmaceutical Sector			
	Method Used			
	AHP	VIKOR	TOPSIS	F-AHP
AHP	IV	I	IV	IV
VIKOR	III	III	I	I
TOPSIS	II	IV	II	II
F-AHP	I	II	III	III

Alternatives method priorities	Sectors C – Service Sector			
	Method Used			
	AHP	VIKOR	TOPSIS	F-AHP
AHP	I	I	III	IV
VIKOR	IV	IV	I	II
TOPSIS	III	III	IV	III
F-AHP	II	II	II	I

Alternatives method priorities	Sectors D – Healthcare Sector			
	Method Used			
	AHP	VIKOR	TOPSIS	F-AHP
AHP	II	II	II	IV
VIKOR	III	III	III	II
TOPSIS	I	I	IV	I
F-AHP	IV	IV	I	III

Here it is concluded that vendor selection by AHP, VIKOR are best fitted to prescribed values whereas, TOPSIS and FUZZY AHP is found to be inappropriate because of inconsistency in rankings. The model enables and helps businesses understand their current level of performance on their strengths and performance and competition during a much more durable way. Future work will end in the event of a sustainable evaluation tool for a range of sectors.

7. CONCLUSION

In this research AHP-VIKOR model is more effective compared with TOPSIS & FUZZY AHP model for choosing a vendor with priorities criteria within the supply chain. The models developed try and suggest how the MCDM models are relevant to vendor selection. The target of this research was to priorities criteria and sub-criteria that will support the choice of vendors in various areas of the provision chain. Vendors

help to build a robust business reputation for the organization. The choice of vendors depends upon qualitative and quantitative criteria. In case of future research as described above various models (for.eg.) Fuzzy VIKOR, Fuzzy TOPSIS, Fuzzy ANP or ELECTRE may be utilized to the identical problems and the resulting output may be juxtaposition with an existing hybrid model which harmonize the neuter methodology in absorbing the strong side of performances to rectify the problem. The result shows that the model has the aptitude to be flexible and apply in numerous sectors for selection of an appropriate vendors. Furthermore, hybrid models combining the various methodologies integrate the strong sides to develop this problem.

8. REFERENCES

- [1] Shaniana, A, and O, Savadogo, "TOPSIS multiple-criteria decision support analysis for material selection of metallic bipolar plates for polymer electrolyte fuel cell", *Journal of Power Sources*, 159 (2006), pp. 1095–1104.
- [2] Abylaev, M., Pal, R. and Torstensson, H. (2014) 'Resilience challenges for textile enterprises in a transitional economy and regional trade perspective – a study of Kyrgyz conditions', *Int. J. Supply Chain and Operations Resilience*, Vol. 1, No. 1, pp.54–75.
- [3] Afkham, L., Abdi, F., & Rashidi, A. (2012). Evaluation of service quality by using fuzzy MCDM: A case study in Iranian health-care centers. *Management Science Letters*, 2(1), 291–300. <https://doi.org/10.5267/j.msl.2011.08.009>.
- [4] Gupta, A, P. C. T. & R. K. G. (2013). Evaluation and selection of inventory policies by mcdm-matrix method-a case study for passenger vehicles for manufacturing industry in india. *International Journal of Research in Business Management (IJRBM)*, 1(2), 1–10. Retrieved from <http://www.impactjournals.us/journals.php?type=2&id=78>.
- [5] Jayant, A, Rajhans kumar, (2017). Development of decision support system for vendor selection using Ahp-Vikor based hybrid approach. *American Journal of Engineering Research*, Vol. 6, No.195-208.
- [6] Tas, Aysegul, (2012). A Fuzzy AHP approach for selecting a global vendor in pharmaceutical industry. *African Journal of Business Management*, 6(14). <https://doi.org/10.5897/ajbm11.2939>.
- [7] Ahmadi, B, H., Hashemi Petrudi, S. H., & Wang, X. (2017). Integrating sustainability into Vendor selection with analytical hierarchy process and improved grey relational analysis: a case of telecom industry. *International Journal of Advanced Manufacturing Technology*, 90(9–12), 2413–2427. <https://doi.org/10.1007/s00170-016-9518>.
- [8] Bansal, S., Chhimwal, M., & Jayant, A. (2015). A Comprehensive VIKOR and TOPSIS Method for Vendor selection in Supply Chain Management : A Case Study. 2(12), 8–13.
- [9] Barrios, M. A. O., De Felice, F., Negrete, K. P., Romero, B. A., Arenas, A. Y., & Petrillo, A. (2016). An AHP-topsis integrated model for selecting the most appropriate tomography equipment. *International Journal of Information Technology and Decision Making*, 15(4), 861–885. <https://doi.org/10.1142/S021962201640006X>.
- [10] Demir, A. (2019). A Benchmarking of Service Quality in Telecommunication Services: Case Study in Kurdistan Region of Iraq. *International Journal of Social Sciences & Educational Studies*, 5(3). <https://doi.org/10.23918/ijsses>.
- [11] Frej, E.A., L.R.P. Roselli, J. Araújo de Almeida, A. Teixeira de Almeida, A Multi-criteria Decision Model for Vendor selection in Food Industry Based on FITradeoff Method. *Center for Decision Systems and Information Development (CDSID)*, 19 October 2017.
- [12] Bottani, E., A Rizzi, An adapted multi-criteria approach to vendors and product selection - An application oriented to lead-time reduction. *International Journal of Production Economics*, 2008. 111: p. 763-781.
- [13] Forghani, A., Sadjadi, S. J., & Moghadam, B. F. (2018). A Vendor selection model in pharmaceutical supply chain using PCA, Z-TOPSIS and MILP: A case study. *PLoS ONE*, 13(8), 1–17. <https://doi.org/10.1371/journal.pone.0201604>.
- [14] Ganguly, A., Kumar, C., & Chatterjee, D. (2019). A Decision-making Model for Vendor selection in Indian Pharmaceutical Organizations. *Journal of Health Management*, 21(3), 351–371. <https://doi.org/10.1177/0972063419868552>.
- [15] Gupta, S., Soni, U., & Kumar, G. (2019). Green vendor selection using multi-criterion decision making under fuzzy environment: A case study in manufacturing industry. *Computers and Industrial Engineering*, 136(140), 663–680. <https://doi.org/10.1016/j.cie.2019.07.038>.
- [16] Gupta, A. K., Singh, O. P., & Garg, R. K. (2015). Analytic Network Process (ANP): An Approach for Vendor selection in an Automobile Organization. *European Journal of Advances in Engineering and Technology*, 2(9), 83–89.
- [17] Galankashi, M. R., Helmi, S. A., & Hashemzahi, P. (2016). Vendor selection in automobile industry: A mixed balanced scorecard-fuzzy AHP approach. *Alexandria Engineering Journal*, 55(1), 93–100. <https://doi.org/10.1016/j.aej.2016.01.005>.
- [18] Ghannadpour, S. F., Reza Hoseini, A., & Ahmadi, E. (2018). Selection of Sustainable Vendor for Medical Centers with Data Envelopment Analysis (DEA) & Multi-Attributed Utility Theory (MAUT) Approaches. *International Journal of Hospital Research*, 7(1), 82–96.
- [19] Ishtiaq, P., Khan, S. A., & Haq, M. U. (2018). A multi-criteria decision-making approach to rank vendor selection criteria for hospital waste management: A case from Pakistan. *Waste Management and Research*, 36(4), 386–394. <https://doi.org/10.1177/0734242X18755894>.
- [20] Jain, V., Sangaiah, A. K., Sakhujia, S., Thoduka, N., & Aggarwal, R. (2018). Vendor selection using fuzzy AHP and TOPSIS: a case study in the Indian manufacturing industry. *Neural Computing and Applications*, 29(7), 555–564. <https://doi.org/10.1007/s00521-016-2533>.
- [21] Jiang, P., Hu, Y. C., Yen, G. F., & Tsao, S. J. (2018). Green Vendor selection for sustainable development of the manufacturing industry using grey decision-making. *Sustainable Development*, 26(6), 890–903. <https://doi.org/10.1002/sd.1860>.

- [22] K.G., R., G.B., B., S., M., & M., C. (2016). An Empirical Study on Selection of Supply Chain Partner by Multi-Criteria Decision Making Method VIKOR - A Case of Manufacturing Industry. *International Journal of Engineering and Technology*, 8(6), 2997–3004. <https://doi.org/10.21817/ijet/2016/v8i6/160806263>.
- [23] Keramati, A., Ahmadizadeh-Tourzani, N., Nazari-Shirkouhi, S., Teshnizi, E. S., & Ashjari, B. (2014). A QFD-ANP methodology for vendor selection under perspective of requirements in manufacturing industry. *International Journal of Productivity and Quality Management*, 14(4), 492–517. <https://doi.org/10.1504/IJPMQ.2014.065560>.
- [24] Kubde, R. A. (2012). The Analytic Hierarchy Process Based Vendor selection Approach for Collaborative Planning Forecasting and Replenishment Systems. *International Journal of Engineering Research and Technology (IJERT)*, 1(7), 1–12.
- [25] Kirytopoulos, K., Leopoulos, V., & Voulgaridou, D. (2008). Vendor selection in pharmaceutical industry: An analytic network process approach. *Benchmarking*, 15(4), 494–516. <https://doi.org/10.1108/14635770810887267>.
- [26] Mohanty, S. (2015). Vendor Selection for Service Sector Industry: a Case Study on Vendor selection to Indian Telecom Service Provider using AHP Technique. 32–44.
- [27] Nadar, A. F., & Rani, R. M. (2020). Vendor selection using Fuzzy AHP and Fuzzy Vikor for XYZ Pharmaceutical Manufacturing Company. 7(1), 14–21.
- [28] Nag, K., & Helal, M. (2016). A Fuzzy TOPSIS approach in multi-criteria decision making for vendor selection in a pharmaceutical distributor. *IEEE International Conference on Industrial Engineering and Engineering Management*, 2016-December, 1126–1130. <https://doi.org/10.1109/IEEM.2016.7798053>.
- [29] Perçin, S. (2019). An integrated fuzzy SWARA and fuzzy AD approach for outsourcing provider selection. *Journal of Manufacturing Technology Management*, 30(2), 531–552. <https://doi.org/10.1108/JMTM-08-2018-0247>.
- [30] Pourghahreman, N., & Rajabzadeh Qhatari, A. (2015). Vendor selection in an agent based pharmaceutical supply chain: An application of TOPSIS and PROMETHEE II. *Uncertain Supply Chain Management*, 3(3), 231–240. <https://doi.org/10.5267/j.uscm.2015.4.001>.
- [31] Thiruchelvam, S, J.E. Tookey, Evolving Trends of Vendor selection Criteria and Methods. *International Journal of Manufacturing and Mechanical Engineering (IJAME)*, 2011. 4: p. 437-454.
- [32] Singh, B., Grover, S., & Singh, V. (2016). Integrated MCDM for Benchmarking Techniques in Indian Service Industries. *International Journal of Innovation and Technology Management*, 13(6), 1–18. <https://doi.org/10.1142/S0219877017500055>.
- [33] Stević, Ž., Pamučar, D., Puška, A., & Chatterjee, P. (2020). Sustainable Vendor selection in healthcare industries using a new MCDM method: Measurement of alternatives and ranking according to COMPROMISE solution (MARCOS). *Computers and Industrial Engineering*, 140, 106231. <https://doi.org/10.1016/j.cie.2019.106231>.
- [34] Stephen, G. F., Boluwaji, A., Olumide, O., & David, A. (2016). Decision support model for vendor selection in healthcare service delivery using analytical hierarchy process and artificial neural network. *African Journal of Business Management*, 10(9), 209–232.