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Evaluation and Selection of Supplier in A Healthcare Supply Chain using Analytic Hierarchy Process under Fuzzy Stochastic Environment

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ABSTRACT

Supplier selection process is one of the main key processes of the supply chain management. So, selection of a supplier has become an important issue for development of a proper supply chain system. The objective of supplier selection process is to minimize risk in purchasing, enhance overall profit of the customer, and build the long lasting and close relations between suppliers and buyers. Hence, it is important to follow a systematic procedure to evaluate and select a best supplier with the help of their respective criteria's in present competitive ambiance. Multi Criteria Decision Making (MCDM) methods can fulfill such need of the selection of best supplier as selection of supplier being MCDM problem.

Here, we have provided a case study for supplier selection using Analytical Hierarchy Process (AHP) one of the MCDM technique. The aim of this study was to evaluate the best supplier using fuzzy stochastic data. Judgment of decision makers were taken to rate the suppliers. Four suppliers being evaluated using AHP technique. To achieve this target, demand, quality, profit and service were considered as criteria's. Quality and service were considered as fuzzy variables while demand and profit were considered to be stochastic variables.

This method can be used when one have to select one particular supplier from number of suppliers in short period of time. It will be also helpful to the Pharmacists to select the best supplier who can fulfill all their needs. This study contributed on utility of crisp and fuzzy AHP methodology but also provided comprehensive literature review of MCDM problems. This study presented systematic way for selection of supplier using decision maker's judgment under fuzzy stochastic environment and it is limited to

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case study area. However this can be applied by interested researchers in their related interests considering other criteria's that suit their study area by taking experts opinions from their field.

1. Introduction

The objective of supplier selection process is to minimize risk in purchasing, enhance overall profit of the purchaser, and build the close and long term relationships between suppliers and buyers. Process of Supplier selection is key process of the Supply Chain Management (SCM). So, selection of a supplier has become an important issue for development of a proper supply chain system.

The main objective of SCM is to enrich the operational productivity, profitability and competitive positions of SCM partners (Bhosale and Umap 2020). Main challenge of any retailer is to balance both satisfaction of customer and profit. Finding out the best supplier that fulfills all the needs of retailer under different criteria makes overall benefits to retailer.

SCM and supplier selection have recently attracted a lot of attention in the business literature. To boost their management performance and competitiveness, several sellers strive to interact with their suppliers. As a result, once a provider becomes a member of a well-established supply chain, its influence on the overall supply chain's success. As a result, selecting a supplier has become a critical issue in the establishment of an effective supply chain system. The major purpose of the supplier selection process is to reduce purchase risk, increase total profit, and develop close, long-term relationships between the buyer and the supplier. (Monczka *et al*., 1998). Choosing a supplier can make the decision-making process easier by eliminating the need to choose from a list of available suppliers. For selection of a supplier, criteria can consider quantitative and qualitative dimensions as well. (Choi and Hartley, 1996; Dowlatshahi, 2000; Verma and Pullman, 1998; Weber *et al*., 1991, 1998). More than one decision-makers may be there in the decision process of supplier selection (Boer *et al*., 1998). Sumrit, D. (2020) gave comprehensive MCDM to select the best potential supplier for VMI collaboration in healthcare organization and revealed most evaluation criteria while selecting supplier. Serap Akcan (2019) provided different hybrid models for selecting the best supplier for hospitals. The results showed that the presented hybrid methods are consistent with each other and give the same ranking for the selection of the best supplier.

In general, it can be inferred that supplier selection incorporates a variety of criteria, numerous combinations of decision-making models, group decisions, and various levels of uncertainty. Finding the ideal technique to evaluate suppliers is tough, and the seller might utilize a variety of methods to do it.

The Analytic Hierarchy Process (AHP) is a process for categorizing complex decisions that utilizes psychology and math. It was developed in the 1970's by Thomas L. Saaty and has been used extensively since it's creation.

The process of assigning weights to each decision criteria uses individual's experiences, represented in pair wise comparisons, to come up with relative values. Note that while most of the surveys adopted five point Likert scale, AHP's questionnaire is 9 to 1 (Aktepe, Ersoz, 2011)

This approach is specifically helpful in group decision making contexts (Saaty, Peniwati 2008) such as government, business, industry, healthcare, shipbuilding and education (Salem *et al*. 2017).

Here, in this paper we have applied AHP to fuzzy stochastic data.

2. Crisp Analytic Hierarchy Process (Crisp-AHP)

The measure used in AHP is to construct a matrix which expresses the relative values of a set of attributes. The number assigned to each attribute corresponds to its size and relative importance, with more important attributes being larger than less important one (Yadav, Jayswal, 2013).

Table 1: Saaty's table for intensity of importance.

Scale	**Numerical Rating**	**Reciprocal**
Extremely preferred	9	1/9
Very strong to extremely	8	1/8
Very strongly preferred	7	1/7
Strongly to very strongly	6	1/6
Strongly preferred	5	1/5
Moderately to strongly	4	1/4
Moderately preferred	3	1/3
Equally to moderately	2	1/2
Equally preferred	1	1

Saaty's Scale of Relative Importance [Saaty 2005]

Intensity of Importance:

It is common to always use odd numbers from the table above to make sure that there is a reasonable distinction among the measurement points. The use of even numbers should only be adopted if there is a need for negotiation between the evaluators. When a natural consensus cannot be reached, it raises the need to determine a middle point as the negotiated solution (compromise) (Saaty 1980).

Basic assumption:

- A basic but very reasonable assumption is that if attribute A is absolutely more important than attribute B and is rated at 9, then B must be absolutely less important than A and is valued at 1/9.
- These pairwise comparisons are carried out for all factors to be considered, usually not more than 7, and the matrix is completed. The matrix is of a very particular form which neatly supports the calculations which then ensue.

Steps involved:

"Consider n elements to be compared $C_1, C_2, \ldots C_n$ and denote the relative weight (or priority or significance) of C_i with respect to C_j by a_{ij} and form a square matrix $A=(a_{ij})$ of order n with the constraints that,

$a_{ij} = \frac{1}{a_{ji}}$ for all $i \neq j$ and $a_{ii} = 1$ for all i.

Such a matrix is said to be a reciprocal matrix. The weights are consistent if they are transitive i.e.

$a_{ik} = a_{ij}a_{jk}$ for all i, j and k

Such a matrix might exist if the a_{ij} are calculated from exactly measured data. Then find a vector of order 'n' such that

$$Aw = \lambda w$$

For such a matrix, w is said to be an Eigen vector (of order n)".

Judgment (Saaty, 1980):

If the consistency ratio (CR) is much in excess of 0.1, the judgments are untrustworthy because they are too close for comfort of randomness and the exercise is valueless or must be repeated. It is easy to make a minimum number of judgments after which the rest can be calculated to enforce a perhaps unrealistically perfect consistency

Consistency ratio (CR) = $\frac{\lambda_{max} - n}{n-1}$

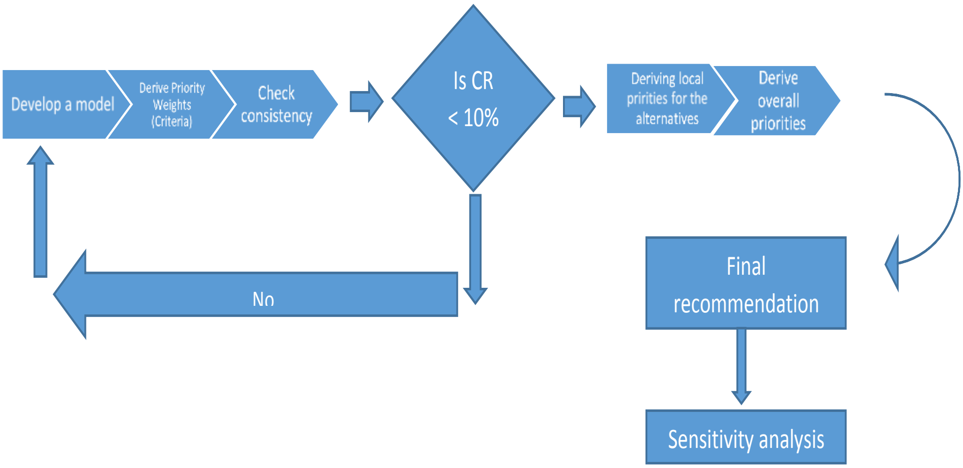
Consistency Index (CI) = $\frac{CR}{CI}$

Table 2: Consistency index table (Saaty 1980).

Sample size n	1	2	3	4	5	6	7	8
CI value	0	0	0.58	0.90	1.12	1.24	1.32	1.41

AHP is one of the main mathematical models currently available to support the decision theory (Vargas 2010).

Flow Diagram 1: Steps involved in AHP (Crisp data)



3. Fuzzy Analytic Hierarchy Process (Fuzzy-AHP)

AHP decision making tool developed by Saaty has found success in many different areas of human decision making, including ranking problems. AHP basically evaluates the most relevant criteria for various alternatives and presents a decision support system to solve MCDM problems. It does not consider personal evaluations and so, fuzzy logic was applied. Moreover, in decision making problems, some fuzzy coefficients/parameters may occur in an objective function. In order to handle this kind of coefficients or parameters, these quantities are represented by fuzzy numbers. With Fuzzy-AHP all pairwise comparisons are done through linguistic variables, which are represented by using triangular numbers (Kilincci, Onal, 2011).

Van Laarhoven and Pedrycz (1983) performed one of the first fuzzy AHP applications. They characterized the triangular membership function for the pair wise examinations. Buckley (1985) likewise added to the subject, by deciding fuzzy priorities of comparison ratios. Chang (1996) added another strategy related with deciding relative significance weights for both the alternatives and criteria.

Many difficulties which are being looked by supply chain experts can be tended to by growing new scientific instruments (Banaeian *et al.* 2018). (Galankashi *et al.* 2015) incorporated both classic and green key performance for selection of suppliers, they additionally positioned these actions utilizing well-qualified's viewpoint to make supplier selection structure explicit for electrical enterprises. (Galankashi *et al.* 2016) started a clever thought for the determination of supplier's selection in automobile industries when no. of criteria are more with respect to performance which could befuddle the decision makers. They addressed FAHP model by a study based information assortment which was filled by three specialists from scholarly and industry areas. As an administrative ramifications, the proposed approach is adaptable to be changed over to different methodologies by changing criteria or weight of points of view. (Khorramrouz *et al.* 2019) fostered a FAHP model to focus on the flaws of the sugar business. (Shaw *et al.* 2012) expressed supplier determination is an essential vital choice for long haul endurance of the firm. They introduced a coordinated methodology for choosing the best supplier in the production network, tending to the fossil fuel byproduct issue, utilizing fuzzy AHP and fuzzy multi-objective linear programming.

The results from this study used Buckley's methods (1985).

The steps of the procedure are as follows

Steps included

1. Decision maker compares the criteria's using linguistic terms as shown in table below
   Table 3:

Saaty scale	**Scale**	**Numerical Rating**	**Reciprocal**
9	Extremely preferred	(9,9,9)	(1/9,1/9,1/9)
7	Very strongly preferred	(6,7,8)	(1/8,1/7,1/6)
5	Strongly preferred	(4,5,6)	(1/6,1/5,1/4)

3	Moderately preferred	(2,3,4)	(1/4,1/3,1/2)
1	Equally preferred	(1,1,1)	(1,1,1)
2		(1,2,3)	(1/3,1/2,1)
4	The middle values between adjacent scales	(3,4,5)	(1/5,1/4,1/3)
6		(5,6,7)	1/7,1/6,1/5)
8		(7,8,9)	(1/9,1/8,1/7)

"The pairwise comparative matrix is shown in equation (1) where ${\tilde{d}_{ij}}^{k}$ shows the preference of k^{th} decision maker, for i^{th} criteria over j^{th} criteria using triangular fuzzy no. Here, demonstration of triangular number is shown by using 'tilde'.

Eg- ${\tilde{d}_{12}}^{1}$ is showing preference of 1^{st} decision maker for 1^{st} criteria over 2^{nd} criteria.

$$\tilde{A}_k = \begin{bmatrix} {\tilde{d}_{11}}^{k} & {\tilde{d}_{12}}^{k} & \dots & {\tilde{d}_{1n}}^{k} \\ {\tilde{d}_{21}}^{k} & {\tilde{d}_{22}}^{k} & \dots & {\tilde{d}_{2n}}^{k} \\ \cdots & \cdots & \dots & \cdots \\ {\tilde{d}_{n1}}^{k} & {\tilde{d}_{n1}}^{k} & \dots & {\tilde{d}_{nn}}^{k} \end{bmatrix} \tag{1}$$

2. If there are more than one decision makers, their preferences ${\tilde{d}_{ij}}^{k}$ are averaged to $\tilde{d}_{ij}$ which can be calculated as shown below:

$$\tilde{d}_{ij} = \frac{\sum_{k=1}^{K} {\tilde{d}_{ij}}^{k}}{K} \tag{2}$$

3. After doing averaged preferences, pairwise comparison matrix can be updated as shown below:

$$\tilde{A} = \begin{bmatrix} \tilde{d}_{11} & \tilde{d}_{12} & \cdots & \tilde{d}_{1n} \\ \tilde{d}_{21} & \tilde{d}_{22} & \cdots & \tilde{d}_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ \tilde{d}_{n1} & \tilde{d}_{n2} & \cdots & \tilde{d}_{nn} \end{bmatrix} \tag{3}$$

4. According to (Buckley, 1985) Geometric mean of fuzzy comparison values of each criterion is used to calculate weights. Fuzzy geometric mean value $\tilde{r}_i$ represents triangular values.

$$\tilde{r}_i = \left(\prod_{j=1}^{n} \tilde{d}_{ij}\right)^{1/n} \quad i = 1,2,\dots,n \tag{4}$$

Here the equation used to multiply two fuzzy no. is

5. The fuzzy weights for each criteria can be found by equation (5) using next 3 sub steps.
a. Find the vector summation of each $\tilde{r}_i$
b. Find inverse of summation vector. Replace the fuzzy triangular number, to make it in an increasing order.
c. To find the fuzzy weight of criterion i($\widetilde{w}_i$), multiply each $\tilde{r}_i$ with reverse order

Fuzzy weights for every criteria are calculated as

$$\widetilde{w}_i = \tilde{r}_i \otimes (\tilde{r}_1 \oplus \tilde{r}_2 \oplus \dots\dots \oplus \tilde{r}_n)^{-1}$$

$$= (lwi, mwi, uwi) \tag{5}$$

Using following formula, we can multiply all the fuzzy geometric mean values.

$$\tilde{A}_1 \otimes \tilde{A}_2 = (l_1, m_1, u_1) \otimes (l_2, m_2, u_2)$$
$$= (l_1 l_2, m_1 m_2, u_1 u_2)$$

Using following formula, we can add all the fuzzy geometric mean values.

$$\tilde{A}_1 \oplus \tilde{A}_2 = (l_1, m_1, u_1) \oplus (l_2, m_2, u_2)$$
$$= (l_1 + l_2, m_1 + m_2, u_1 + u_2)$$

For reciprocal of fuzzy no., we have the formula,

$$\tilde{A}^{-1} = (l, m, u)^{-1} = \left(\frac{1}{u}, \frac{1}{m}, \frac{1}{l}\right)$$

6. If we want weights to be in fuzzy then this four fuzzy no's can be used as a fuzzy weights for four criteria for further calculations or we can defuzzify this four fuzzy nos. to get crisp numerical values.
   Defuzzification can be done by using Centre of Area method proposed by (Chou, Chang, 2008)

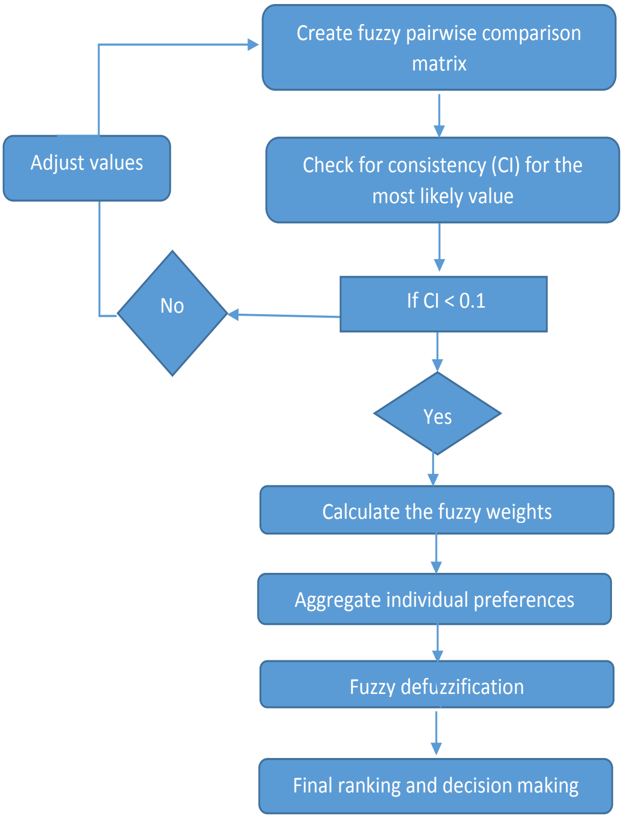
Centre of Area (COA) $w_i = \frac{(lw_i + mw_i + uw_i)}{3}$ (6)

7. M_i is non fuzzy number. But it needs to be normalized by using following equation.

$$N_i = \frac{M_i}{\sum_{i=1}^{n} M_i} \tag{7}$$

By performing above 7 steps, normalized weight of both criteria and alternatives are found. Then scores of each alternative are calculated by multiplying criteria with its relative weight. The alternative which scores maximum is recommended to decision maker".

Flow Diagram 2: Steps involved in Fuzzy AHP.



4. Hierarchy Process (Fuzzy Stochastic-AHP)

Since the publication of Zadeh's paper in 1965, fuzzy set theory has served as a powerful tool for facing imprecision that is not strictly stochastic. In fuzzy environments, it is assumed that some constraints are satisfied at least sometimes. Zadeh and Dubois and Prade (1965, 1987) introduced the possibility constraints which are very pertinent to real-world decision-making problems. Defuzzification is also needed to avoid dealing with fuzziness every time when you have chance constraints or random data.

(Awasthi *et al.* 2009) studied a model with single manufacturer/retailer, and model found that for individual manufacturers, hiring a large amount of suppliers could match their demand.

(Zhang, Zhang 2011) were studying how to figure out the best supplier for a company under stochastic demand, when they needed enough products, who would give them a good price.

(Hashemzahi *et al.* 2020) their automated algorithm models the relationships between variables and uses a mathematical approach to select suppliers according to environmental sustainability, least cost, and maximised customers' satisfaction. Like previous studies, this study also faced some limitations.

Here supplier selection was done fuzzy-stochastic environments. In Fuzzy-stochastic model, demand and profit were expressed as random variable with normal distribution and quality as well as service were assumed to be imprecise and vague. The fuzzy stochastic problem was first converted to an equivalent fuzzy problem and then to equivalent crisp problem and solved by using methodology in section 3 and 2 respectively.

Here we introduced the fuzzy and fuzzy random criteria in a real-world supplier evaluation and selection problem– i.e. fuzzy and fuzzy-stochastic environments. The constraints were taken in equality and inequality sense respectively in fuzzy and fuzzy stochastic environment. The demand was deterministic and profit depended on the demand. The quality and service were taken in fuzzy sense. The model was illustrated through numerical examples and results were presented.

Here evaluation and selection of supplier was done in stochastic fuzzy environment using AHP method. It helped to choose the supplier that best suits the Pharmacist's requirements.

This paper deal with some criteria in fuzzy environment and some criteria with stochastic environment. The purpose of this paper was to demonstrate the use of such type of constraints in a supplier selection problem.

Numerical Example

It's an obvious fact that it isn't enjoyable to change diapers. It's foul and in some cases chaotic. Expendable diapers assist guardians with limiting the pressure and battles of changing their children by keeping the cycle speedy. It is of one-time use. Dispensable diapers are intended to be discarded. That is their greatest selling point for most guardians. Rather than cleaning and wash a reusable diaper or depend on a diaper administration, you can simply wrap an expendable diaper up, put it in the diaper bucket, and quit mulling over everything. It's advantageous on the grounds that one you can throw out utilized diapers assuming they're in a rush. The washing system takes time, and putting away made a mess in reusable pants when you're it is muddled and chaotic to get things done. Dispensable diapers can move discarded and you can continue on with your day. It is possibly more sterile and travel friendly. There are plenty varieties of diaper brands available in the market. The pharmacist wants to select its supplier for baby diapers. To achieve this target, demand, quality, profit and service are considered as criteria's.

Flow Diagram 3: Hierarchy of Criteria and the alternatives.

Numerical Example of Fuzzy Stochastic Analytic Hierarchy Process (Fuzzy Stochastic-AHP):

We are considering quality and service as fuzzy variables.

Table 3: Fuzzy Pair wise comparison matrix.

	Quality	Service
Quality	(1,1,1)	(1.4706,1.5385,1.6667)
Service	(0.6,0.65,0.68	(1,1,1)

Using (Buckley, 1985), we have obtained Geometric mean of fuzzy comparison values of each criterion.

Table 4: Geometric mean of fuzzy comparison values of each criterion.

	Quality	Service	Fuzzy Geometric mean ri
Quality	(1,1,1)	(1.4706,1.5385,1.6667)	(1.21267813,1.24034735,1.290994)
Service	(0.6,0.65, 0.68	(1,1,1)	(0.77459667,0.80622577,0.824621)

Next the fuzzy weights for every criteria were calculated using eq. (5) then we had taken reciprocal of fuzzy number,

If we want weights to be in fuzzy, then below two fuzzy numbers can be used as fuzzy weights for two criteria further calculation. Or we can defuzzify these two fuzzy numbers to get crisp numerical values, defuzzification is done by using Centre of Area method.

Table 5:

	Fuzzy Geometric mean $\tilde{r}_i$	Fuzzy weight $\widetilde{w}_i$	Defuzzified weights M_i	Normalized weights N_i
Quality	(1.21267813,1.24034735, 1.290994)	(0.573203845,0.606061, 0.649631)	0.60963167	0.65527733
Service	(0.77459667,0.80622577, 0.824621)	(0.153239234,0.393939, 0.414951)	0.32070979	0.34472266

Sum	(1.987275,2.046573121, 2.115615574)
Reciprocal	(0.472676,0.488621682, 0.503201672)

After getting normalized non fuzzy relative weights, for each criterion, similar methodology was being followed to find respective values of criterion. It means, same procedure needs to be followed two more times. So, instead of explaining for it, their calculations and its outcome will be given as below:

Table 6: Normalized non fuzzy relative weights for each supplier for each criterion.

	Quality	Service
Supplier 1	0.270249	0.279151
Supplier 2	0.183502	0.188755
Supplier 3	0.287326	0.287711
Supplier 4	0.258922	0.244383

By using table 5 and 6 above individual scores obtained by each alternative for each criteria were as below:

Table 7: Individual scores obtained by suppliers.

Criteria	Normalized weights N_i	Supplier 1	Supplier 2	Supplier 3	Supplier 4
Quality	0.655277	0.17708825	0.12024477	0.188278	0.169666
Service	0.344723	0.09622974	0.06506819	0.099181	0.084244
	Sum	0.27331799	0.18531296	0.287459	0.25391
	Rank	2	4	1	3

Based on the results obtained, supplier 3 have scored maximum and approved as best supplier among all four with respect to four criteria’s and fuzzy preferences given by decision maker.

Now for stochastic environment

Consider, demand and profit as stochastic variables

Table 8: The pairwise comparison matrix.

Criteria	Demand	Profit
Demand	1	0.777670198
Profit	1.285892147	1
Sum	2.285892147	1.777670198

Divide each element of the matrix with sum of its column, to get normalized relative weight. Then normalized Eigen vector was obtained by taking average of rows.

Table 9: Calculation of Eigen vector.

Criteria	Demand	Profit	Eigen vector
Demand	0.437465959	0.437465959	0.437465959
Profit	0.562534041	0.562534041	0.562534041

The Eigen vector or the relative importance or value of demand, and profit is (0.437465959, 0.562534041). Thus profit was most valuable and demand was behind.

Check consistency (calculation of λ_{max}):

The next stage was to calculate λ_{max} so as to lead to the consistency index and consistency ratio.

Table 10: Calculation of λ_{max}.

Criteria	Demand	Profit
Eigen vector	0.437465959	0.612403101
Total sum	2.285892147	1.777670198

$\lambda_{max} = \sum_{i=1}^{2}\left(\prod_{i=1}^{2} Eigen\ vector * Total\ sum\right)$ = 2.088650741

Decision:

Consistency Index = $\frac{(\lambda_{max}-n)}{n-1}$ = 0. 088650741

Table 11: Random Consistency Index Table.

Sample size n	1	2	3	4	5	6	7	8
C. I. value	0	0	0.58	0.90	1.12	1.24	1.32	1.41

Random Consistency Index (C. I.) = 0 from table above

Consistency Ratio = $\frac{CI}{RI}$ = 0.088650741<0.1

Thus, Pharmacists subjective evaluation about his preference to criteria's was consistent.

Now, we will derive Eigen vectors for all alternatives using the same methodology

Table 12: Eigen vectors for all alternatives.

	Demand	Profit
Supplier 1	0.307067	0.237194
Supplier 2	0.21889	0.263037
Supplier 3	0.307067	0.263037
Supplier 4	0.181172	0.236733
Criteria weights	0.15592	0.119035

After multiplication of criteria weights with corresponding Eigen vectors for all alternatives and adding it we get overall priorities for all the suppliers.

Table 13: Calculation of overall priorities for all the suppliers.

	Demand	Profit	Overall Priorities	Rank
Supplier 1	0.134331195	0.133429552	0.267760747	2
Supplier 2	0.09575686	0.147967069	0.243723929	3
Supplier 3	0.134331195	0.147967069	0.282298264	1
Supplier 4	0.079256797	0.133170362	0.212427159	4

It shows that supplier 3 is better than supplier 1 followed by supplier 2 and supplier 4 is behind.

Now, we will combine the results obtained from table 7 and 13.

	Supplier 1	Supplier 2	Supplier 3	Supplier 4
Fuzzy	0.27331799	0.18531296	0.287459	0.25391
Stochastic	0.26776075	0.24372393	0.282298	0.212427
Average	0.27053937	0.21451844	0.284879	0.233169
Rank	2	4	1	3

Based on the results obtained, supplier 3 have scored maximum and approved as best supplier among all four with respect to four criteria's.

5. Sensitivity analysis

Sensitivity analysis to examine the robustness and stability of the ranking with respect to weights of the criteria was performed. It helped to validate how the priorities of the alternatives change as we vary the priority of a Criterion. For example if a service becomes much more important does the best choice of diapers change?

Weights				Ranking			
Fuzzy variables		**Stochastic variables**					
Quality	**Service**	**Demand**	**Profit**	**Supplier 1**	**Supplier 2**	**Supplier 3**	**Supplier 4**
0.7	0.3	0.7	0.3	0.279512	0.208606	0.29065	0.2262
0.3	0.7	0.7	0.3	0.281293	0.209657	0.290727	0.223293
0.7	0.3	0.3	0.7	0.265538	0.217435	0.281844	0.237313
0.6	0.4	0.6	0.4	0.276464	0.211076	0.288467	0.228252
0.4	0.6	0.6	0.4	0.277354	0.211601	0.288506	0.226798
0.6	0.4	0.4	0.6	0.269476	0.215491	0.284064	0.233808
0.5	0.5	0.5	0.5	0.273415	0.213546	0.286285	0.230303
Actual weights				0.270539	0.214518	0.284879	0.233169
				Rank 2	**Rank 4**	**Rank 1**	**Rank 3**

So by varying weight of fuzzy variables and stochastic variables rankings of the suppliers were obtained and we have found that for almost all varied values of weights of all criterion, we got supplier 3 at the position one followed by supplier 1 at position 2, supplier 4 at position 3 and supplier 2 at last position. Hence there was no effect on ranking of the suppliers even if the fuzzy and stochastic weights of variables changes.

6. Results

Selection of supplier is one of the most important tasks of pharmaceuticals in healthcare as most criteria's conflict each other, suppliers should be examined properly. Supplier selection comes under MCDM problem and it plays crucial role in supply chain management. Here, Analytic Hierarchy process technique was used and it was empowered with fuzzy stochastic data.

Quality and service were considered as fuzzy data. Final ranking obtained after applying fuzzy model was supplier 3 (0.287459)> supplier 1 (0.27331799)> supplier 4(0.25391)> supplier 2(0.18531296).

The demand and profit are considered to be stochastic data. And the final ranking obtained after applying stochastic model was supplier 3 (0.284879)> supplier 1 (0.2705393)> supplier 4(0.233169)> supplier 2(0.214518).

Combining the criteria's from both models and respective results together the priorities of all the suppliers were like supplier 3 (0.284879) was first, supplier 1 (0.27053937) was second, supplier 4 (0.233169) was third and supplier 2 (0.21451844) was forth using fuzzy stochastic AHP.

7. Conclusion

In present competitive ambiance, due to increased globalization, there are plenty of suppliers and variety of criterias to deal while choosing the best supplier out of them. Hence it is important to follow a systematic procedure to evaluate and select a best supplier with the help of their respective criteria's. Supplier selection process is one of the main key processes of the supply chain management. So, selection of a supplier has become an important issue for development of a proper supply chain system. The objective of supplier selection process is to minimize risk in purchasing, enhance overall profit of the customer, and build the long lasting and close relations between suppliers and buyers. Hence, Multi Criteria Decision Making methods can fulfill such need of the selection of best supplier as selection of supplier being MCDM problem.

In this paper, we presented methodology to rank the suppliers and also choosing of best supplier on the basis of four criteria's namely demand, quality, service and profit using AHP. Using the judgment of decision makers about the suppliers and by considering Quality and service are as fuzzy variables while demand and profit as stochastic variables suppliers were ranked.

In fuzzy stochastic AHP method, Supplier 3> Supplier 1> Supplier 4> Supplier 2 in the decreasing order of preference. The results of AHP framework is able to assist decision makers to examine the rankings of the suppliers as well as strength and weaknesses of suppliers. However, adequacy of assessment at the underlying levels relies upon the precision and the worth of the judgment given by them.

The proposed procedure can be used for choosing elective choices connected with creation arranging choices, item improvement process, order production, logistic management and site selection etc.

This method can be used when one have to select one particular supplier from number of suppliers in short period of time. It will be also helpful to the Pharmacists to select the best supplier who can fulfill all their needs. This study contributed on utility of crisp and fuzzy AHP methodology but also provided comprehensive literature review of MCDM problems. This study presented systematic way for selection of supplier using decision maker's judgment under fuzzy stochastic environment and it is limited to case study area. However this can be applied by interested researchers in their related interests considering other criteria's that suit their study area by taking experts opinions from their field.

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