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Modified Fuzzy DEMATEL Technique and its uses for Producing Supplier Selection Criteria

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ABSTRACT: To select the best supplier is one of the major tasks for industries in order to increase and improve their technology and advancement of manufacturing goods. In the present study, the fuzzy DEMATEL method is used to select the best influential criteria and to represent the rank wise criteria of supplier selection problem. The DEMATEL technique contains matrices and graphs for each complex causal relationship function. The main purpose of the study is to find out the best supplier criteria among the list of suppliers. And by applying Fuzzy DEMATEL technique, set up the ranking of all criteria, which is used to find out the most significant criteria. The results are shown in the casual relation diagram, the cause group can be easily separated from the evaluation criteria which are C1, C2, C3, C4, C5, C8, C11, C14 and the effect group includes C6, C7, C9, C10, C12, and C13. It can be concluded that the value (R+C) of each criteria shows the strength index of each influences received also it provides the degree of problem.
By applying this technique following conclusion comes: The criteria C6 have the greatest value of 9.553, shows the most significant criteria in the supply selection case study problem. The criteria C5 of value 2.123 is the largest positive value among all (R-C), shows the most influential criteria among all the factors. The most negative value among all (R-C) is C4 which is -2.348 shows the received value of most influence from other criteria.

Keywords: FDEMATEL (Fuzzy Decision Making Trial and Evaluation Laboratory), MCDM (Multi criteria decision making), SS (Supplier Selection), LCSC (Low Carbon Supply Chain), FLS (Fuzzy Linguistic Scale), TFN (Triangular Fuzzy Number).

I. INTRODUCTION

In the today's competitive environment, the target of every industry is to earn best profit margin with continuous customer expectations against good quality product with the short time delivery. Every industry adopts some new technology advancement in their system to maximize their business processes. To gain this kind of aim, experts and higher authority members have reached to the few conclusions: for every competitive industry, it is mandatory for them to work with the help of supply chain managers and supply partners to increase profit ratio and total performance ratio. The purchasing chain system and upstream chain system should be in their proper functioning with their industries partners. Most of the industries collectively apply their resources with their supply chain partnership and also involve a separate department of research and development. Higher authority experts and members are agreeing with the decision that selection of supplier in industry is one of the major important criteria of a logistics department, which can help them for saving of material cost and enhancement of their competitive advantage. Different suppliers are divided by their different characteristics such as higher body involvement, support and dedication, to fulfill the requirement of customer and suppliers, Major roles of government rules and regulations and support system, Effective information sharing system and technological aspects, Coordination, understanding and trust between the industrial members and partners, To buildup the reputation of industry in the market, Involvement of the environmental protection factors during manufacturing and business process, Awareness of supply chain management system to the suppliers, Expertise of industrial workers, customers and suppliers, Industry control over supplier selection criteria, Processes and Strategies developed by industry to implement low carbon process, Increment of the customer service system, Increment of the system speed and response, Economic profit control by the involvement of business process and methods [1]. Every supplier is as important as their value in the firm. Now it become very important to determine that which criteria should be applied so that the most appropriate approach can be selected, which can satisfy company strategy. The casual relationship between criteria's can support the decision developer to make their effective judgment. The fuzzy DEMATEL is the most effective technique which is used to measure the influence of each criteria on the given supplier selection problem. We have seen in most of the research that the supplier selection is totally based on either the type of industry or the techniques used. Due to the complexity of problem, many researchers can't find out the appropriate result. Most of the literature supports that DEMATEL is the best technique for supplier selection problem.

II. LITERATURE REVIEW

Selection of most appropriate supplier is a very complicated task for every industry for their decision making process. Many researchers and scientist has

been focus of the facts and figures getting from the analysis criteria and the performance parameter of each supplier [10]. From the starting of research, a number of literatures have been analyzed by the researchers to summarize the decision approach. Mangla *et al.,* (2018) explain about various types of costs, minimization of the cost of environmental and maximization of the supplier level. Also apply approach of fuzzy to exanimate supplier performance [30].

Chang *et al.,* (2011) explains that there are three important parameters like delivery, quality and performance [29]. Weber (1992) introduces some of the beneficial parameters as delivery, price, quality, capacity, facilities and technology [25]. Haouari *et al.*, (2007) suggested the most important critical barriers related to supply chain industry, these factors are directly related to supplier selection [2]. Bakir, *et al.,* (2018) determines the critical factors of the problem and establish the mutual relationship between them [27].

S. No.	Researcher	Applied Modeling Theory	Contributions
1.	Sankar *et al.,* (2016) [28]	Fuzzy DEMATEL	Solution of a decision making group problem in a fuzzy environment.
2.	Mangla *et al.,* (2018) [30]	Fuzzy DEMATEL and DELPHI	To improve the issues related to logistics such as service quality, on time delivery, reduction of cost, satisfaction of customer and quality benchmarking performance in supply chain.
3.	Chang *et al.,* (2011) [29]	Fuzzy DEMATEL	Analysis and forecasting of electronic industrial suppliers. The results getting from the research help the enterprises and precisely forecast on the basis of crucial factors.
4.	Garg *et al.,* (2014) [31]	Fuzzy DEMATEL	The research has implications for researchers and practitioners in better understanding of issues related to sustainable manufacturing.
5.	Luthra et al., (2015) [32]	Interpretive Structural Modeling (ISM)	Helping of the researchers/business practitioners/scholars for broadening of their research in this particular area and developing new hypothesis/theories.
6.	Fang *et al.,* (2019) [33]	fuzzy AHP, fuzzy DEA, fuzzy TOPSIS	Sustainable supply chain management practices are applied as a criterion to evaluate and examine suppliers on the basis of environmental, economic and social aspect.
7.	Phochanikorn *et al.,* (2019) [34]	fuzzy DEMATEL, fuzzy ANP	To decrease the gaps in all alternatives and reached to the best levels and also it is very useful for both suppliers and buyers to measure the all related factors for green supplier performance improvement.
8.	Ashish *et al.*, (2018) [35]	MOORA and COPRAS methods	This approach is very helpful for solving complex supplier selection problem with fewer calculations by defining the each step.
9.	Govindan *et al.,* (2019) [36]	Fuzzy ANP, fuzzy DEMATEL, (MOMILP) Multi objective mixed-integer linear programming	In this research suppliers were examined with the help of three criteria such as quality, circularity and on time delivery by using integrated approach of fuzzy ANP and Fuzzy DEMATEL, then finally four suppliers were selected.

III. FUZZY DEMATEL

This technique DEMATEL (Decision Making Trial and Evaluation Laboratory) was generated by the program of science and human affairs of BM institute (Battelle Memorial) in Geneva in 1973 [23]. It was firstly experimented and used as intertwined and complicated groups by Gabus and Fontela in 1975 [3]. DEMATEL is one of the best techniques in MCDM (multi criteria decision making) framework. It is also useful to convert various design analytics into quantitative analysis [4], [17]. To find out the exact result and to form the problem structure of complex problematique, DEMATEL is very useful. The primary function of DEMATEL method is to establish the relationship between variables, criteria and causal dimensions, which is useful to understand the structure model of system [5], [26]. Finally the cause and effect relation between functions can be measured. DEMATEL method can effectively represents and formulate the individual map and diagram which is useful to justify the right decision of the respondent [6].
The cause and effect relation between the criteria and variables can be clearly seen by the respondent.

In the present scenario, crisp logical values are inadequate. There are many evaluation criteria techniques are available, in which mostly gives imperfect and uncertain results [7], [18]. The human judgmental effort about preferences is also uncertain and unclear and very difficult to obtain the exact numerical values. DEMATEL method can analyze group values of the processing functions. In case of real life situations, the decisions of human judgment with the outcomes are very difficult to obtain [8], [19]. Thus fuzzy based applied theory is clubbed with the DEMATEL is used to solve complex MCDM problems. As many researchers, Chen (2011) have optimized the human judgments about the outcomes are very uncertain, unclear and difficult to establish by their complex values [12].
The steps includes in DEMATEL techniques are discussed as:
Step 1: To find out the decision objective and form an examination committee.
The decision making process includes the analysis of decision objective, collection of relevant information's,

establish the most possible range of the criteria variables alternatives, examination of the variables alternatives for their advantages and disadvantages, selection of the best alternatives, finally analyze that how many decision objectives are achieved [9, 20]. In the present paper fuzzy DEMATEL technique is employed to analyze the supplier selection variables criteria [21].

Step 2: To make examination linguistic criteria and to design a scale of fuzzy linguistic system [22].

Generate the examination and examination factors with suggestion getting from experts committee and proper evaluation of the various literatures [11]. On the basis of the literature survey and expert committee suggestions, 14 criteria were determined. These supplier criteria's with their specific codes are present in Table 2.

Table 1: Supplier selection criteria with codes.

S. No.	Criteria	Code symbol
1	Higher body involvement, support and dedication	C1
2	To fulfill the requirement of customer and suppliers	C2
3	Major roles of government rules and regulations and support system	C3
4	Effective information sharing system and technological aspects	C4
5	Coordination, understanding and trust between the industrial members and partners	C5
6	To buildup the reputation of industry in the market	C6
7	Involvement of the environmental protection factors during manufacturing and business process	C7
8	Awareness of supply chain management system to the suppliers	C8
9	Expertise of industrial workers, customers and suppliers	C9
10	Industry control over supplier selection criteria	C10
11	Processes and Strategies developed by industry to implement low carbon process	C11
12	Increment of the customer service system	C12
13	Increment of the system speed and response	C13
14	Economic profit control by the involvement of business process and methods	C14

Set up the linguistic values of variables and also define its terms set intervals. The linguistic set variable is the one whose values are set of words, which defines the problem effectively [14]. According to this linguistic term variable, the present study elaborates each and every human logic variables. For example : No Change, Very Small Change, Small Change, Big Change, Very Big Change and it shows TFN (triangular fuzzy number) in Table 3. The TFN number represent in Fig. 1.

Table 2: The linguistic scale with their specific values.

Linguistic Terms	Numbers
No Change	(0, 0.11, 0.33)
Very Small Change	(0.11, 0.33, 0.55)
Small Change	(0.33, 0.55, 0.77)
Big Change	(0.55, 0.77, 0.99)
Very Big Change	(0.77, 0.99, 1)

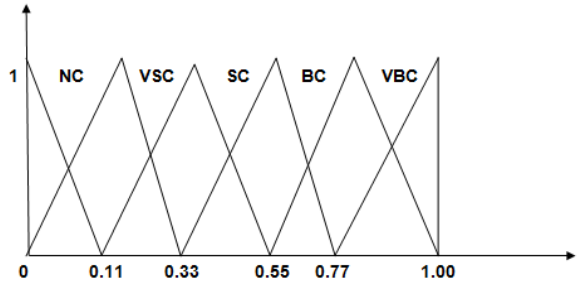

Fig. 1. TFN (Fuzzy triangular number for scale of linguistic variable).

Step 3: Generate the direct relation matrix by average method of the decision makers [13].

In this step, pair wise comparison of influence and decision makers is maintained with the suggestions getting from the experts. The criteria matrix $\bar{Y}$ is established in which $b_{ij} = (l_{ij}, m_{ij}, u_{ij})$, it represents the matrix degree for which variable I affects variable j for experts [24]. For establishing the relationship between the criteria, groups of experts committee were asked to form a comparative pair wise in terms of linguistic scale.

$$\bar{Y} = \frac{\bar{Y}_1 + \bar{Y}_2 + \ldots\ldots + \bar{Y}_t}{t}$$

Where $\bar{Y}$ is the direct relation fuzzy matrix. The simplified form of matrix $\bar{Y}$ is denoted as:

$$\bar{Y} = \begin{matrix} C1 \\ C2 \\ C3 \\ .. \\ C14 \end{matrix} \begin{pmatrix} 0 & \bar{Y}_{12} \ldots\ldots & \bar{Y}_{1n} \\ \bar{Y}_{21} & 0 \ldots\ldots & \bar{Y}_{2n} \\ .. & .. \ .. \ .. \ .. \ .. & .. \\ .. & .. \ .. \ .. \ .. \ .. & .. \\ \bar{Y}_{n1} & \bar{Y}_{n2} \ldots\ldots & 0 \end{pmatrix}$$

In this study DEMATEL expert questionnaire were developed. It contains 10 set of questionnaires which target the supplier department of industry having a rich experience in their personal field and establish the relationship between the criteria's [15].

These set of questionnaires sent to each group decision makers and asked them to indicate their influences of each criteria. Measure the average values of all responses of experts and summarize the expert's opinion [16]. It will help us to setup the direct relation fuzzy matrix $\bar{Y}$ as represent in Table 4.

Table 3: Linguistic Scale variable matrix.

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}	C_{14}
C_1	NC	VSC	SC	VSC	VSC	BC	VBC	SC	SC	VBC	SC	BC	BC	SC
C_2	VSC	NC	VSC	NC	VSC	SC	BC	SC	BC	BC	VSC	BC	VBC	SC
C_3	VSC	NC	NC	VSC	VSC	SC	BC	NC	SC	BC	VSC	VBC	SC	VSC
C_4	VSC	VSC	SC	NC	NC	VBC	VBC	VSC	SC	VBC	BC	VBC	BC	SC
C_5	NC	SC	SC	VSC	NC	BC	VBC	SC	BC	VBC	SC	BC	BC	BC
C_6	SC	VSC	VSC	SC	SC	NC	VSC	VSC	SC	SC	NC	SC	VSC	VSC
C_7	SC	NC	NC	BC	VSC	VSC	NC	VSC	BC	SC	VSC	VSC	VSC	VSC
C_8	VSC	SC	VSC	NC	NC	VBC	BC	NC	BC	VBC	SC	VBC	VSC	SC
C_9	NC	SC	VSC	SC	NC	SC	SC	SC	NC	BC	NC	BC	VSC	VSC
C_{10}	SC	NC	NC	VSC	NC	VSC	VSC	NC	SC	NC	VSC	NC	SC	SC
C_{11}	VSC	SC	NC	SC	VSC	BC	BC	NC	VSC	BC	NC	BC	VSC	NC
C_{12}	SC	VSC	SC	VSC	NC	NC	NC	VSC	SC	VSC	VSC	NC	VSC	VSC
C_{13}	SC	SC	VSC	SC	VSC	SC	SC	NC	NC	BC	NC	BC	NC	NC
C_{14}	NC	NC	VSC	VSC	SC	BC	BC	VSC	SC	VBC	VSC	BC	SC	NC

Table 4: Fuzzy Direct Relation Matrix.

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}	C_{14}
C_1	.2008	.4777	.7667	.4777	.4777	.7596	.9296	.7667	.7667	.9296	.7667	.7596	.7596	.7667
C_2	.4777	.2008	.4777	.2008	.4777	.7667	.7596	.7667	.7596	.7596	.4777	.7596	.9296	.7667
C_3	.4777	.2008	.2008	.4777	.4777	.7667	.7596	.2008	.7667	.7596	.4777	.9296	.7667	.4777
C_4	.4777	.4777	.7667	.2008	.2008	.9296	.9296	.4777	.7667	.9296	.7596	.9296	.7596	.7667
C_5	.2008	.7667	.7667	.4777	.2008	.7596	.9296	.7667	.7596	.9296	.7667	.7596	.7596	.7596
C_6	.7667	.4777	.4777	.7667	.7667	.2008	.4777	.4777	.7667	.7667	.2008	.7667	.4777	.4777
C_7	.7667	.2008	.2008	.7596	.4777	.4777	.2008	.4777	.7596	.7667	.4777	.4777	.4777	.4777
C_8	.4777	.7667	.4777	.2008	.2008	.9296	.7596	.2008	.7596	.9296	.7667	.9296	.4777	.7667
C_9	.2008	.7667	.4777	.7667	.2008	.7667	.7667	.7667	.2008	.7596	.2008	.7596	.4777	.4777
C_{10}	.7667	.2008	.2008	.4777	.2008	.4777	.4777	.2008	.7667	.2008	.4777	.2008	.7667	.7667
C_{11}	.4777	.7667	.2008	.7667	.4777	.7596	.7596	.2008	.4777	.7596	.2008	.7596	.4777	.2008
C_{12}	.7667	.4777	.7667	.4777	.2008	.2008	.2008	.4777	.7667	.4777	.4777	.2008	.4777	.4777
C_{13}	.7667	.7667	.4777	.7667	.4777	.7667	.7667	.2008	.2008	.7596	.2008	.7596	.2008	.2008
C_{14}	.2008	.2008	.4777	.4777	.7667	.7596	.7596	.4777	.7667	.9296	.4777	.7596	.7667	.2008

Step 4: Generate Normalized direct relation fuzzy matrix. In this step, the normalized direct relation fuzzy matrix is generated by the help of DEMATEL method and the data getting from direct relation matrix. It can be calculated by using formula (3, 4).

$$bi = \sum_{j=1}^{n} \hat{Y} = \left(\sum_{j=1}^{n} lij, \sum_{j=1}^{n} mij, \sum_{j=1}^{n} uij \right) \quad \text{and} \quad d = \max_{1 \le i \le n} \sum_{j=1}^{n} uij \qquad (1)$$

$$\bar{O} = \begin{pmatrix} \bar{O}_{11} & \bar{O}_{12} & \ldots\ldots & \bar{O}_{24} \\ \bar{O}_{21} & \bar{O}_{22} & \ldots\ldots & \bar{O}_{24} \\ \ldots & \ldots & \ldots\ldots & \ldots \\ \bar{O}_{141} & \bar{O}_{142} & \ldots\ldots & \bar{O}_{156} \end{pmatrix} \quad \text{where } \bar{O}_{ij} = \frac{\hat{Y}_{ij}}{s} = \left[\frac{lij}{s}, \frac{mij}{s}, \frac{uij}{s} \right] \qquad (2)$$

Table 5: Normalized fuzzy relation matrix.

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}	C_{14}
C_1	0.0209	0.0497	0.0798	0.0497	0.0497	0.0791	0.0968	0.0798	0.0798	0.0968	0.0798	0.0791	0.0791	0.0798
C_2	0.0497	0.0209	0.0497	0.0209	0.0497	0.0798	0.0791	0.0798	0.0791	0.0791	0.0497	0.0791	0.0968	0.0798
C_3	0.0497	0.0209	0.0209	0.0497	0.0497	0.0798	0.0791	0.0209	0.0798	0.0791	0.0497	0.0968	0.0798	0.0497
C_4	0.0497	0.0497	0.0798	0.0209	0.0209	0.0968	0.0968	0.0497	0.0798	0.0968	0.0791	0.0968	0.0791	0.0798
C_5	0.0209	0.0798	0.0798	0.0497	0.0209	0.0791	0.0968	0.0798	0.0791	0.0968	0.0798	0.0791	0.0791	0.0791
C_6	0.0798	0.0497	0.0497	0.0798	0.0798	0.0209	0.0497	0.0497	0.0798	0.0798	0.0209	0.0798	0.0497	0.0497
C_7	0.0798	0.0209	0.0209	0.0791	0.0497	0.0497	0.0209	0.0497	0.0791	0.0798	0.0497	0.0497	0.0497	0.0497
C_8	0.0497	0.0798	0.0497	0.0209	0.0209	0.0968	0.0791	0.0209	0.0791	0.0968	0.0798	0.0968	0.0497	0.0798
C_9	0.0209	0.0798	0.0497	0.0798	0.0209	0.0798	0.0798	0.0798	0.0209	0.0791	0.0209	0.0791	0.0497	0.0497
C_{10}	0.0798	0.0209	0.0209	0.0497	0.0209	0.0497	0.0497	0.0209	0.0798	0.0209	0.0497	0.0209	0.0798	0.0798
C_{11}	0.0497	0.0798	0.0209	0.0798	0.0497	0.0791	0.0791	0.0209	0.0497	0.0791	0.0209	0.0791	0.0497	0.0209
C_{12}	0.0798	0.0497	0.0798	0.0497	0.0209	0.0209	0.0209	0.0497	0.0798	0.0497	0.0497	0.0209	0.0497	0.0497
C_{13}	0.0798	0.0798	0.0497	0.0798	0.0497	0.0798	0.0798	0.0209	0.0209	0.0791	0.0209	0.0791	0.0209	0.0209
C_{14}	0.0209	0.0209	0.0497	0.0497	0.0798	0.0791	0.0791	0.0497	0.0798	0.0968	0.0497	0.0791	0.0798	0.0209

Step 5: Calculate the Total relation matrix.
By using normalized direct relation matrix $\bar{O}$, the total relation fuzzy matrix can be calculated by using following formula.

$$\bar{T} = (I - X)^{-1}$$

$$\bar{T} = \lim_{r \to \infty} (\bar{O} + \bar{O}^2 + \cdots \ldots . \bar{O}^r) \qquad (3)$$

$$[l_{ij}] = Z_l * (I - X_l)^{-1}$$
$$[m_{ij}] = Z_m * (I - X_m)^{-1} \qquad (4)$$
$$[u_{ij}] = Z_u * (I - X_u)^{-1}$$

$$\bar{T} = \begin{matrix} t_{11} & t_{12} \ldots\ldots\ldots\ldots t_{1n} \\ t_{21} & t_{22} \ldots\ldots\ldots\ldots t_{2n} \\ \ldots & \ldots \ldots \ldots \ldots \ldots \\ \ldots & \ldots \ldots \ldots \ldots \ldots \\ t_{n1} & \ldots\ldots\ldots\ldots\ldots t_{nn} \end{matrix} \quad \text{and } t_{ij} = (l_{ij}, m_{ij}, u_{ij}) \qquad (5)$$

Table 6: Total relation fuzzy matrix.

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}	C_{14}
C_1	0.311	0.309	0.337	0.346	0.270	0.431	0.453	0.328	0.441	0.502	0.334	0.447	0.409	0.373
C_2	0.309	0.256	0.283	0.288	0.247	0.395	0.398	0.303	0.402	0.443	0.278	0.409	0.390	0.342
C_3	0.284	0.232	0.233	0.291	0.226	0.361	0.365	0.224	0.370	0.405	0.254	0.391	0.344	0.286
C_4	0.332	0.299	0.329	0.310	0.236	0.435	0.439	0.291	0.429	0.488	0.323	0.451	0.397	0.362
C_5	0.311	0.337	0.336	0.345	0.241	0.430	0.451	0.327	0.439	0.501	0.332	0.446	0.408	0.371
C_6	0.320	0.270	0.273	0.326	0.261	0.321	0.354	0.265	0.386	0.423	0.241	0.391	0.332	0.302
C_7	0.293	0.219	0.220	0.300	0.213	0.317	0.293	0.239	0.350	0.386	0.244	0.327	0.299	0.273
C_8	0.309	0.309	0.281	0.287	0.220	0.408	0.395	0.246	0.402	0.457	0.305	0.423	0.346	0.341
C_9	0.255	0.284	0.258	0.312	0.196	0.360	0.363	0.279	0.314	0.403	0.227	0.373	0.315	0.288
C_{10}	0.268	0.195	0.195	0.248	0.169	0.286	0.290	0.190	0.317	0.294	0.218	0.269	0.298	0.273
C_{11}	0.275	0.279	0.225	0.307	0.218	0.349	0.354	0.218	0.331	0.392	0.220	0.362	0.307	0.252
C_{12}	0.275	0.230	0.260	0.253	0.173	0.270	0.273	0.224	0.329	0.333	0.228	0.280	0.281	0.254
C_{13}	0.307	0.279	0.256	0.308	0.221	0.353	0.358	0.220	0.309	0.396	0.224	0.366	0.283	0.256
C_{14}	0.265	0.241	0.268	0.299	0.261	0.372	0.376	0.259	0.381	0.435	0.263	0.385	0.354	0.268

Step 6: Draw and design a causal relation diagram. Calculate the sum of row and column of total relation fuzzy matrix, which is denoted by symbols R and C. Calculate the value (R-C) and (R+C). The (R+C) is known as prominence and (R-C) is known as influence or relation. The prominence (R+C) represents the significance or cause of criteria in supply chain and (R-C) explains about the entire effect of the criteria.

The total relation matrix contains both indirect and direct effects. If the value (R-C) is positive, it belongs to a cause group and if the value (R-C) is negative, then the whole criteria represents the effect group. Draw the cause and effect mapping by using (R-C) and (R+C). The mapping of (R-C) and (R+C) represents the casual relationship between each criterion, which is useful to solve the above problem. It can also helpful to recognize the difference between cause and effect criteria.

Table 7: The scores of each criteria Implemented on Supplier with their related values.

CF Implementation on Supplier	R	C	R+C	R-C	Category
C_1	5.291	4.114	9.405	1.177	Cat. of Cause
C_2	4.743	3.739	8.482	1.004	Cat. of Cause
C_3	4.266	3.754	8.02	0.512	Cat. of Cause
C_4	5.121	4.22	9.341	0.901	Cat. of Cause
C_5	5.275	3.152	8.427	2.123	Cat. of Cause
C_6	4.465	5.088	9.553	-0.623	Cat. of Effect
C_7	3.973	5.162	9.135	-1.189	Cat. of Effect
C_8	4.729	3.613	8.342	1.116	Cat. of Cause
C_9	4.227	5.2	9.427	-0.973	Cat. of Effect
C_{10}	3.51	5.858	9.368	-2.348	Cat. of Effect
C_{11}	4.089	3.691	7.78	0.398	Cat. of Cause
C_{12}	3.663	5.32	8.983	-1.657	Cat. of Effect
C_{13}	4.136	4.763	8.899	-0.627	Cat. of Effect
C_{14}	4.427	4.241	8.668	0.186	Cat. o Cause

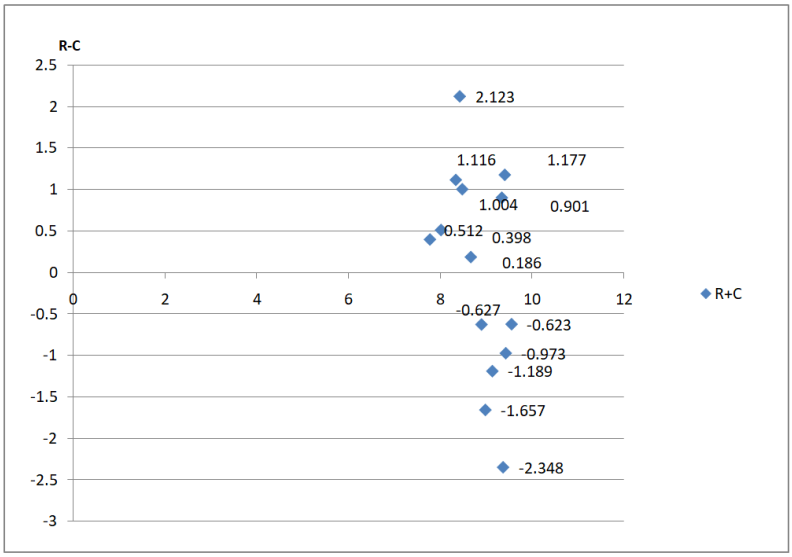

Fig. 2. The casual relation model diagram for criteria.

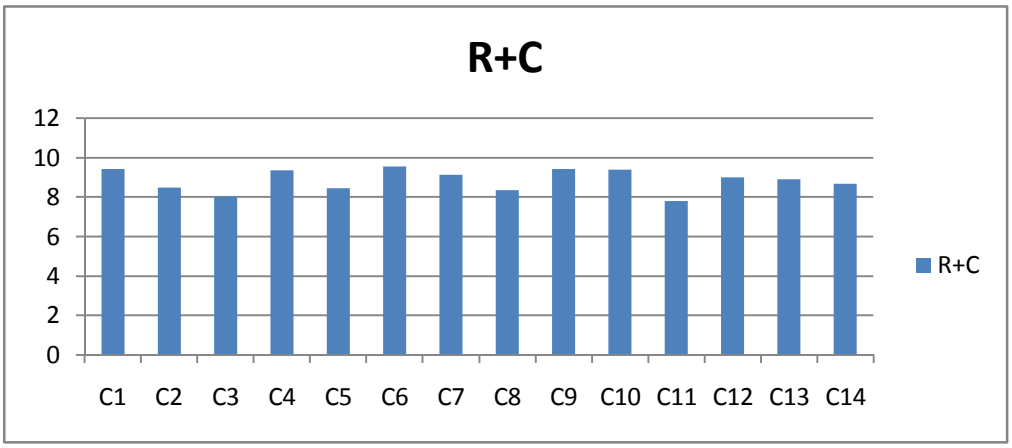

Fig. 3. The casual relation rating diagram for criteria.

IV. CONCLUSION

In the present study, the fuzzy DEMATEL method is used to measure the most effective and suitable criteria for supplier selection problem. It can be measured with the help of ranking of each criterion. The result shows that the fuzzy DEMATEL technique can provide the effective relationship and helps for the identification of best supply selection criteria. In the casual relation diagram, the cause group can be easily separated from the evaluation criteria which are C1, C2, C3, C4, C5, C8, C11, C14 and the effect group includes C6, C7, C9, C10, C12, and C13. It can be concluded that the value (R+C) of each criteria shows the strength index of each influences received also it provides the degree of problem. It is well shown in Fig. 2 and Table 7. The criteria C6 have the greatest value of 9.553, shows the most significant criteria in the supply selection case study problem. The criteria C5 of value 2.123 is the largest positive value among all (R-C), shows the most influential criteria among all the factors. The most negative value among all (R-C) is C4 which is -2.348 shows the received value of most influence from other criteria. Table 8 represents the ranking of all criteria based on influence and prominence degree.

Table 8: Ranking of supplier selection criteria.

Criteria	R+C	Rank 1	R-C	Rank 2
Higher body involvement, support and dedication (C1).	9.405	3	1.177	2
To fulfill the requirement of customer and suppliers (C2).	8.482	10	1.004	4
Major roles of government rules and regulations and support system (C3).	8.02	13	0.512	6
Effective information sharing system and technological aspects (C4).	9.341	5	0.901	5
Coordination, understanding and trust between the industrial members and partners (C5).	8.427	11	2.123	1
To buildup the reputation of industry in the market (C6).	9.553	1	-0.623	9
Involvement of the environmental protection factors during manufacturing and business process (C7).	9.135	6	-1.189	12
Awareness of supply chain management system to the suppliers (C8).	8.342	12	1.116	3
Expertise of industrial workers, customers and suppliers (C9).	9.427	2	-0.973	11
Industry control over supplier selection criteria (C10).	9.368	4	-2.348	14
Processes and Strategies developed by industry to implement low carbon process (C11).	7.78	14	0.398	7
Increment of the customer service system (C12).	8.983	7	-1.657	13
Increment of the system speed and response (C13).	8.899	8	-0.627	10
Economic profit control by the involvement of business process and methods (C14).	8.668	9	0.186	8

Ranking (1)*: the criteria rank based on prominence.
Ranking (2)*: the criteria rank based on influence.
This should clearly explain the main conclusions of the work highlighting its importance and relevance.

V. FUTURE SCOPE

By changing the tools and Techniques used for example Fuzzy TOPSIS, Fuzzy ANP, AHP, etc, different results can be obtained. Different kinds of industries have different criteria variables of supplier selection. More appropriate results can be measured through these tools and techniques. The numbers of supplier selection variables are more or less dependent upon the researchers. More the number of criteria variables can make the problem more complex so that the section of the best supplier is more difficult.

Conflict of Interest. The authors don't have any conflicts of interest.

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