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Fuzzy-TOPSIS Analysis for Standard Alternative Selection: A Multiple Attribute Decision-Making Method and Application for Small and Medium Manufacturing Enterprises (SMEs)

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FUZZYTOPSISANALYSISFORSTANDARDALTERNATIVESELECTIONAMULTIPLEATTRIBUTESDECISIONMAKINGMETHODANDAPPLICATIONFORSMALLANDMEDIUMMANUFACTURINGENTERPRISESSMES

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I. Introduction

a) Purposes of SMEs

The small and medium manufacturing enterprises (SMEs) manufactures a great number of metal products every day. Manufacturing SME has a big contribution from repairing metal parts to manufacturing complex parts. There is wide range of activities behind the manufacturing system, from raw material to finished product until the product is used by customer or recycled. One of the most important roles of SMEs is poverty alleviation through job creation. The developed as well as developing countries are taking extreme benefits from SMEs and that are capable to accelerate the economy of any country. In developing countries, SMEs are major source of income. The following TABLE express importance of SMEs to the national economy.

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Importance of SMEs on Economy of Asian Countries

country	SMEs as % of all enterprises	SMEs employees as % of total employees population
Japan	98.9	69.2
Singapore	99.7	57.0
Hong-Kong	98.0	60.0
Thailand	99.7	58.0
Taiwan	97.7	68.8
Philippines	99.6	70.0
Malaysia	96.1	45.0

b) Problems with SMEs

Small and medium enterprises in the manufacturing sector are faced with challenge of competition with established business. One of the major challenges that SMEs face in relation to adoption of maintain the standard that's why productivity is low and delicate.

According to Talha (2002) in order to compete effectively, companies must be capable of manufacturing high quality products at a low cost, and also provide a first class customer service. Customers' needs are changing as well as newly configured product is essential to manufacture while SMEs cannot keep pace with the performance needed. So it is very essential to change them to capable of. But they can't be changed having small investment, small budgeting, small technical support, hazardous environment and small opportunity due to economic and environmental lacking. So it is an important and necessary research, how the SMEs can be made enable without changing infrastructure, equipment, environment, budget, capacity and environment.

c) Previous Work

SMEs have received noticeable attention in the literature. Some examples of the literature on small and medium enterprises are given follows. Hudson et al. have examined the problems associated with PM for small to medium-sized enterprises (SMEs) and has proposed a procedural framework specifically tailored to their needs. They showed Improving control through effective performance measurement in SMEs. Tomomi et al. have focused on the adoption of green or sustainable practices in Small and Medium Enterprises (SMEs). Sarkis (2006) found that early adoption and increased investment in environment risk management did not increase performance for small firms in the metal finishing industry. Paying particular attention to the needs of small and medium sized enterprises (SMEs), Project Acorn by Gascoigne j. provides a framework for the systematic management of environmental issues within individual organizations and the supply chains to which they belong [1]. Toyli et al. (2008) analyzed the relationship between logistics performance and financial performance in Finnish small and medium-sized enterprises (SMEs). Several studies in South Africa (Mutezo, 2006; Maas and Herrington, 2006; Angela and Motsa, 2006; Herrington et al., 2008; Musara and Fatoki, 2011) have alluded to lack of access to financing as one of the major challenges impeding the survival and growth in the SME sector. Wagner, B. A. et al. (2003) worked on E-business and E-supply chain strategy in small and medium sized businesses (SMEs). In a study in India's machine tools SMEs, Pillai (2010) found that proper inventory management practices results in lower inventory costs. In another study, Lee (2006) revealed that many Chinese small manufacturing firms face size-related difficulties in implementing JIT. Lee suggested that Chinese small firms can achieve their goals by implementing only feasible elements of JIT without too much capital investment. Bayraktar, E. et al. (2009) made a causal analysis of the impact of information systems and supply chain management practices on operational performance having evidence from manufacturing SMEs in Turkey. Bhagwat, R., & Sharma, M. K. (2006) worked on Management and practice of information system in Indian SMEs. While it is acknowledged that large firms have an advantage for adopting sustainable practices more than SMEs and that SMEs adoption is necessary in the long run, studies found that the rate of return on early adoption is not encouraging. Banomyong, R., & Supatn, N. (2011) developed supply chain performance tool for SMEs in Thailand. There is also a vast literature on business success of small and medium enterprises (SMEs). Audretsch (2005) showed the relationship between ownership, decision making and employee deployment and the performances of the SMEs. In a research study on SME's in Indonesia (Robert, 2007) founded that SMEs operate on traditional lines in marketing. Strict reaction on account of competition should be responded proactively by SMEs by doing business development and research Information access it stands for the availability of business information is also important to initiate new enterprises and to run the existing enterprise profitably. Technology also plays an important role in this respect. Technology has a close relationship with improvement of production process. Different studies have also revealed the similar results that lack of new technology and equipment are hindrances of SME development (Swierczek & Ha, 2007). In Indonesian study it was revealed that business has no sufficient relation with the success of an SME (Huggins, 2007).

d) Contribution of This Paper

Works on SME were seen frequent formerly. While it is acknowledge that large firms have an advantage for adopting change discussed above where SMEs have no option but SMEs adoption is necessary. More research is thus needed on how SMEs should approach to a standard performance. In this paper standard alternative has been selected incorporation with TOPSIS and fuzzy analysis.

It is a common problem found in many cases of quantitative decision making the human assessments is uncertain and it is often difficult for decision makers to supply exact numerical values for specific criteria. In this regard most of the selection parameters can't be given precisely and the evaluation data of alternatives' characteristics is expressed in linguistic term by the decision makers. Moreover human judgment on qualitative attributes is always subjective and thus imprecise. For the sake of modeling this type of characteristics in case of human approach, fuzzy logic could be the best means.

There are many more operational tools for this type of analysis. Among those TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) is applied to solve this type of multi-criteria problem. TOPSIS method is developed by Hwang and Yoon (1981) based on the concept that the chosen alternative should have the shortest distance from the positive ideal solution and the farthest from the negative ideal solution for solving a multi-criteria decision making problem. Briefly the positive ideal solution is made up of all the best values attainable of criteria, whereas the negative is composed of all worst values attainable of criteria.

The rest of the paper is organized as follows: Section 2 consists of briefly discussion on SME and fuzzy-TOPSIS. Methodology is discussed in section 3. Rest of the paper is comprised of calculation, result&

discussion and conclusion. There is also reference and appendix annexed at the last portion.

II. Fuzzy-Topsis

The fuzzy TOPSIS approach involves fuzzy assessments of criteria and alternatives in TOPSIS (Hwang and Yoon, 1981) [2]. The TOPSIS approach chooses alternative that is closest to the positive ideal solution and farthest from the negative ideal solution. A positive ideal solution is composed of the best performance values for each criterion whereas the negative ideal solution consists of the worst performance values. The various steps of fuzzy TOPSIS are presented as follows:

- *Step 1: Assignment of ratings to the criteria and the alternatives*

Let us assume there are J possible candidates called A = {A_1, A_2......... A_j} which are to evaluate against n criteria, C = {C_1, C_2.................C_i}. The criteria weights are denoted by w= (1, 2, 3,..............m). The performance ratings of each decision maker D=(1,2,3...........k) for each alternative A_j(j=1,2,3.........n) with respect to criteria C_i(i=1,2,3........m) are denoted by R_k=X_{ijk}(i=1,2,3...m; J=1,2,3...n; K=1,2,3........k) with membership function $\mu_{rk}(x)$

- *Step 2 :* Compute aggregate fuzzy ratings for the criteria and the alternatives. If the fuzzy ratings of all decision makers is described as triangular fuzzy number R_k=(a_k, b_k, c_k) K=1,2,3.......k; then the aggregated fuzzy rating is given by R=(a, b, c), K=1,2,3......k where

$$a=\min\{a_k\},\ b=\frac{1}{k}\sum_{k=1}^{k} b_k,\quad c=\max\{c_k\} \qquad (1)$$

If the fuzzy rating and importance weight of the k^{th} decision maker are X_{ijk}=(a_{ijk},b_{ijk},cijk) and W_{ijk}=(w_{jk1},w_{jk2},w_{jk3}); i=1,2,3.....m; j=1,2,3......n; respectively ,then the aggregated fuzzy ratings (X_{ij}) of alternatives with respect to each criteria are given by X_{ji}=(a_{ij},b_{ij},c_{ij}) where

$$a_{ij}=\min\{a_{ijk}\},\ b_{ij}=\frac{1}{k}\sum_{k=1}^{k} b_{ijk},\ ;\ c_{ij}=\max\{c_{ijk}\} \qquad (2)$$

The aggregated fuzzy weights (W_{ij}) of each criterion are calculated as w_j= (w_{j1},w_{j2},w_{j3}) where

$$W_{j1}=\min\{w_{jk1}\},\ b_{j2}=\frac{1}{k}\sum_{k=1}^{k} w_{jk2};\ w_{j3}=\max\{c_{jk3}\} \qquad (3)$$

- *Step 3 :* Compute the fuzzy decision matrix. The fuzzy decision matrix for the alternatives (D) and the criteria (W) is constructed as follows:

$$D=\begin{bmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mn} \end{bmatrix} \quad i=1, 2, 3\ldots m;\ J=1, 2, 3\ldots n;$$

W= (w_1, w_2, w_3............w_n)

- *Step 4 :* Normalize the fuzzy decision matrix. The raw data are normalized using linear scale transformation to bring the various criteria scales into a comparable scale. The normalized fuzzy decision matrix R is given by

$$R=[r_{ij}]_{mxn}\ i=1,2,3\ldots\ldots m;\ j=1,2,3\ldots\ldots n$$

Where,

$$r_{ij}=\left(\frac{a_{ij}}{c_j^*},\frac{b_{ij}}{c_j^*},\frac{c_{ij}}{c_j^*}\right) \text{ and } c_j^*=\max c_{ij} \text{ (Benefit criteria)} \qquad (4)$$

$$r_{ij}=\left(\frac{a_j}{c_{ij}},\frac{a_j}{b_{ij}},\frac{a_j}{a_{ij}}\right) \text{ and } a_j=\min a_{ij} \text{ (cost criteria)} \qquad (5)$$

- *Step 5 :* Compute the weighted normalized matrix. The weighted normalized matrix V for criteria is computed by multiplying the weights (w_j) of evaluation criteria with the normalized fuzzy decision matrix.

$$v=[v_{ij}]_{mxn};\ i=1,2,3\ldots m;\ j=1,2,3\ldots n \text{ where } v_{ij}=r_{ij}(.)w_j \qquad (6)$$

$$A^*=(v_1^*,v_2^*,v_3^*\ldots v_n^*) \text{ where } v_j^*=\max\{v_{ij3}\};\ i=1,2,3\ldots m;\ j=1,2,3\ldots n \qquad (7)$$

$$A=(v1,v2,v3\ldots v_n) \text{ where } v_j=\min\{v_{ij1}\};\ i=1,2,3\ldots m;\ j=1,2,3\ldots n \qquad (8)$$

- *Step 7 :* Compute the distance of each alternative from FPIS and FNIS. The distance (d_i^*, d_i^-) of each weighted alternative i=1, 2, 3........m from the FPIS and the FNIS is computed as follows:

$$d^*_i=\sum_{j=1}^{n} d_v(v_{ij},v^*_j) \quad i=1,2,3\ldots m \qquad (9)$$

$$d^-_i=\sum_{j=1}^{n} d_v(v_{ij},v^-_j) \quad i=1,2,3\ldots m \qquad (10)$$

Where d_v (a, b) is the distance measurement between two fuzzy numbers a and b.

- *Step 8 :* Compute the closeness coefficient (CC_i) of each alternative. The closeness coefficient CC_i represents the distances to the fuzzy positive ideal solution (A^*) and the fuzzy negative ideal solution (A) simultaneously .The closeness coefficient of each alternative is calculated as

$$CC_i=\frac{dd_i}{d_i+d_i^*} \quad i=1, 2, \qquad (11)$$

- *Step 9 :* Rank the alternatives. In step9, the different alternatives are ranked according to the closeness coefficient (CC_i) in decreasing order. The best alternative is closest to the FPIS and farthest from the FNIS.

III. Methodology

In order to identify the causes behind the production quality three SMEs were observed. Then some fundamental points were selected. The points were of two types: qualitative and quantitative. Even menial errors were tried to be overcome, so before taking the data they were checked and rechecked. There were some categorizations set for quantitative data analysis. Criteria weights are calculated as the triangular fuzzy numbers and then these fuzzy criteria weights are inserted to the fuzzy TOPSIS methodology to rank the alternatives.

The data were taken on the following points: Working space(in sq. ft.), light (in lumen), salary of workers, age of machines, cutting tool quality, maintenance of machines, waste disposal system, basement space, floor quality, welding rod, safety measures, handling equipment ,working conditions, amount of work per hour, amount of scrap material, quality of material used etc.

Then using fuzzy logic the qualitative and quantitative data analysis was performed.

The Process flow diagram is described below:

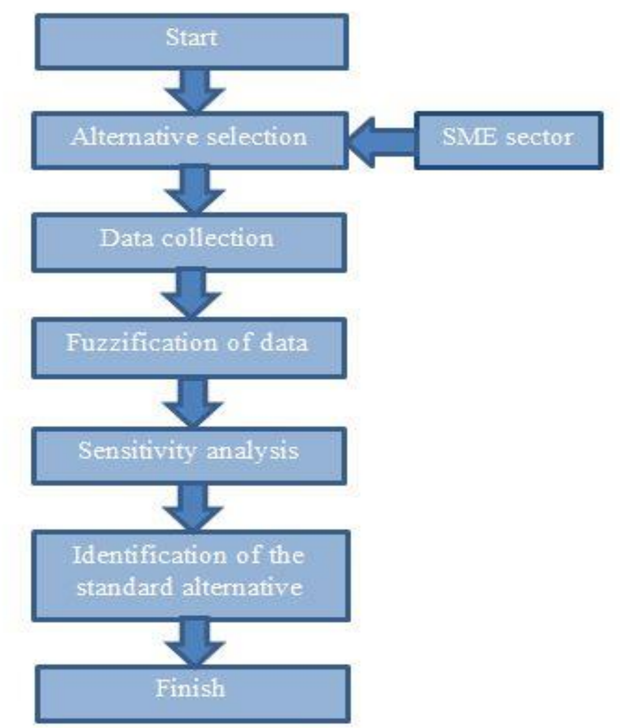

Figure 1 : process flow diagram of proposed methodology

Finding maximum (At table no.4)

Max=Max (Alternative1, Alternative 2, Alternative 3) [alternatives from table no. 3]

=Max (7, 9, 9, 3, 5, 7, 5, 7, 9)

=9

It is shown for the first element. Similarly others were calculated.

Finding minimum (At table no.4)

Min =Min (Alternative 1, Alternative 2, Alternative 3) [alternatives from table no. 3]

=Min (1, 3, 5, 1, 3, 5, 1, 3, 5)

=1

It is shown for the first element. Similarly others were calculated.

According to equation no. 4 normalized fuzzy was calculated represented in table 4.

For the Alternative 1;

a_{11}= 7/9 = 0.78

For the Alternative 2; (For Benefit Criteria)

a_{21}= 3/9 = 0.33

For the Alternative 3;

a_{31}= 5/9 = 0.56

It is shown for the first element. Similarly others were calculated.

According to equation no. 5

For Alternative 1;

a_{13}, 1= 1/5 =0.20

For Alternative 2; (For Cost criteria)

a_{13}, 2= 1/1 =1

For Alternative 3;

a_{13}, 3= 1/1 =1

It is shown for the first element. Similarly others were calculated.

At the Table no.5 the weighted normalized matrix was calculated from equation (6);

For alternative 1;

a_{11} =0.78*3=2.33

For alternative 2;

a_{21}=0.33*5=1.00

For alternative 3;

a_{31}=0.56*7=1.67

It is shown for the first element. Similarly others were calculated.

At the Table no.6

Fuzzy negative ideal solution (FNIS) was calculated by using equation (8).

Min (a_{11}) = Min (2.33, 5.00, 7.00, 1.00, 2.78, 5.44, 1.67, 3.89, 7.00)

=1.00;

It is shown for the first element. Similarly others were calculated.

The fuzzy positive ideal solution (FPIS) was Calculated by using equation (7).

Max (a_{11}) =Max (2.33, 5.00, 7.00, 1.00, 2.78, 5.44, 1.67, 3.89, 7.00)

=7.00;

It is shown for the first element. Similarly others were calculated.

The distance of each alternative from FPIS and FNIS was calculated using equation following equation.

$$d(a,b) = \sqrt{\frac{1}{3}[(a_1 - b_1)^2 + (a_1 - b_2)^2 + (a_1 - b_3)^2]} \quad (12)$$

For Alternative 1(D-), using equation 12.

$$d(a_{11}) = \sqrt{\frac{1}{3}[(1 - 2.33)^2 + (1 - 5)^2 + (1 - 7)^2]}$$

$$= \sqrt{17.93}$$

=4.23

It is shown for the first element. Similarly others were calculated.

At table no.7

For Alternative 1(D+), using equation 12.

$$d(a_{11}) = \sqrt{\frac{1}{3}[(7 - 2.33)^2 + (7 - 5)^2 + (7 - 7)^2]}$$

$$= \sqrt{8.59}$$

=2.93

It is shown for the first element. Similarly others were calculated.

At table no. 8

Calculation of the closeness coefficient (CC) of each alternative was performed by equation no. (11);

For Alternative 1 calculation of (cc); cc = 63.25/ (63.25+78.57) = 0.446 =44.60%.

It is shown for the first element. Similarly others were calculated.

IV. Result & Discussion

Table no. 8 shows the final result. There are three values for three alternatives. The alternative having highest value is the best, hereby standard among all. The analysis shows "alternative 1'' as the standard manufacturing SME (small and medium enterprise).So the best possible alternative is "alternative 1. It is said in previous section that, on qualitative characteristics human assessment is uncertain and often subjective so the alternative characteristics are expressed in linguistic terms. There were some characters tics which were qualitative, but due to simplicity they were also transferred to quantitative. And for the purpose of confidentiality the real name of the manufacturing SMEs were not disclosed.

V. Conclusion

For the selection of the best alternative the proposed method is a unique one. As the best is selected by the analysis then is can be said as standard. So changing the others comparing to it can make them well efficient in production. So drastically change is not needed for SMEs. The proposed method will help the SMEs to cope with the competition in the era of industrialization. To our knowledge no previous work investigated such a solution with TOPSIS and fuzzy analysis. As the proposed method is novel, it might be applied to other MADM problem.

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Appendix

Table 1 : Linguistic terms for performance variables

Linguistic term	Membership function
Very poor(VP)	(1,1,3)
Poor(P)	(1,3,5)
Fair(F)	(3,5,7)
Good(G)	(5,7,9)
Very Good(VG)	(7,9,9)

Table 2 : Data analysis

ID	Criteria	Definition	Alternative 1	Alternative 2	Alternative 3	criteri
V1	Working space	Space available for working.	(7,9,9)	(3,5,7)	(5,7,9)	B
V2	Light	Required brightness for working condition by electrical devices.	(3,5,7)	(7,9,9)	(5,7,9)	B
V3	Material quality	Level of material performance.	(7,9,9)	(3,5,7)	(3,5,7)	B
V4	Scrap material	Material that are useless after working.	(1,3,5)	(1,3,5)	(1,3,5)	C
V5	Waste disposal	An action process of waste disposing.	(7,9,9)	(7,9,9)	(7,9,9)	B
V6	Voltage of current	Available voltage from the power supply.	(1,3,5)	(1,3,5)	(3,5,7)	C
V7	Wire quality	Category of wire according to performance.	(5,7,9)	(3,5,7)	(3,5,7)	B
V8	Maintenance of machine	The process of maintaining of Machine.	(5,7,9)	(5,7,9)	(5,7,9)	B
V9	Gas welding quality	Distinctive attribute of gas welding	(1,3,5)	(1,3,5)	(1,1,3)	B
V10	Basement space of machine	Available space for the machine holding in basement	(1,3,5)	(1,3,5)	(1,3,5)	C
V11	Cutting fluid quality	The standard of cutting fluid against similar kind	(1,3,5)	(5,7,9)	(1,1,3)	B
V12	Output/hour	Amount of production hourly(kg)	(1,3,5)	(3,5,7)	(5,7,9)	B
V13	No. of worker	Quantity of worker appointed in working	(3,5,7)	(5,7,9)	(3,5,7)	C
V14	Temperature	The degree or intensity of heat present in working condition	(5,7,9)	(7,9,9)	(3,5,7)	C
V15	Worker's experience	Skill of worker	(3,5,7)	(1,3,5)	(5,7,9)	B
V16	Working environment	Conditions in which a worker operates machines	(1,1,3)	(3,5,7)	(1,1,3)	B
V17	Floor quality	Lower surface of the working room	(3,5,7)	(3,5,7)	(3,5,7)	B
V18	Welding rod	Distinctive attribute of welding rod	(3,5,7)	(3,5,7)	(3,5,7)	C
V19	Safety measure	Equipment that ensure safety like Googols, apron, Hand gloves, cades.	(1,1,3)	(1,3,5)	(1,1,3)	C
V20	Handling equipment	The equipment used for lifting, holding.	(1,1,3)	(1,1,3)	(1,1,3)	C
V21	Lubricant quality	Distinguishing performance level of lubricant used.	(5,7,9)	(5,7,9)	(5,7,9)	C
V22	Salary of worker	Payment of worker	(1,1,3)	(1,3,5)	(3,5,7)	C
V23	Age of machine	Length of time machine has been worked	(3,5,7)	(3,5,7)	(1,1,3)	C
V24	Belt quality	Categorization of belt basis of performance	(3,5,7)	(5,7,9)	(1,3,5)	C

*B is for Benefit criteria.

*C is for cost criteria.

Table 3 : Fuzzy direct matrices for alternatives

Weightage			Alternative 1			Alternative 2			Alternative 3		
3	5	7	7	9	9	3	5	7	5	7	9
7	9	9	3	5	7	7	9	9	5	7	9
5	7	9	7	9	9	3	5	7	3	5	7
5	7	9	7	9	9	7	9	9	7	9	9
3	5	7	5	7	9	3	5	7	3	5	7
5	7	9	5	7	9	5	7	9	5	7	9
3	5	7	1	3	5	1	1	3	1	1	3
3	5	7	1	3	5	5	7	9	1	1	3
5	7	9	1	3	5	3	5	7	5	7	9
5	7	9	3	5	7	1	3	5	5	7	9
7	9	9	1	1	3	3	5	7	1	1	3
3	5	7	3	5	7	3	5	7	3	5	7
5	7	9	1	3	5	1	3	5	1	3	5
3	5	7	1	3	5	1	3	5	3	5	7
3	5	7	1	3	5	1	3	5	1	3	5
5	7	9	3	5	7	5	7	9	3	5	7
3	5	7	5	7	9	7	9	9	3	5	7
3	5	7	3	5	7	3	5	7	3	5	7
7	9	9	1	1	3	1	3	5	1	1	3
5	7	9	1	1	3	1	1	3	1	1	3
3	5	7	5	7	9	5	7	9	5	7	9
7	9	9	1	1	3	1	3	5	3	5	7
5	7	9	3	5	7	3	5	7	1	1	3
3	5	7	3	5	7	5	7	9	1	3	5

Table 4 : Fuzzy normalized matrix for alternatives

					Normalized Fuzzy				
Max/Min		Alternative 1			Alternative 2			Alternative 3	
9	0.78	1.00	1.00	0.33	0.56	0.78	0.56	0.78	1.00
9	0.33	0.56	0.78	0.78	1.00	1.00	0.56	0.78	1.00
9	0.78	1.00	1.00	0.33	0.56	0.78	0.33	0.56	0.78
9	0.78	1.00	1.00	0.78	1.00	1.00	0.78	1.00	1.00
9	0.56	0.78	1.00	0.33	0.56	0.78	0.33	0.56	0.78
9	0.56	0.78	1.00	0.56	0.78	1.00	0.56	0.78	1.00
5	0.20	0.60	1.00	0.20	0.20	0.60	0.20	0.20	0.60
9	0.11	0.33	0.56	0.56	0.78	1.00	0.11	0.11	0.33
9	0.11	0.33	0.56	0.33	0.56	0.78	0.56	0.78	1.00
9	0.33	0.56	0.78	0.11	0.33	0.56	0.56	0.78	1.00
7	0.14	0.14	0.43	0.43	0.71	1.00	0.14	0.14	0.43
7	0.43	0.71	1.00	0.43	0.71	1.00	0.43	0.71	1.00
1	1.00	0.33	0.20	1.00	0.33	0.20	1.00	0.33	0.20
1	1.00	0.33	0.20	1.00	0.33	0.20	0.33	0.20	0.14
1	1.00	0.33	0.20	1.00	0.33	0.20	1.00	0.33	0.20
3	1.00	0.60	0.43	0.60	0.43	0.33	1.00	0.60	0.43
3	0.60	0.43	0.33	0.43	0.33	0.33	1.00	0.60	0.43
3	1.00	0.60	0.43	1.00	0.60	0.43	1.00	0.60	0.43
1	1.00	1.00	0.33	1.00	0.33	0.20	1.00	1.00	0.33
1	1.00	1.00	0.33	1.00	1.00	0.33	1.00	1.00	0.33

5	1.00	0.71	0.56	1.00	0.71	0.56	1.00	0.71	0.56
1	1.00	1.00	0.33	1.00	0.33	0.20	0.33	0.20	0.14
1	0.33	0.20	0.14	0.33	0.20	0.14	1.00	1.00	0.33
1	0.33	0.20	0.14	0.20	0.14	0.11	1.00	0.33	0.20

Table 5 : Weighted matrices for alternatives

Weighted Fuzzy								
Alternative 1			Alternative 2			Alternative 3		
2.33	5.00	7.00	1.00	2.78	5.44	1.67	3.89	7.00
2.33	5.00	7.00	5.44	9.00	9.00	3.89	7.00	9.00
3.89	7.00	9.00	1.67	3.89	7.00	1.67	3.89	7.00
3.89	7.00	9.00	3.89	7.00	9.00	3.89	7.00	9.00
1.67	3.89	7.00	1.00	2.78	5.44	1.00	2.78	5.44
2.78	5.44	9.00	2.78	5.44	9.00	2.78	5.44	9.00
0.60	3.00	7.00	0.60	1.00	4.20	0.60	1.00	4.20
0.33	1.67	3.89	1.67	3.89	7.00	0.33	0.56	2.33
0.56	2.33	5.00	1.67	3.89	7.00	2.78	5.44	9.00
1.67	3.89	7.00	0.56	2.33	5.00	2.78	5.44	9.00
1.00	1.29	3.86	3.00	6.43	9.00	1.00	1.29	3.86
1.29	3.57	7.00	1.29	3.57	7.00	1.29	3.57	7.00
5.00	2.33	1.80	5.00	2.33	1.80	5.00	2.33	1.80
3.00	1.67	1.40	3.00	1.67	1.40	1.00	1.00	1.00
3.00	1.67	1.40	3.00	1.67	1.40	3.00	1.67	1.40
5.00	4.20	3.86	3.00	3.00	3.00	5.00	4.20	3.86
1.80	2.14	2.33	1.29	1.67	2.33	3.00	3.00	3.00
3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
7.00	9.00	3.00	7.00	3.00	1.80	7.00	9.00	3.00
5.00	7.00	3.00	5.00	7.00	3.00	5.00	7.00	3.00
3.00	3.57	3.89	3.00	3.57	3.89	3.00	3.57	3.89
7.00	9.00	3.00	7.00	3.00	1.80	2.33	1.80	1.29
1.67	1.40	1.29	1.67	1.40	1.29	5.00	7.00	3.00
1.00	1.00	1.00	0.60	0.71	0.78	3.00	1.67	1.40

Table 6 : Negative distances of alternatives

FNIS	FPIS	D-					
MIN	MAX	Alternative 1		Alternative 2		Alternative 3	
1.00	7.00	17.93	4.23	7.64	2.76	14.93	3.86
2.33	9.00	9.63	3.10	32.86	5.73	22.88	4.78
1.67	9.00	29.05	5.39	11.13	3.34	11.13	3.34
3.89	9.00	11.93	3.45	11.93	3.45	11.93	3.45
1.00	7.00	14.93	3.86	7.64	2.76	7.64	2.76
2.78	9.00	15.28	3.91	15.28	3.91	15.28	3.91
0.60	7.00	15.57	3.95	4.37	2.09	4.37	2.09
0.33	7.00	4.81	2.19	19.62	4.43	1.35	1.16
0.56	9.00	7.64	2.76	17.96	4.24	33.38	5.78
0.56	9.00	17.96	4.24	7.64	2.76	33.38	5.78
1.00	9.00	2.75	1.66	32.49	5.70	2.75	1.66
1.29	7.00	12.63	3.55	12.63	3.55	12.63	3.55
1.80	5.00	3.51	1.87	3.51	1.87	3.51	1.87
1.00	3.00	1.53	1.24	1.53	1.24	0.00	0.00
1.40	3.00	0.88	0.94	0.88	0.94	0.88	0.94

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3.00	5.00	2.06	1.43	0.00	0.00	2.06	1.43
1.29	3.00	0.70	0.84	0.41	0.64	2.94	1.71
3.00	3.00	0.00	0.00	0.00	0.00	0.00	0.00
1.80	9.00	26.77	5.17	9.49	3.08	26.77	5.17
3.00	7.00	6.67	2.58	6.67	2.58	6.67	2.58
3.00	3.89	0.37	0.61	0.37	0.61	0.37	0.61
1.29	9.00	31.70	5.63	11.95	3.46	0.45	0.67
1.29	7.00	0.05	0.23	0.05	0.23	16.46	4.06
0.60	3.00	0.16	0.40	0.01	0.12	2.51	1.59
			63.25		59.51		62.77

Table 7 : Positive distances of alternatives

D+					
Alternative 1		Alternative 2		Alternative 3	
8.59	2.93	18.75	4.33	12.71	3.56
21.48	4.63	4.21	2.05	10.04	3.17
10.04	3.17	27.97	5.29	27.97	5.29
10.04	3.17	10.04	3.17	10.04	3.17
12.71	3.56	18.75	4.33	18.75	4.33
17.12	4.14	17.12	4.14	17.12	4.14
18.99	4.36	28.27	5.32	28.27	5.32
27.52	5.25	12.71	3.56	35.92	5.99
43.92	6.63	27.97	5.29	17.12	4.14
27.97	5.29	43.92	6.63	17.12	4.14
49.99	7.07	14.20	3.77	49.99	7.07
14.80	3.85	14.80	3.85	14.80	3.85
5.78	2.40	5.78	2.40	5.78	2.40
1.45	1.20	1.45	1.20	4.00	2.00
1.45	1.20	1.45	1.20	1.45	1.20
0.65	0.81	4.00	2.00	0.65	0.81
0.87	0.93	1.72	1.31	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00
13.33	3.65	30.61	5.53	13.33	3.65
6.67	2.58	6.67	2.58	6.67	2.58
0.30	0.54	0.30	0.54	0.30	0.54
13.33	3.65	30.61	5.53	51.93	7.21
30.82	5.55	30.82	5.55	6.67	2.58
4.00	2.00	5.31	2.30	1.45	1.20
	78.57		**81.89**		**78.34**

Table 8 : Final performance of alternatives

	CC		
	Alternative 1	Alternative 2	Alternative 3
	0.45	0.42	0.44
Percentage=	**44.60**	**42.09**	**44.48**