QUALITATIVE AND QUALITATIVE MODELING OF RED BRICK MANUFACTURING FIRMS UNDER GREEN AND TRADITIONAL SUPPLY CHAIN USING FMF

Nishat Iqbal[1], Abhijeet Kumar Gupta[2], Narendra Patel[3]
[1]M-Tech Scholar, [2]Assistant Professor, [3]Assistant Professor
Department of Mechanical Engg, Dr. C.V. Raman University, Kota, Bilaspur, (C.G.), India.

ABSTRACT

In last decade, each firm has begun to establish the production with rapid rate due to rich demand of goods with best quality. Many firm perceived the necessity to balance the production chain of organization. In the presented research work, the authors have proposed a DSS (consist of implementation of ML-MCDM with FMF of MOORA methods on constructed multi criterion decision making supplier evaluation appraisement module) for measuring the performance's score of clay brick suppliers under concerns of G-T SCs corresponding to fuzzy as well as non-fuzzy information. An analysis is conducted amongst the performance scores against alternatives.

Keywords: Multi-Criterion Decision Making (MCDM), Benchmarking, Performance Measurement (PM), Fuzzy, FMF.

I. INTRODUCTION

A brick is founded in the late 19th century, as distinct from the older universities 'built of stone'. A brick is counted as building stuff, which is explored to construct the walls, pavements and other elements in the field of construction. Usually, the term brick is referred to a unit composed of red soil, but it is now explored to denote any rectangular units by lying in mortar. A brick is constructed by the red bearing soil, sand, and lime, or concrete material/stuffs. Bricks are produced in many categories, types, materials, and sizes, which may vary with region and time period, and are produced in bulk quantities. Two basic categories of bricks are fired and non-fired bricks. Fired brick is a similar term referring to a rectangular building unit composed of similar materials, but is usually non-fired. Fired bricks are one of the longest-lasting and strongest building stuff, now and again referred to as artificial stone. These bricks had decreasing demand nowadays as of its strength and high water absorbing capacity and may conduct the good amount of electricity, while leakage on rainy season. The brick industry is growing as the demand for bricks is increasing in the towns and villages due to the fast fiscal growth, urbanization. It is alarming to note that 300 mm depth of fertile top soil in India will be consumed for burnt clay brick manufacturing in about 60 years. Fig: 1. Red bricks dimensions

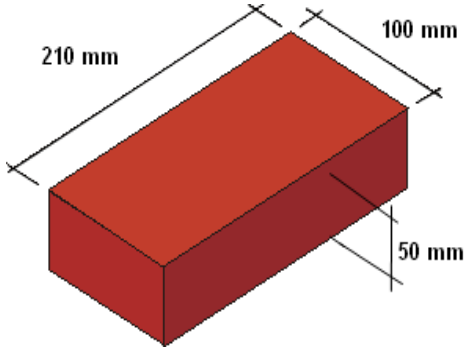

Fig: 1. Red bricks dimensions

II. SUPPLY CHAIN MANAGEMENT

Supply Chain Management (SCM) is described as the procedure of planning and executing, and at the same time managing the supply chain by the mainly efficient potential way. Supply chain management involves controlling of finished products from the source of origin the consumption level. The conventional supply chain concerned with two or more firms, which were enabled the connection among the

consumers and the vendors. In this conventional technique, therefore the finished products are delivered to the purchasers through a chain of warehouses. SC is a system of business that are involved, through upstream and downstream connection, in the dissimilar procedure and actions, which create worth in the term of goods and services in the hands of the final purchasers.

III. GROUP DECISION MAKING

It is a type of participatory process in which multiple individuals acting collectively analyze problems or situations, consider and evaluate alternative courses of action, and select from among the alternatives a solution or solutions. The number of people involved in group decision-making varies greatly, but often ranges from two to seven. The individuals in a group may be demographically similar or quite diverse [1-9].

Decision-making groups may be relatively informal in nature, or formally designated and charged with a specific goal. The process used to arrive at decisions may be unstructured or structured. The nature and composition of groups, their size, demographic makeup, structure, and purpose, all affect their functioning to some degree. The external contingencies faced by groups (time pressure and conflicting goals) impact the development and effectiveness of decision-making groups.

IV. BENCHMARKING

The benchmarking process is significance as it has observed as potential tool for analyzing complex real problems due to its ability to judge different alternatives (Choice, strategy, policy) under various criteria. These alternatives may be further explored in-depth for their final implementation. The benchmarking processes deals with a set of (contradictory) criterions, which lay down of well-defined limitations. Therefore, benchmarking process is obviously associated with the technique of arithmetical programming for solving with optimization dilemma. In benchmarking process, objectives are considered as alternatives, which have linked with defined criterions. The objective of benchmarking process is to select optimum alternative amongst all/considered. Fig. 3 has revealed the MCDM benchmarking model [1-9].

V. FUZZY SET THEORY:

Prof. Zadeh proposed the concept of fuzzy logic in 1965. Fuzzy logic theory is a control tool and technique, which encompasses the data by allowing partial set membership rather than crisp set membership or non-membership.

Fuzzy logic deals with the concept of partial truth, where the truth value may range between completely true and completely false. Fuzzy logic found their application where the valuable information is neither completely true nor completely false, or which are partly true and partly false [1-3].

Fuzzy logic deals with reasoning that is approximate rather than fixed and exact. Compared to traditional binary sets. Fuzzy logic variables may have a truth value that ranges in degree between 0 and 1. Reason for exploring fuzzy than stochastic and triangular fuzzy Membership Function (MF) than others fuzzy MF:

To encounter this type of information; non-deterministic data sets systems are build, which portrays an degree of complete information by baking this incomplete information. This can be done by stochastic and fuzzy modeling. Stochastic modeling usually deals with the modeling of the system by estimating probability distribution based on past data sets, whereas Fuzzy sets theory transforms the oral natural language of the human beings into efficient mathematical data sets and does not oblige preceding data sets to assign fuzzy variable [104].

VI. THE FMF METHOD:

The Full Multification Form technique was introduced by [18]. Here, $\prod_{x_i=t}^{m_{x_1x_2\ldots x_{(i-1)}}} M_{x_1x_2\ldots x_{(i-1)}\ldots\ldots\ldots\ldots\ldots\ldots r_{x_1x_2\ldots x_ip}}$, denotes the product of criterion $i=1,\ldots,n;$ of the alternative $t;$ to be maximized with being the number of criterion to be maximized and where $\prod_{m_{x_1x_2\ldots x_{(i-1)}}}^{x_i=t-1} M_{x_1x_2\ldots x_{(i-1)}\ldots\ldots\ldots\ldots\ldots\ldots r_{x_1x_2\ldots x_ip}}$ denotes the product of criterion $i=1,\ldots,n;$ of the alternative $t;$ to be minimized, Thus MOORA summarizes

$$\frac{\prod_{x_i=t}^{m_{x_1x_2\ldots x_{(i-1)}}} M_{x_1x_2\ldots x_{(i-1)}\ldots\ldots\ldots\ldots r_{x_1x_2\ldots x_ip}}}{\prod_{x_i=t-1}^{m_{x_1x_2\ldots x_{(i-1)}}} M_{x_1x_2\ldots x_{(i-1)}\ldots\ldots\ldots\ldots r_{x_1x_2\ldots x_ip}}} \ldots\ldots r_{x_1x_2\ldots x_ip}$$

……..……...(1)

VII. CASE STUDY

Procedural hierarchy: case application

This section considers the real case of a Colony Developer Company 'Rishabh Colonizer' situated in the Bhilai, Chhattisgarh, India; desire to place an order of red-brick to supplier firms (considered the Eco, S.K and Flypro red-brick manufacturers) up to that time until project does not complete via participating in global green issues as per various rule and regulations imposed by the government. The selection of best red brick supplier subjected with the consideration of the green cum traditional SC measures and their metrics against company's partners 'Eco, S.K and Flypro red-brick manufacturers' is considered as a challenging issue. Preliminary, Rishabh Colonizer conducted the brainstorming session and at last looked for three alternative industries i.e. Eco, S.K and Flypro red-brick manufacturers and searched the appropriate technique to choose the best alternative under green cum traditional SC.

Step 1: a fuzzy and non-fuzzy based red-brick supplier performance evaluation module/index is constructed, is given in Table 1, 2 and 3. A rating scale is given in Table 4.

Step 2: Later five decision makers of Rishabh Colonizer assessed the weights for 1st 2nd 3rd and 4th in term of linguistic, given in Table 5, 6 and 7. Later, five decision makers of Rishabh Colonizer assessed the rating for 4th, 3rd , 2nd in term of linguistic, given in Table 8, 9 and 10.

The authors applied the formulation of reference paper [8] to compute Defuzzified value and weighted matrix, given in Table 11.

Step 3: The authors applied to [Equa. 1]; on weighted normalized matrix to compute rank of the alternatives has been computed, given in Table 12, shown by fig.2.

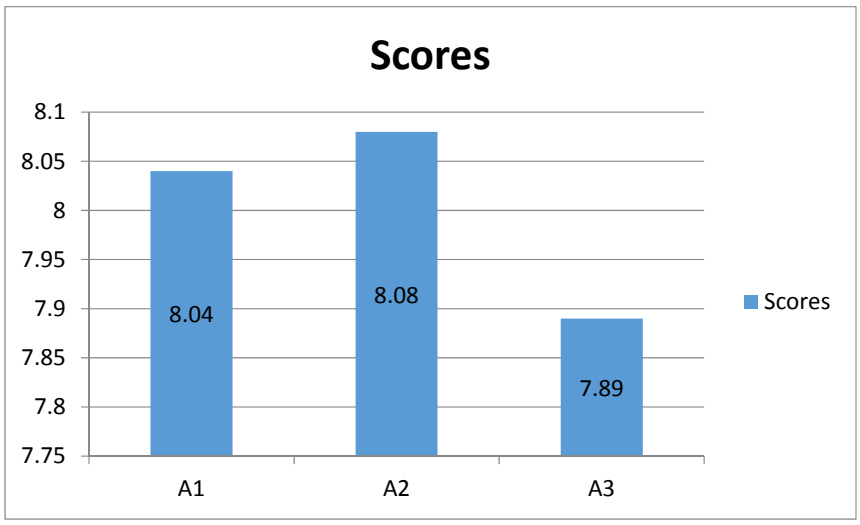

Fig 2. Rank of the alternatives has been computed

VIII. APPLICATION

Colonizer can use proposed approach/method for measuring the performance's scores of the clay brick supplier candidate. Presented approach/method is also found well for other industries in substituting measures and metrics (included in decision making hierarchical structural module) corresponding to fuzzy cum non fuzzy information under scope of considering alternatives i.e. red brick, coal refinery, refractive material refinery etc suppliers

IX.CONCLUSION

Presented Decision support systems (DSSs) might assist the mangers of manufacturing firms towards measuring the performance's scores of the alternatives clay brick supplier candidate under green cum traditional architectures in extant of fuzzy cum non fuzzy information. The

presented decision making hierarchical structural framework in depicted DSS, is found active to undertake many industrial decision making problems in substituting the chain of architectures corresponding to fuzzy cum non fuzzy information under scope of considering alternatives i.e. red brick, coal refinery.

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Table: 1 Green red brick supplier evaluation appraisement index for red-brick alternative A_1 **(**Eco red-brick manufacturer in Bhilai, C.G).

Goal (f_x)	**Measures; (INR/Unit), f_{x_1}**	**Metrics; (INR/Unit), $f_{x_1x_2}$**	**Metrics; (INR/Unit), $f_{x_1x_2x_3}$**	**Metrics; (INR/Unit), C_{ijkl}**
Green Red Brick Partner Evaluation Appraisement Index	Supply chain management,C_1	Supply in time, $C_{1,1}$	Quality, C_{111}	Credit, C_{1111}
		Solving problems with suppliers, $C_{1,2}$	Complaint for product, C_{112}	
		Communication with other companies, $C_{1,3}$		
	Eco-design, C_2	Reuse of waste material, $C_{2,1}$		
	Operation management, C_3	Innovation of technique, $C_{3,1}$		
	Outside environmental management, C_4	Waste of water, $C_{4,1}$		
	Production cost, C_5	Material Procurement cost (loading and unloading material charge),$C_{5,1}$	Loading material labor charge from material supplier company;(0.02), C_{511}	
			Unloading material labor charge at brick making company;(0.02); C_{512}	
			Fuel consumption;(0.10), C_{513}	
			Truck hiring (cleaner and driver charge);(0.05),C_{514}	
			Documentation costs; (0.01),C_{515}	
			Raw material cost;(0.10),C_{516}	
		Tempering;(0.04),$C_{5,2}$		
		Moulding;(0.10),$C_{5,3}$		
		Drying;(0.01),$C_{5,4}$		
		Firing; (0.03),$C_{5,5}$		
		Sorting;(0.1),$C_{5,6}$		
	Transportation cost, C_6	Loading finished brick's labor charge at brick making company; (0.02),$C_{6,1}$		
		Unloading finished brick's labor charge at rishabh colonizer;(0.02),$C_{6,2}$		
		Fuel consumption; (0.10),$C_{6,3}$		
		Truck hiring (cleaner and driver charge);(0.05),$C_{6,4}$		
		Documentation costs; (0.01),$C_{6,5}$		
	Water pollution treatment costs; (0.012), C_7			
	Energy consumption costs, C_8	Hydraulic machine power consumption cost;(0.12),$C_{8,1}$		
		Water supply motor power consumption cost;(0.05),$C_{8,2}$		
		Overall lighting and other appliance running cost;(0.03), $C_{8,3}$		
	Air pollution treatment costs;(0.020),C_9			
	Chemical waste treatment costs; (0.010),C_{10}			
	Solid waste treatment costs;(0.020),C_{11}			
	Other indirect expenses;(0.060),C_{12}			
	Staff salary; (0.080);C_{13}			

Table: 2 Green supplier evaluation appraisement index for red-brick alternative A_2 **(**S.K red-brick manufacturer in Bhilai, C.G).

Goal (f_x)	**Measures; (INR/Unit), f_{x_1}**	**Metrics; (INR/Unit), $f_{x_1x_2}$**	**Metrics; (INR/Unit), $f_{x_1x_2x_3}$**	**Metrics; (INR/Unit), C_{ijkl}**
Green Red Brick Partner Evaluation Appraisement Index	Supply chain management,C_1	Supply in time, $C_{1,1}$	Quality, C_{111}	Credit, C_{1111}
		Solving problems with suppliers, $C_{1,2}$	Complaint for product, C_{112}	
		Communication with other companies, $C_{1,3}$		
	Eco-design, C_2	Reuse of waste material, $C_{2,1}$		
	Operation management, C_3	Innovation of technique, $C_{3,1}$		
	Outside environmental management, C_4	Waste of water, $C_{4,1}$		
	Production cost, C_5	Material Procurement cost (loading and unloading material charge),$C_{5,1}$	Loading material labor charge from material supplier company;(0.02), C_{511}	
			Unloading material labor charge at brick making company;(0.02); C_{512}	
			Fuel consumption; (0.11), C_{513}	
			Truck hiring (cleaner and driver charge); (0.05),C_{514}	
			Documentation costs; (0.02),C_{515}	
			Raw material cost; (0.11),C_{516}	
		Tempering;(0.04),$C_{5,2}$		
		Moulding;(0.10),$C_{5,3}$		
		Drying;(0.01),$C_{5,4}$		
		Firing; (0.03),$C_{5,5}$		
		Sorting;(0.1),$C_{5,6}$		
	Transportation cost, C_6	Loading finished brick's labor charge at brick making company; (0.02),$C_{6,1}$		
		Unloading finished brick's labor charge at rishabh colonizer;(0.02),$C_{6,2}$		
		Fuel consumption; (0.12),$C_{6,3}$		
		Truck hiring (cleaner and driver charge); (0.04),$C_{6,4}$		
		Documentation costs; (0.01),$C_{6,5}$		
	Water pollution treatment costs; (0.012), C_7			
	Energy consumption costs, C_8	Hydraulic machine power consumption cost;(0.11),$C_{8,1}$		
		Water supply motor power consumption cost;(0.07),$C_{8,2}$		
		Overall lighting and other appliance running cost;(0.04), $C_{8,3}$		
	Air pollution treatment costs; (0.030),C_9			
	Chemical waste treatment costs; (0.010),C_{10}			
	Solid waste treatment costs; (0.030),C_{11}			
	Other indirect expenses; (0.080),C_{12}			
	Staff salary; (0.070);C_{13}			

Table: 3 Green supplier evaluation appraisement index for red-brick alternative A_3 **(**Flypro red-brick manufacturer in Bhilai, C.G)

Goal (f_x)	**Measures; (INR/Unit), f_{x_1}**	**Metrics; (INR/Unit), $f_{x_1x_2}$**	**Metrics; (INR/Unit), $f_{x_1x_2x_3}$**	**Metrics; (INR/Unit), C_{ijkl}**
Green Red Brick Partner Evaluation Appraisement Index	Supply chain management,C_1	Supply in time, $C_{1,1}$	Quality, C_{111}	Credit, C_{1111}
		Solving problems with suppliers, $C_{1,2}$	Complaint for product,C_{112}	
		Communication with other companies, $C_{1,3}$		
	Eco-design, C_2	Reuse of waste material, $C_{2,1}$		
	Operation management, C_3	Innovation of technique, $C_{3,1}$		
	Outside environmental management, C_4	Waste of water, $C_{4,1}$		
	Production cost, C_5	Material Procurement cost (loading and unloading material charge),$C_{5,1}$	Loading material labor charge from material supplier company;(0.02), C_{511}	
			Unloading material labor charge at brick making company;(0.02); C_{512}	
			Fuel consumption;(0.10), C_{513}	
			Truck hiring (cleaner and driver charge);(0.04),C_{514}	
			Documentation costs; (0.01),C_{515}	
			Raw material cost; (0.13),C_{516}	
		Tempering;(0.03),$C_{5,2}$		
		Moulding;(0.10),$C_{5,3}$		
		Drying;(0.02),$C_{5,4}$		
		Firing; (0.04),$C_{5,5}$		
		Sorting;(0.2),$C_{5,6}$		
	Transportation cost, C_6	Loading finished brick's labor charge at brick making company; (0.02),$C_{6,1}$		
		Unloading finished brick's labor charge at rishabh colonizer;(0.02),$C_{6,2}$		
		Fuel consumption; (0.12),$C_{6,3}$		
		Truck hiring (cleaner and driver charge); (0.06),$C_{6,4}$		
		Documentation costs; (0.01),$C_{6,5}$		
	Water pollution treatment costs; (0.012), C_7			
	Energy consumption costs, C_8	Hydraulic machine power consumption cost;(0.14),$C_{8,1}$		
		Water supply motor power consumption cost;(0.04),$C_{8,2}$		
		Overall lighting and other appliance running cost;(0.03), $C_{8,3}$		
	Air pollution treatment costs; (0.021),C_9			

	Chemical waste treatment costs; (0.011),C_{10}			
	Solid waste treatment costs; (0.022),C_{11}			
	Other indirect expenses; (0.061),C_{12}			
	Staff salary; (0.090);C_{13}			

Table 4: Linguistic scale

Linguistic Term (Appropriateness Rating)	Corresponding Fuzzy Numbers	Linguistic Term (Priority Weights)	Corresponding Fuzzy Numbers
Unsatisfactory (U)	(0,0,0.25)	Unimportant (UI)	(0,0.1,0.3)
Poor (P)	(0,0.25,0.5)	Slightly Important (SI)	(0,0.2,0.5)
Medium (M)	(0.25,0.5,0.75)	Fairly Important (FI)	(0.3,0.45,0.7)
Satisfactory (S)	(0.5,0.75,1)	Important (I)	(0.5,0.7,0.8)
Excellent (E)	(0.75,1,1)	Very Important (VI)	(0.7,0.9,1)

Table 5: Priority weights against 1st level indicators for alternative **A_1, A_2 and A_3**

1st level indices	E_1	DM_2	DM_3	DM_4	DM_5
C_1	I	VI	VI	VI	VI
C_2	VI	I	I	FI	FI
C_3	VI	FI	I	I	I
C_4	VI	FI	VI	I	FI
C_5	VI	VI	VI	FI	VI
C_6	I	VI	VI	VI	VI
C_7	I	VI	VI	FI	VI
C_8	VI	VI	FI	FI	VI
C_9	VI	VI	VI	FI	SI
C_{10}	VI	VI	VI	FI	SI
C_{11}	VI	VI	VI	I	FI
C_{12}	I	UI	FI	I	FI
C_{13}	I	UI	FI	I	FI

Table 6: Priority weights against 2nd level indices for alternative **A_1, A_2 and A_3**

2nd level indices	DM_1	DM_2	DM_3	DM_4	DM_5
$C_{1,1}$	VI	VI	VI	I	FI
$C_{1,2}$	I	UI	FI	I	FI
$C_{1,3}$	I	UI	FI	I	FI
$C_{2,1}$	I	FI	FI	FI	FI
$C_{3,1}$	I	FI	FI	VI	SI
$C_{4,1}$	I	VI	FI	UI	SI
$C_{5,1}$	I	VI	FI	UI	VI
$C_{5,2}$	I	VI	VI	FI	VI
$C_{5,3}$	I	VI	UI	FI	VI
$C_{5,5}$	VI	I	UI	VI	VI
$C_{5,6}$	VI	FI	FI	VI	VI
$C_{6,1}$	VI	VI	FI	UI	VI
$C_{6,2}$	I	UI	VI	FI	FI
$C_{6,3}$	I	UI	VI	I	FI
$C_{6,4}$	I	FI	UI	FI	FI
$C_{6,5}$	I	FI	FI	FI	SI
$C_{8,1}$	I	VI	FI	SI	SI

$C_{8,2}$	I	VI	FI	SI	VI
$C_{8,3}$	I	UI	FI	I	FI

Table 7: Priority weights against 3rd and 4th level indices for alternative **A_1, A_2 and A_3**

3rd level indices	DM_1	DM_2	DM_3	DM_4	DM_5
C_{111}	FI	FI	FI	VI	VI
C_{112}	FI	FI	FI	VI	VI
C_{511}	UI	UI	UI	UI	UI
C_{512}	FI	FI	FI	FI	FI
C_{513}	FI	FI	FI	FI	FI
C_{514}	VI	VI	VI	VI	VI
C_{515}	FI	FI	FI	VI	VI
C_{516}	FI	FI	FI	VI	VI
4th level indices	DM_1	DM_2	DM_3	DM_4	DM_5
C_{1111}	FI	FI	FI	VI	VI

Table 8: Priority rating against 4th, 3rd and 2nd level indices for alternative **A_1**

4th level indices	DM_1	DM_2	DM_3	DM_4	DM_5
C_{1111}	S	M	M	M	P
3rd level indices	DM_1	DM_2	DM_3	DM_4	DM_5
C_{112}	S	M	E	M	P
2nd level indices	DM_1	DM_2	DM_3	DM_4	DM_5
$C_{1,3}$	P	M	U	M	M
$C_{2,1}$	S	M	M	M	P
$C_{3,1}$	S	M	E	M	P
$C_{4,1}$	U	E	M	M	M

Table 9: Priority rating against 4th, 3rd and 2nd level indices for alternative **A_2**

4th level indices	DM_1	DM_2	DM_3	DM_4	DM_5
C_{1111}	E	U	M	M	E
3rd level indices	DM_1	DM_2	DM_3	DM_4	DM_5
C_{112}	E	M	U	E	E
2nd level indices	DM_1	DM_2	DM_3	DM_4	DM_5
$C_{1,3}$	E	U	U	M	E
$C_{2,1}$	E	U	M	M	E
$C_{3,1}$	E	M	U	E	E
$C_{4,1}$	E	E	E	E	E

Table 10: Priority rating against 4th, 3rd and 2nd level indices for alternative **A_3**

4th level indices	DM_1	DM_2	DM_3	DM_4	DM_5
C_{1111}	U	M	M	M	M
3rd level indices	DM_1	DM_2	DM_3	DM_4	DM_5
C_{112}	S	E	E	E	P
2nd level indices	DM_1	DM_2	DM_3	DM_4	DM_5
$C_{1,3}$	S	M	U	M	M
$C_{2,1}$	U	M	M	M	M
$C_{3,1}$	S	E	E	E	P
$C_{4,1}$	S	S	E	E	M

Table 11: Computed weighted normalized matrix ***(all the indices are beneficial***) for alternatives A_1, A_2 and A_3

1st level indices	A_1	A_2	A_3
C_1	0.67	0.83	0.77
C_2	0.54	0.63	0.45
C_3	0.52	0.60	0.67
C_4	0.36	0.68	0.56
C_5	0.79	0.77	0.62
C_6	0.83	0.78	0.73
C_7	0.75	0.75	0.75
C_8	0.71	0.64	0.69
C_9	0.67	0.44	0.63
C_{10}	0.75	0.75	0.69
C_{11}	0.49	0.32	0.44
C_{12}	0.49	0.36	0.48
C_{13}	0.45	0.52	0.40

Table 12: Computed preferences order for red-brick suppliers **A_1**, **A_2** and **A_3** by FMF

Alternatives	Scores	Preference order
$(M_1)/A_1$	0.000000000120	2
$(M_2)/A_2$	0.000000000280	1
$(M_3)/A_3$	0.000000000110	3