Study of a fuzzy logic-based approach to supplier selection

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Abstract. Because of globalization, huge competition is existed among the manufacturing organizations to survive their production into the global market. Today's global market customer generates dynamic demands which further forces the organizations to respond them quickly. The main aim of supply chain management is to give maximum focuses on the aspects of the customers like improved customer service, performance of business, and more profitability too. The process of supplier selection is considered as one of the important decision making process at the strategic level of an organization. It is expected to have a improved partnership with the better suppliers at strategic stage which will expected to yield the improved quality, improved flexibility and also will reduces the lead time of the product. This project work addresses the aspects and issues for enabling the process of supplier selection. For this a new comprehensive technique called as fuzzy simple multi attributes rating technique (Fuzzy SMART) is strategically aligned with the fuzzy logic and same concept will be applied to enable the process of supplier selection.

1 Introduction:

Today manufacturing sector is considered as a modern manufacturing paradigm which is expected to have a increased competition among the manufacturing organizations to have a ultimately forces those organization to have advanced system of manufacturing. These advanced systems of manufacturing can capable the organization to satisfy their customer with respect to their varied needs about the products. This process of advanced manufacturing systems forces the manufacturing firms to have their business process outsourcing as an essential constituent to adopt themselves to have a such supply chain management that can fulfill the varied demand of the customers continuously. The process of purchasing is considered as one of the most significant procedure in many organizations, because the process of purchase includes the components like purchased parts, supplier and components, which typically considered as a 40 to 60 percent of the organization end product sales. The recent supply management practices is meant to retain the relationship of long term relationships with suppliers, and utilize very few and reliable suppliers in their organization for the purpose of production. Thus it's very essential to choose a right

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suppliers that yields to have a better evaluation of set of price list proposed by the suppliers, and the process of selection is dependent on multiple range of factors like the like qualitative. The process of supplier selection is regarded as one of the most important activities of the purchasing part of the organization is a chain of supply network. Since it may include the factors of the supplier like quality, cost, and service delivery. The process of selecting supplier is very complex, since it is required to amalgamate the manufacturers, suppliers and end customers into the supply chain according to the scene of architecture of virtual enterprise and selecting the supplier for the particular product and also for the service. In real world two types of problems of supplier selection exist. The first problem addresses uses related to satisfying the one supplier will able to fulfill all the needs proposed by single buyer or single sourcing. In this case the management is required to a only single decision related to say that which supplies is the best the second problem is concerned to multiply supplies also turned as a multiple sourcing, which addresses the issues like none of the supplies is able to fulfill all needs of the buyers. In such situations management is required to divide the quantities of order between the every quantities of order between the every suppliers for the arrived reasons like maintaining a continuous and constant environment of competitiveness. The process of selecting supplies is considered as one of the multi criteria decision making, it is referred as (MCDM) problem because of this process includes the several criteria and many sub criteria. This process of selecting supplies characterizing their relationship were termed as a modern organizational issues, which needs to adopt the principle of supply chain, Because a wrong selection of suppliers leads to increase the dropping huge market shares and margin of profit of an particular organization. Thus this project work gives its preference on using the MCDM. Technique of Fuzzy SMART for an organization to enable the process of supplies selection and is demonstrated by conducting a case study in an Indian Pump manufacture company.

2 Literature Survey

Weber et al (1991) have given a overview related to various criteria for supplies selection. Also the authors went reviews the 74 project works based on selecting suppliers in a literature of academic with respect to use of such criteria. The authors discussed that the price of the net is regarded as a most discussed criteria, whereas the criteria like quality and delivery occupies the next positions. The most important of address of this particular criteria in that, the managers should not identifies the supplier based on the criteria of low cost, but they should consider performance of delivery, quality and related attributes.

Mohanty (1993) have listed the almost all views of material managers related to selection of suppliers for the environment of today's business competiveness.

Chapman (1993) the article of the chapman has examined the attributes of suppliers which considered as a most related the important attributes like cost, quality and delivery performance.

Verma and Pullman (1998) have addressed the issue of excelling the suppliers in each and every dimensions of performance. Thus the conceptual and empirical numbers of articles on the issue of selection of supplies have been appeared.

3 The Conceptual Model for Supplies Selection

This section of theirs discusses about the proposed project model for supplier selection. The model has been developed by referring the detailed literature review provided in above chapter. This FUZZY SMART model consist of multiple 10 criteria were shown in fig 1. The various sub criteria for every criterion were also been shown in the figure 1.

The show criteria in figure 1 are the criteria of either quantitative and qualitative. The grouping of both quantitative and qualitative criteria was as shown in table 1.

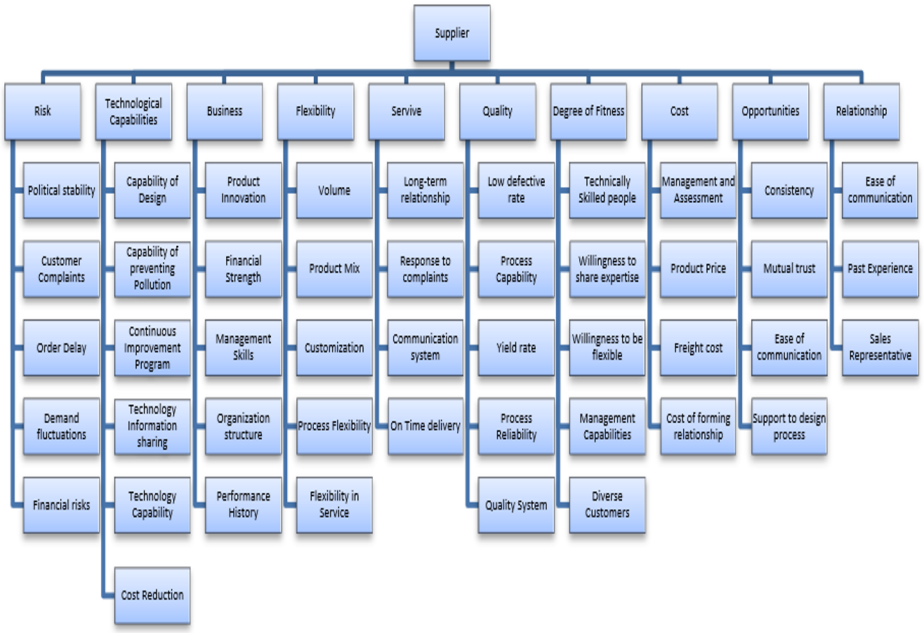

Fig. 1. Hierarchy of supplier selection

Table 1. Quantitative and Qualitativecriteria in supplier selection process

Qualitative Sub-Criteria	**Quantitative Sub-Criteria**	**Qualitative Sub-Criteria**
Political Stability (C11)	Order delays(C13)	Communication system(C53)
Customer Complaints (C12)	Demand fluctuations(C14)	Quality system(C65)
Capability of Design(C21)	Financial risks(C15)	Technically skilled people(C71)
Capability of preventing Pollution(C22)	Financial strength(C32)	Willingness to share expertise (C72)
Continuous Improvement Program (C23)	Volume(C41)	Willingness to be flexible(C73)
Technology Information sharing (C24)	Product mix(C42)	Management capabilities(C74)
Technology Capability (C25)	On time delivery(C54)	Diverse customers(C75)
Cost Reduction Capabilities(C26)	Low defective rate(C61)	Consistency(C91)
Product Innovation(C31)	Process capability(C62)	Mutual trust(C92)
Management Skills(C33)	Yield rate(C63)	Ease of communication(C93)
Organization Structure(C34)	Process reliability(C64)	Support to design process(C94)
Performance History(C35)	Measurement and assessment cost(C81)	Ease of communication(C101)
Customization (C43)	Product price(C82)	Past experience(C102)
Process flexibility(C44)	Freight cost(C83)	Sales representative(C103)
Flexibility in service(C45)	Cost of forming relationship(C84)	
Long-term relationship(C51)		
Response to complaints(C52)		

4 The Case Study

The proposed project work needs to be demonstrating for that a case study has been conducted at Jay Pumps, which manufactures varied domestic and industrial pumps at wide range. The company was established at 1980, with just employees of 10, know the annual company turns over rupees 2 cross. The other products of the company are centrifugal pumps and submersible pumps. The data required for conducting the project work has been gathered from the various evacuation of the company. The company situated Coimbatore, India. The main task of the company is to manufacture pumps by assembling its various components. To manufacture either pumps like centrifugal or submersible by the process of purchasing such pumps specific components. This scenario of company forces the decision makers to assess the each and every supplier carefully and the associated trade-offs between the different criteria of the company required to be considered in order to reach the individual and regid evaluation of the suppliers.

In this project work, to carry out a case study, a component of name copper wires, which chosen to do the project analysis. Copper wires were supplied by three potential suppliers namely supplier A, supplier B and supplier C. Before establishing a long term relationship with these three suppliers the company first established a short term relationship with these there suppliers for obtaining, the data related to quantitative, historical and real about these three suppliers. The company is required to select any two of these suppliers as a business partners. A meeting was held to decide these suppliers for that a five members were invited to their meeting for providing the related information and opinions in this meeting. The some related attitude and the five manager's opinions will play an important role to come out with a one decision opinion by these members about the case.

After this, the management will make a committer with special members for deciding to select the best supplier for copper wires. This special committee consists five managers from the varied functional department s of the company. Those are a) Operations manager termed as D1 b) Engineering managers termed as D2; c) General marking managers termed as D3; d) Purchasing managers termed as D4; e) R&D manager termed as D5.

This five special members committer will organizer series of meetings to decide upon the best profile on a lean supply chain to have to meet the low cost strategy by the corporate and have the derived levels of suppliers. The committee of the having the several meetings, it will come out with the following profiles,

i) The supplier should be desirable to have a phenomenon of continuous improvement in order to achieve the strategies like reduction of cost, internal responsiveness and flexibility. ii) After enabling the concept of lean supply chain, the suppliers should be enable to provide the dimensions of low cost and high quality. iii) In a lean supply chain, the criteria a low cost is imperative in nature, since the concept of cost is critical for the winner market. iv) It is very important to consider the culture and strategies of organization for deciding the required suppliers, by enabling their contribution to the criteria of overall cost and appeal to quality for the products continuously for a long period of time.

4.1 Supplier Selection Based on Fuzzy SMART Approach Aggregate Assessment of Fuzzy Weights;

The selection criteria for the copper wires is done offer having the collection five members set up for their criteria and sub criteria, the linguistic variable are used to weigh the opinions of these five managers to assess the important of criteria and sub criteria, offer their the aggregate fuzzy weight of these criteria on and sub criteria were determine.

The table 2 shows the triangular fuzzy numbers (TFNs) for used by the final DMs in the process of supplier selection. If also shows their respective ratings.

Table 2: TFN of importance weight s and ratings used in the supplier selection process.

Importance weights		**Ratings**	
Linguistic variables	**TFNs**	**Linguistic variables**	**TFNs**
Very low (VL)	(0, 0, 1)	Very poor (VP)	(0, 0, 10)
Low (L)	(0, 1, 3)	Poor (P)	(0, 10, 30)
Medium low (ML)	(1, 3, 5)	Medium poor (MP)	(10, 30, 50)
Medium (M)	(3, 5, 7)	Fair (F)	(30, 50, 70)
Medium high (MH)	(5, 7, 9)	Medium good (MG)	(50, 70, 90)
High (H)	(7, 9, 10)	Good (G)	(70, 90, 100)
Very high (VH)	(9, 10, 10)	Very good (VG)	(90, 100, 100)

The figure 2, shows the respective fuzzy number of dms which are used to select the importance weights of the listed sub criteria are as shown in table 3. The table 4 shows the criteria. As per the evaluation values the fuzzy weights of every criteria and sub criteria where determined are listed in table 3 and 4.

Criteria	DMs Linguistic Weights					Aggregated Weights		
	D1	D2	D3	D4	D5	Fuzzy	Defuzzified	Normalized
C11	M	MH	ML	ML	M	(2.561,4.561,6.561)	4.561	0.303
C12	M	ML	MH	H	M	(3.829,5.829,7.634)	5.764	0.382
C13	L	M	ML	ML	L	(0.805,5.829,7.634)	2.195	0.146
C14	L	VL	ML	L	VL	(0.805,2,3.78)	1.285	0.085
C15	VL	L	VL	ML	L	(0.22,1.024,2.61)	1.268	0.084
C21	H	VH	MH	H	VH	(7.341,8.951,9.78)	8.691	0.179
C22	H	VH	H	VH	MH	(7.341,8.951,9.78)	8.691	0.179
C23	H	VH	MH	H	MH	(6.51,8.317)	8.13	0.168
C24	H	MH	VH	H	MH	(6.61,8.39,9.585)	8.195	0.169
C25	M	MH	H	MH	H	(4.659,6.659,8.439)	6.586	0.136
C26	H	MH	VH	H	MH	(6.61,8.39,9.585)	8.195	0.169
C31	L	VL	ML	L	VL	(0.22,1.024,2.61)	1.285	0.039
C32	H	VH	MH	H	VH	(7.39,8.976,9.78)	8.715	0.265
C33	H	VH	MH	H	VH	(7.39,8.976,9.78)	8.715	0.265
C34	M	ML	MH	M	MH	(3.488,5.488,7.488)	5.488	0.167
C35	H	VH	MH	H	VH	(7.39,8.976,9.78)	8.715	0.265
C41	M	MH	M	MH	M	(3.78,5.78,7.78)	5.78	0.157
C42	H	VH	MH	H	VH	(7.39,8.976,9.78)	8.15	0.219
C43	H	H	H	H	H	(7,9,10)	8.667	0.222
C44	M	MH	ML	M	MH	(4.854,6.854,8.488)	6.732	0.172
C45	MH	MH	MH	MH	MH	(5,7,9)	7	0.171
C51	H	H	H	H	H	(7,9,10)	8.667	0.255
C52	H	MH	H	MH	H	(6.22,8.22,9.61)	8.017	0.236

Fig. 2. Shows the respective fuzzy number of dms

4.2 Calculation Of The Criterion Aggregate FuzzyRatings;

This section document the aggregate fuzzy ratings using the variable of linguistic ratings required to assess the crisp rating of fuzzy for the arrived alternatives with the virtue of every such criteria in order to compute the aggregate ratings of fuzzy and also to construct the matrix of fuzzy ratings.

4.3 Individual Sub Criteria Aggregating Fuzzy Ratings Computation:

To determine the quantitative value of sub criteria, the company gathers the realistic data

which are historical in nature; those data have not been assessed by the special managers for the selection of the three suppliers S1, S2 and S3 are as shown in table 3. The values were determined and same were document in table3.

Table 3: Real data and normalized fuzzy rating (NFR) of each supplier with respective all quantitative criteria

Sub-Criteria	Suppliers	Real Data (Crisp values)	Benefit/cost	NFRs
C13	A1	17	Cost	(100,100,100)
	A2	19		(33.33,33.33,33.33)
	A3	20		(0,0,0)
C14	A1	12	Cost	(75,75,75)
	A2	15		(0,0,0)
	A3	11		(100,100,100)
C15	A1	15	Cost	(100,100,100)
	A2	19		(20,20,20)
	A3	20		(0,0,0)
C32	A1	90	Benefit	(100,100,100)
	A2	85		(0,0,0)
	A3	89		(80,80,80)
C41	A1	81	Benefit	(0,0,0)
	A2	90		(100,100,100)
	A3	87		(66.67, 66.67, 6.67)
C42	A1	100	Benefit	(100,100,100)
	A2	95		(50,50,50)
	A3	92		(0,0,0)
C54	A1	97	Benefit	(100,100,100)
	A2	93		(20,20,20)
	A3	92		(0,0,0)
C61	A1	83	Benefit	(33.34,33.34,33.34)
	A2	82		(0,0,0)
	A3	85		(100,100,100)
C62	A1	77	Benefit	(66.67,66.67,66.67)
	A2	78		(100,100,100)
	A3	75		(0,0,0)
C63	A1	99	Benefit	(100,100,100)
	A2	96		(25,25,25)
	A3	95		(0,0,0)
C64	A1	99	Benefit	(100,100,100)
	A2	95		(0,0,0)
	A3	98		(75,75,75)
C81	A1	84	Cost	(100,100,100)
	A2	86		(33.33,33.33,33.33)
	A3	87		(0,0,0)
C82	A1	85	Cost	(100,100,100)
	A2	87		(20,20,20)
	A3	90		(0,0,0)
C83	A1	86	Cost	(100,100,100)
	A2	90		(0,0,0)
	A3	86		(100,100,100)
C84	A1	75	Cost	(100,100,100)
	A2	79		(0,0,0)
	A3	76		(75,75,75)

Also, to rate the variables in term of linguistic scales which are as shown in table 1 and their associated fuzzy ratings in order to evaluate the three suppliers S1, S2 & S3 with respect to their respective sub criteria, followed rating for rating every sub criteria will be computed.

Table 4. Linguistic and aggregated ratings of sub criteria

Sub-criteria	Suppliers	DMs Linguistic ratings					Aggregated fuzzy ratings
		Dl	D2	D3	D4	D5	
Political Stability (C11)	A1	F	MG	G	MG	F	(46.585,66.585,84.39)
	A2	MP	G	MG	F	F	(69.512,110,148.537)
	A3	G	MG	G	F	G	(74.9, 105.122,129.756)
Customer Complaints (C12)	A1	P	VP	MP	F	F	(24.146, 47.073,75.854)
	A2	P	VP	MP	P	F	(8.78, 26.585,55.366)
	A3	MP	P	VP	MP	F	(1.707,9.268,23.171)
Capability of Design(C21)	A1	F	MG	G	MG	F	(49.024,70.88,78)
	A2	MG	F	G	MG	G	(106.098,146.585,182.683)
	A3	F	MG	G	MG	G	(106.585,147.073,183.171)
Capability of preventing Pollution(C22)	A1	G	MG	VG	G	MG	(137.805,176.098,198.293)
	A2	MG	V	VG	G	VG	(170.976,219.268,246.829)
	A3	GT	G	MG	G	MG	(170.976,219.268,246.829)
Continuous Improvement Program (C23)	A1	G	MG	VG	MG	G	(142.195,190.244,232.195)
	A2	MG	G	MG	G	VG	(138.293,176.585,198.537)
	A3	G	MG	VG	G	MG	(171.951,220,247.073)
Technology Information sharing (C24)	A1	F	MG	G	G	MG	(160.732,210.976,241.951)

4.4 Fuzzy rating matrix construction:

To calculated the aggregate fuzzy rating for the every supplier criteria, Followed by this the fuzzy rating matrix has been constructed and the matrix is as shown in table 5.

Table 5: Fuzzy rating matrix

suppliers		A1	A2	A3
Criteria	C1	(52.7140 ,67.5320, 83.9210)	(34.2490, 52.3150, 71.2380)	(28.9060, 34.0360, 38.8140)
	C2	(105.0397,140.9882,169.6058)	(123.2985, 160.0543, 183.2844)	(98.6435,133.3696,61.0836)
	C3	(117.2546,146.5472 ,166.4399)	(101.8350,138.4047,168.6785)	(123.6240,158.2775,183.1623)
	C4	(52.7350,70.1060 ,90.7090)	(68.6310, 83.5260,96.3490)	(55.6100, 73.2240,87.9260)
	C5	(105.9326,126.4344,139.7002)	(144.1004,175.2982,190.5637)	(109.8930,148.3702,178.9232)
	C6	(96.1023,105.7368,110.5793)	(69.9380, 76.4630,78.1960)	(68.5300, 80.2545,90.7045)
	C7	(91.8034,129.5228,159.7163)	(101.3494,137.9811,164.7749)	(109.2502,138.8721,159.1351)
	C8	(100.0000,100.0000,100.0000)	(17.8333,17.8333,17.8333)	(28.3250,28.3250,28.3250)
	C9	(170.9961,210.2719,232.7737)	(186.4564,235.5624,260.5854)	(182.2868,226.5548,248.4599)
	C10	(83.1433,110.7180,133.6974)	(83.1433,103.8940,114.339393)	(102.6407,128.9626,142.1927)

The table 6 lists the computed total fuzzy values of every suppliers obtained. After this the total crisp value is determined and the some are documented. As per the available track records, the final managerial meeting is able to know the risk coefficient α1, α2, α3 as 0.1, 0.2, and 0.15 respectively. After that it is easy to select the suppliers whose TCV is maximum. The list supplier ranking is A1, A3, and A2. The expert committee is able to determine that A3, A2.as the business partners for supplying the copper wires to the JAY PUMPS.

Table 6: Shows the computed total fuzzy values of every suppliers obtained

Supplier	Values		Risk coefficient α_I	
	Fuzzy	TCV		
A1	(104.9750,128.3718,140.7510)		α=0.1	137.1734
A2	(102.8431,127.7181,137.6742)		α=0.2	130.708
A3	(101.0049,126.8140,141.8084)		α=0.15	135.6879

5 Conclusions:

The increased complexity about the product and the nature of dynamic and varied condition of market will stimulate the today's manufacturing sector to implement the advanced system of manufacturing in the manufacturing systems. Today's customer keep on changes the demand this will force the manufacturing companies to outsource their business and adopt the concept of supply chains in their business practices outsourcing and supply chain is a must for today's manufacturer because they may not have all the modern facilities in their production environment in order to the satisfy the rapidly varied demand by the customers this tends to have a best suppliers and select a best supplier for the handle free running of manufacturing system in order to fulfil the needs of the customer continuously the issue of selection of suppliers is considered as one of the multi criteria decision making process since it consists of many numbers of criteria's and sub criteria too this project work documents a case study which is conducted in a pump manufacturing organization this project work adopts the approach of fuzzy SMART for enabling the process of supplier selection the developed model in enable to select the best suppliers the outcome of the case study are much coincides practical environment previling at the case organization as this project work concludes that the process of supplier selection is termed as one of the critical activity for manufacturing organization thus the decision of supplier selection process have various number of risks which requires the scientific assistances by the developed fuzzy SMART model as a one of the multi criterion decision making problem solver.

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