

Multi Criteria Decision Approach for Supplier Selection in Lean Manufacturing System - A Case Study

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Abstract

Background: This paper focusses on selection of the suppliers based on the parameters matching the requirements of manufacturer by selecting data and information from a company supplying components for an automobile component manufacturing firm. The supplier adopts lean practices in line with the manufacturer's requirement and reducing inventory. **Methods:** The study focuses on using three popularly used multi criteria methods i.e., Analytical Hierarchy Processing (AHP), Fuzzy Approach and Analytic Network Process (ANP) for selection of suppliers. The data and information have been obtained from four suppliers and four important criteria including quality, price, service and delivery are selected to choose a supplier. The study is conducted in automobile component manufacturing firm. In each method, the supplier ranking was made and choice is given to purchase manager for final selection of supplier. **Findings:** The methods used for supplier selection, has its own merits and demerits. The implementation of these methods depends on the type of buyer requirements and parameter dependency. However, AHP method is not stable, if numbers of parameters are more than 10; ANP method is not stable when dependency of the parameters are considered. The drawback of fuzzy method is that, it considers the same importance for the parameters which is not true in real situation. **Improvements:** Further study can consider hybrid method for designing an algorithm for supplier selection, which may yield better results and hence better decision making. In a dynamic and changing environment, these analytical tools would be required in many sectors of business, wherever, there is more choice of suppliers.

Keywords: Analytical Hierarchy Processing (AHP), Analytic Network Process (ANP), Fuzzy Logic, Lean Manufacturing System, Supplier Selection

1. Introduction

Supplier selection is an important function that is performed by purchase department in any organization. The process starts from identifying the requirement of the raw material or component in various departments, checking the availability in the stores, verifying the existing vendor list, choosing the vendor based on multiple criteria for selecting new vendor and tracking their performance.

Sufficient time is spent on administrative activities and internal lead time seems to be more in many companies. These non-values added activities could be avoided by developing scientific methods and effective use of computers. Segregating waste and value added activities have become important in many companies adopting lean manufacturing practices to achieve competitiveness. This process involves both qualitative and quantitative parameters and optimizing on the parameters based on

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the type of business is a challenging exercise. The main aim of any supplier selection process includes selecting right supplier, who can supply right quantity at right place at optimum cost and also sustain the relationship in long term. This should enhance win-win situation for both the partners in supply chain. Some of the challenging issues involved in purchasing are: longer lead times, lack of availability of reliable and accurate data, fill rate, communication delay because of involvement of many people, complexity in purchasing procedures and specifications, mismatch of terms and conditions of various suppliers and such others.

Supplier selection process consists of identifying new supplier, decision rules; technical selection; selection based on commercials, final supplier selection and performance monitoring. The firms will identify, evaluate, and contract with different suppliers. In most industries, material costs are the ranging from 45% to 70% of the total product cost. In technology intensive organizations, the cost of materials and service amounts up to 80% of the total product cost. Hence, selecting the right suppliers becomes a strategic decision and there is opportunity to reduce cost across the supply chain. Choosing the right method for supplier selection effectively leads to a reduction in purchase risk and increases the number of Just in Time (JIT) suppliers and hence adopting lean manufacturing practices. Procurement is a great determinant of revenues and costs, according to Langley et al., Axelsson et al. explain that the function of purchasing has gone from buying via procurement to Supply Chain Management (SCM) and thus, further increase its scope by including improved administrative routines and supplier development. The cross functional teams' interactions are needed in order to choose the right purchased product.

According to van Weele, the lean company uses fewer suppliers and involves them in joint improvements and development. The targets are also very clear for suppliers regarding quality, delivery and costs which also enables a simple but efficient selection and performance measurement process. Waters-Fuller and Liker also highlight

geographically close suppliers as a characteristic for lean procurement. Liker and Choi mean that lean companies have more focus on increasing their supplier's capabilities in order to reduce costs and improve quality.

A paper on Extended Fuzzy PROMETHEE based on Fuzzy Rule based System for Supplier Selection Problem addresses SSP under group decision making and fuzzy environment. A hybrid approach including Fuzzy Rule Based System and Preference Ranking Organization Method for Enrichment Evaluations is proposed to select suitable supplier. The numerical illustration and sensitivity analyses are performed to demonstrate the applicability of the method for a supplier selection problem.

2. Supplier Selection through Multi-Criteria Decision Making Techniques

The present study focusses on supplier selection in company supplying components for an automobile component manufacturing firm and has an annual turnover of Rs.15 crores. The company is a lean supplier to automobile manufacturers in the country. The requirement from the manufacturer is accurate and time bound. Hence, the component manufacturer has to be accurate in his supplier selection and meeting the targets of the manufacturer. Hence, the study focuses on using three popularly used multi criteria methods i.e., AHP, Fuzzy Approach and ANP for selection of suppliers. The data and information have been obtained from four suppliers of the automobile component manufacturing firm for validation. The following sections 2.1, 2.2 and 2.3 explain the methods adopted for supplier selection.

2.1 AHP Approach for Selection of Suppliers

Step 1: Decision criteria selected include: Quality, Price, Service and Delivery. The ratio of each attributes is considered and weights are given based on importance.

Criteria	Quality	Price	Service	Delivery
Quality	1.00	2.00	3.00	4.00
Price	0.50	1.00	3.00	3.00
Service	0.25	0.33	1.00	2.00
Delivery	0.33	0.33	0.50	1.00
Total	2.08	3.66	7.50	10.00

Step 2: Comparison of the alternatives based on the criteria includes: Sum the elements in each column, dividing each value by its column sum and computing row average.

Then, the four suppliers are compared pair wise for each criterion. Each pair of suppliers is compared w.r.t the quality and price.as shown in the tables.

Intensity of Importance	Definition
1	Equal
3	Moderate
5	Strong
7	Very Strong
9	Extreme
2,4,6,8	For compromise between the above

Normalized Quality Matrix					
	S1	S2	S3	S4	Weights
S1	0.23	0.40	0.35	0.21	0.30
S2	0.05	0.08	0.12	0.10	0.09
S3	0.04	0.04	0.06	0.08	0.05
S4	0.69	0.48	0.47	0.67	0.56
Total	1.00	1.00	1.00	1.00	1.00

Normalized Price Matrix					
	S1	S2	S3	S4	Weights
S1	0.23	0.21	0.37	0.40	0.30
S2	0.69	0.63	0.52	0.45	0.57
S3	0.05	0.09	0.07	0.10	0.08
S4	0.03	0.07	0.04	0.05	0.05
Total	1.00	1.00	1.00	1.00	1.00

Step: 3: Synthesizing the comparisons to get the priorities of the alternatives: Synthesizing the comparisons to get the priorities of the alternatives w.r.t each criterion and the weights of each criterion w.r.t goal. Local priori-

ties are then multiplied by the weights of the respective criterion. The overall priority of each alternative is shown in the table.

Summary of Results					
	Quality	Price	Service	Delivery	Weights
S1	0.14	0.09	0.08	0.02	0.32
S2	0.04	0.17	0.02	0.01	0.24
S3	0.02	0.02	0.03	0.07	0.15
S4	0.26	0.01	0.01	0.02	0.29
				Total	1.00

2.2 Fuzzy Approach for Selection of Suppliers

This method considers weightages for multi criteria and

the suppliers are selected. The methodology adopted is as follows:

1. Formulae: Result = Intersection (Quality, Price, Service, Delivery)

2. Assumption: The attributes are characterized as: Highest Accepted value and Lowest Accepted value.

3. Highest Accepted Value: Price=500 [Assumption], Delivery Time = 5 Months [Assumption]

4. Lowest Accepted Value:

Quality=5 [Assump], Service=10 [Assumption]

Highest Accepted Value – Comes Under Numerator

Lowest Accepted Value – Comes Under Denominator

5. Construction of Fuzzy sets:

Suppliers	Quality	Price	Service	Delivery
S1	(1,8/5)	(1,5/4)	(1,10/10)	(1,5/4)
S2	(2,7/5)	(2,1)	(2,12/10)	(2,5/3)
S3	(3,8/5)	(3,5/4)	(3,15/10)	(3,5/4)
S4	(4,6/5)	(4,5/4)	(4,10/10)	(4,5/4)

6. Converting the value in fraction from the above table:

Suppliers	Quality	Price	Service	Delivery
S1	(1,1.6)	(1,1.1)	(1,1)	(1,1.2)
S2	(2,1.4)	(2,1)	(2,1.2)	(2,1.6)
S3	(3,1.6)	(3,1.2)	(3,1.5)	(3,1.2)
S4	(4,1.2)	(4,1.2)	(4,1)	(4,1.5)

7. The selection of supplier and their ranks are

Suppliers	Score	Rank
S1	(1,1)	2
S2	(2,1)	3
S3	(3,1.25)	1
S4	(4,1)	4

2.3 IANP Approach for Selection of Suppliers

The following Table 1. Provides the step by step methodology of ANP and validation using the data selected

Step 1: The best supplier is to be selected for an enterprise which manufactures the components and to supply the materials satisfying the selected criteria: Quality, Price, Service, and Delivery.																										
Step 2: Decision matrix having the diagonals equal preference i, e 1	<table><tr><td></td><td>Quality</td><td>Price</td><td>Service</td><td>Delivery</td></tr><tr><td>Quality</td><td>1</td><td></td><td></td><td></td></tr><tr><td>Price</td><td></td><td>1</td><td></td><td></td></tr><tr><td>Service</td><td></td><td></td><td>1</td><td></td></tr><tr><td>Delivery</td><td></td><td></td><td></td><td>1</td></tr></table>		Quality	Price	Service	Delivery	Quality	1				Price		1			Service			1		Delivery				1
	Quality	Price	Service	Delivery																						
Quality	1																									
Price		1																								
Service			1																							
Delivery				1																						
Step 3: Comparing the diagonals with itself based on the weight assignment preference considering Quality. Similarly table is constructed for Price, service, delivery.	<table><tr><td>Quality</td><td>S1</td><td>S2</td><td>S3</td><td>S4</td></tr><tr><td>S1</td><td>1</td><td>0.67</td><td>0.80</td><td>0.75</td></tr><tr><td>S2</td><td>1.50</td><td>1</td><td>0.83</td><td>0.89</td></tr><tr><td>S3</td><td>1.25</td><td>1.20</td><td>1</td><td>0.94</td></tr><tr><td>S4</td><td>1.33</td><td>0.89</td><td>1.07</td><td>1</td></tr></table>	Quality	S1	S2	S3	S4	S1	1	0.67	0.80	0.75	S2	1.50	1	0.83	0.89	S3	1.25	1.20	1	0.94	S4	1.33	0.89	1.07	1
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Step 4: Calculating the vector weight by using $V_i = \sqrt[n]{a[i,j] \times a[i,j+1], a[i,n]}$	<table><tr><td>Quality</td><td>V1=0.759, V2=1.0323, V3=1.0211, V4=1.0125</td></tr><tr><td>Price</td><td>V1=0.50, V2=0.97, V3=0.70, V4=2.42</td></tr><tr><td>Service</td><td>V1=1.61, V2=1.34, V3=0.80, V4=0.54</td></tr><tr><td>Delivery</td><td>V1=0.759, V2=1.0323, V3=1.0211, V4=0.54</td></tr></table>	Quality	V1=0.759, V2=1.0323, V3=1.0211, V4=1.0125	Price	V1=0.50, V2=0.97, V3=0.70, V4=2.42	Service	V1=1.61, V2=1.34, V3=0.80, V4=0.54	Delivery	V1=0.759, V2=1.0323, V3=1.0211, V4=0.54																	
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Step 5: Obtaining the weights equal to 1. Normalizing the vector weight using $PV_i=V_i/\Sigma V_i$	Quality	PV1=0.154, PV2=0.2053, PV3=0.2030, PV4=0.2013							
	Price	PV1=0.09, PV2=0.16, PV3=0.12, PV4=0.41							
	Service	PV1=0.30, PV2=0.25, PV3=0.15, PV4=0.10							
	Delivery	PV1=0.154, PV2=0.2053, PV3=0.2030, PV4=0.2013							
Step 6: Final matrix by considering the weights of criteria and alternatives. [Priority is considered].	Criteria alternatives	Quality	Price	Service	Delivery	S1	S2	S3	S4
	Quality	---	---	---	---	0.0836	0.0836	0.0861	0.0606
	Price	---	---	---	---	0.2328	0.2328	0.2396	0.156
	Service	---	---	---	---	0.1384	0.1384	0.1133	0.3364
	Delivery	---	---	---	---	0.5449	0.5449	0.56	0.4468
	S1					---	---	---	---
	S2					---	---	---	---
	S3					---	---	---	---
	S4					---	---	---	---

Step 7: Selection of the best alternative using: $S_i = \sum((a_{ij}) * v_{ij}))$	$S_1 = (0.1510 * 0.0836 + 0.09 * 0.2328 + 0.30 * 0.1384 + 0.135 * 0.5449) = 0.1476$ $S_2 = (0.2053 * 0.0836 + 0.16 * 0.2328 + 0.25 * 0.1384 + 0.2702 * 0.5449) = 0.2371$ $S_3 = (0.20308 * 0.0861 + 0.12 * 0.2396 + 0.15 * 0.1133 + 0.2027 * 0.560) = 0.1767$ $S_4 = (0.2013 * 0.0606 + 0.41 * 0.1560 + 0.10 * 0.3364 + 0.2162 * 0.4468) = 0.2016$
Step 8: Selection of best supplier: Best supplier = $\max(S_i)$	From the above values, supplier 2 is having the greater value. Hence, he is considered as the best supplier for the automobile company in all the criteria considered in the problem statement.

3. Results and Discussion

Four suppliers and four criteria for supplier selection were considered. In each method, the supplier ranking was made and choice is given to purchase manager for final selection.

All the methods were used for supplier selection, has its own merits and demerits. The implementation of these methods depends on the type of buyer requirements and parameter dependency. However, AHP method is not

stable, if number of parameters is more than 10; ANP method is not stable when dependency of the parameters are considered. The drawback of fuzzy method is that, it considers the same importance for the parameters which is not true in real situation. Hence, as a future scope of work, hybrid method is feasible in designing an algorithm for supplier selection.

Method	Supplier1	Supplier2	Supplier3	Supplier4
Analytic Hierarchic Processing	1	3	4	2
Fuzzy Logic Approach	2	3	1	4
Analytic Network Processing	2	4	3	1

4. References

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