

# Application of Pairwise Comparison and Numerical Evaluation Techniques for Supplier Selection

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**Abstract:** The process of selecting suppliers for purchasing goods is an important and critical process in the manufacturing. Smoothness in operations and efficiency of any company is highly dependent upon the performance of their material suppliers. There are numerous variables for each vendor on basis of which the vendor has to be selected. These variables are many times contradicting each other and hence an optimum mix of all these variables is required. In the present papers, we have prioritized the variables and compared various available vendors on these variables, with help of pairwise comparison and numerical evaluation. Based upon the performance of various vendors on each variable, an overall score or rating is calculated for each vendor which is used to take decision on selection of vendor(s).

**Keywords:** Supplier selection, Numerical evaluation and pairwise comparison, Supply chain, Procurement.

## 1 INTRODUCTION

One of the most challenging problems faced by the purchase managers is the selection of vendor from a given pool that will supply them necessary materials or components. The process of supplier selection is no longer governed by the sole criterion of price, because the ultimate objective of a purchase manager is to manage the supply chain efficiently so that the whole organization can enjoy the competitive advantage. Selecting a vendor is now as important a process as developing new products. Purchasing commands a significant position in most organizations since purchased parts, components, and supplies represent lion's share of the sales of its end products. Thus, even relatively small cost reductions gained in the acquisition of materials can have a greater impact on profits.

The goal of a purchase manager is to develop a dynamic strategic decision model so that various parameters like quality, delivery time, dependability are taken care of, considering relative importance of various factors at the same time. Also, relation

building with supplier is another practical consideration for long term sustainability of a healthy supply chain. A sound supplier selection decision today can reduce or prevent a host of problems tomorrow.

The supplier selection process is a group decision process [Chen et al. 2006][1]. Hence to fine tune the selection process, inputs from various decision making levels (strategic to operational) are introduced to have a broad view of the problem.

All of factors considered constitute a multi-attribute problem that poses numerous obstacles to decision makers in terms of the decisions to be made. These decisions are also influenced by an environment characterized by imprecise and uncertain requirements, parameters, and relationships, which can make the decision-making process overwhelmingly complex. For example, in the chair manufacturing industry, more than 50 parts are involved in the process of manufacturing a single chair. Now, most of these parts are to be purchased from outside vendors. Also, the required attributes for each vendor are different. Hence, the whole decision making process becomes very complex due to involvement of such a large number of attributes and decision variables.

Burton has shown that expenditure of components and parts acquired from outside suppliers adds up more than 50% of total sales for large automotive manufacturers. For high technology firms, the contribution of

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purchased material and services is about 80% of total production cost (Burton, 1988) [2]. Similarly, for large electrical utilities like TVA, total annual costs of coal purchase are nearly \$1 billion (Bender et al., 1985) [3].

Supplier decisions are one of the most important aspects that firms must incorporate into their strategic processes. As there is increase in importance of purchasing function, decisions pertinent to supplier management have become more strategic. Owing to increase in dependency of organizations on suppliers, the direct and indirect repercussion of poor decision making in supplier selection decisions become critical. For example, in the chair industry, the typical contribution of raw material cost lies between 50-70 percent, which makes purchasing decisions a key determinant of profitability (Gonzalez 2004)[4].

## 2 LITERATURE REVIEW

There are many supplier selection models delineated throughout the literature. Categorical models was quite simple approach towards vendor selection but it was proved to be very efficient and economic too [Petrone (2000)][5]. In this method, the vendors were rated on the basis of several parameters and a single score was obtained from these ratings. The weighing point model was a modification of the categorical models, but more costly owing to the complexities involved in the model. However, it retained efficiency and flexibility in optimization of vendor selection problems. In the Total cost approaches, all costs pertinent to vendor selection process were quantified such as in cost ratio approach [Timmernam (1986)][6] and Total Cost of Ownership (TCO) approach [Ellram (1990)][7], which was ultimately used to make vendor selection decision. Chen-Tung (2006)[1] used fuzzy logic approach to evaluate performance of supplier. The Multiple Attribute Utility Theory (MAUT) model allows a purchase manager to handle several contradictory attributes. It also finds applications where workable sourcing strategies are to be formulated [Bross and Zhao (2004)][9]. Analytical Hierarchical Process (AHP) structured complex vendor selection problem in form of a hierarchy. AHP was used when the vendors were compared on the basis of various parameters. It allows the purchase manager to figure out relative importance of various parameters and then various suppliers

can be ranked on basis of their performances on these parameters [Saaty (1980)][10]. A linear programming model was used to establish number of vendors to utilize and purchase quantity allocation among them, simultaneously [Pan (1989)][11]. ELECTRE method was used to provide a multi criterion decision model which was used to outsource contract selection. A utility function was defined that incorporated cost, delivery time and dependability [Almeida (2007)][12].

Lyes Benyoucef [13] has classified the decision making criterion into four classes, Performance strategy, Quality of service, Innovation and risk. Based upon a fuzzy logic approach, these qualitative attributes are evaluated quantitatively and this knowledge is used for decision making.

It is our purpose to provide a systematic approach for analyzing these decisions concurrently, trying to identify what are the critical aspects that organizations must focus on while facing these challenges. We believe this methodology can allow companies to better understand key variables involved in a manufacturing setting through analytical analysis. We illustrate the methodology with a case study in the sugar manufacturing industry.

The paper is organized as follows: reviews of the relevant literature on supplier management, methodology proposed in this study and its application to a sugar manufacturing industry. In the end, conclusions from the application are discussed.

## 3 METHODOLOGY

### 3.1 General Steps in Supplier Selection Process

The process of supplier selection starts with evaluation of requirements of organization as shown in figure 1. In this step, the gap between current scenario and desired set of conditions is assessed. It is done with input from various levels of managements, right from operational to strategic level. This data provides information on what company 'wants'. This information is used to define objectives in the next step. The objectives are largely dependent upon the type of supply chain, internal environment of organization, and also on the external market conditions. For example, the criterion of dependability becomes much more important if there are

only few suppliers in market. Hence, dependability should be having higher weight age.

After defining objectives, a pool of potential vendors is generated. Now information regarding conformation to organization's needs is gathered through the process of interviewing with the vendors. Many vendors are ruled out in this step since some vendors obviously do not meet organization's requirements. On the remaining vendors, the methodology is applied, in which various factors are quantified and scores for each vendors is generated, on basis of which vendors can be ranked. This result is analyzed and findings are used for final decision making. Based upon the ranking, the best performing vendor can be selected, or the order may be split between two or more vendors.

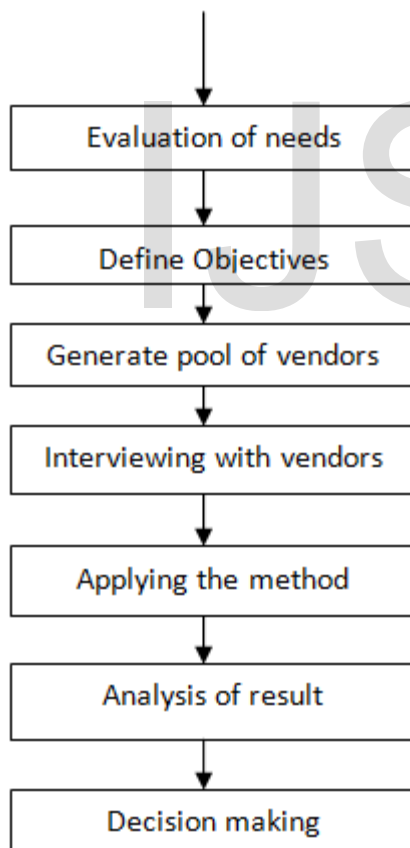


Figure 1: General steps in supplier selection process

### 3.2 Basic Supplier Selection Criterion

There can be a number of supplier selection parameters a purchase manager can take into account, such as;

- Quality
- Delivery time
- Dependability
- Price
- Financial health
- Expertise
- Operational performance metrics
- Business processes & practices
- Enabling behaviors or cultural factors
- Risk factors

### 3.3 How many suppliers?

Another important decision a purchase manager has to make is to decide how many suppliers should be selected for a single item and on what basis these selections should be made. These decisions are influenced primarily by the amounts required, the relative size of the suppliers, and their past performances. It is a usual practice to split the orders between two or three suppliers. This is done to increase the smoothness in the supply chain since the probability of failure decreases if organization depends upon more than one supplier for the same item. Also, it leads to strengthening of supplier buyer relations and a healthy competition among the suppliers.

### 3.4 Supplier selection process

In our case, a sugar manufacturing firm in North India is considered where the method of pair wise comparison and numerical evaluation is applied for selection of supplier.

In the first step, the parameters of supplier selection are defined. There are number of parameters on supplier selection as discussed previously. They are shortlisted based upon expert opinion from various management levels in the organization. Out of these parameters, some are highly important while some don't have very big impact upon the supply chain. So their relative importances are decided by the Pair wise Numerical Comparison method.

### 3.5 Preparing Numerical Evaluation Matrix:

In the short listing phase by experts, five parameters are shortlisted: Price (P), Quality (Q), Delivery Time (Dt), Dependability (D) and Documentation (Do). Now, their relative importances are found out using Pair wise Comparison and Numerical Evaluation Technique. Each of the five parameters is compared with every other parameter and the difference in their relative importance is assigned a number by the experts. If the difference in the importance of two parameters is subtle, then it is assigned 1 in the comparison matrix. Similarly, 2 is assigned for moderate difference and 3 is assigned for large difference. Based upon above analysis, a comparison matrix as shown by Table 1 is obtained. It should be noted that no two parameters can hold equal importance in this method.

Parameter	P	Q	Dt	D	Do
P	---	P-1	P-2	P-3	P-3
Q		---	Q-2	Q-3	Q-3
Dt			---	Dt-1	Dt-3
D				---	D-2
Do					---

Table 1: Pair wise comparison matrix

Based upon the comparison matrix, all the parameters are assigned score points. These score points are used to calculate relative weight ages of parameters and hence their rankings.

### 3.6 Obtaining Final score for each vendor by Numerical Evaluation Matrix:

Once the parameters are prioritized and their weight ages are calculated, Numerical evaluation matrix is used to calculate score for each vendor. In our case, there are five vendors available which are named V1, V2, V3, V4 and V5. Each of these vendors is allocated score for each of the five parameters (Score is shown outside parenthesis). These scores are calculated by assuming one minimum acceptable and one best performing

score for each parameter, and then the score for a particular vendor is calculated by linear interpolation. To obtain the final score for each vendor, the parameter weight ages are multiplied by individual scores for vendors and then all the resultants are added up.

Criterion	P	Q	Dt	D	Do	Final Score
Weight age	0.357	0.321	0.179	0.107	0.036	
V <sub>1</sub>	90 (32.1)	90 (28.9)	85 (15.2)	90 (9.6)	95 (3.4)	89.2
V <sub>2</sub>	70 (25)	80 (25.7)	95 (17)	90 (9.6)	90 (3.2)	80.5
V <sub>3</sub>	65 (23.2)	70 (22.5)	65 (11.6)	85 (9.1)	80 (2.9)	69.3
V <sub>4</sub>	65 (23.2)	70 (22.5)	60 (10.7)	75 (8)	85 (3.1)	67.5
V <sub>5</sub>	60 (21.4)	60 (19.3)	70 (12.5)	70 (7.5)	60 (2.2)	62.9

Table 2: Numerical Evaluation Matrix

### 3.7 Decision Making based upon total scores of suppliers:

Based upon the analysis, we see that vendor 1 and vendor 2 are front runners with marginal difference in their final scores. All the other vendors need to improve a lot to stay in competition. The selection of vendors on basis of these scores is a subjective task. A purchase manager has to take all the dynamic factors into account to select vendors(s) from the given pool. For a relatively static market, the order can be placed to best performing vendors (vendor having highest final score). But in dynamic market situation where there are uncertainty associated with every parameter, it is a practical and safer approach to split the order between more than one vendor. It is also helpful for building and maintaining long term relations with the vendors. In our case, Vendor 1 & Vendor 2 are having highest scores and also, their scores are close enough. Hence, both, Vendor 1 & Vendor 2 shall be selected and the business will be divided in the ratio of 60:40 to have a competition between them for the increase in business share.

#### 4 REFERENCES

- 1) CT Chen, CT Lin, SF Huang(2006), "A fuzzy approach for supplier evaluation and selection in supply chain management," *Production Economics*, Vol. 102, 289-301.
- 2) TT Burton(1988), "JIT/repetitive sourcing strategies: Tying the knot with your suppliers", *Production and Inventory Management Journal*, 38-41.
- 3) PS Bender, RW Brown, MH Isaac, JF Shapiro(1985), "Improving purchasing productivity at IBM with a normative decision support system," *Interfaces*, 15(3), 106-115.
- 4) EG Marvin, Q Gioconda, AMM Carlo (2004), "Determining the importance of the supplier selection process in manufacturing: a case study", *International Journal of Physical Distribution & Logistics Management*, Vol. 34 Issue: 6, 492-504.
- 5) A Petroni, M Braglia (2000), "Vendor Selection Using Principal Component Analysis", *Journal of Supply Chain Management*, 36, 63-69
- 6) M Timmerman, (1986), "An approach to vendor performance evaluation," *The Journal of Supply Chain Management*, Vol. 10, No. 12, 2-8.
- 7) LM Ellram, (1990), "The supplier selection decision in strategic partnerships," *International Journal Purchasing and Materials Management*, Vol. 26, No. 4, 8-14.
- 8) CA Weber, JR Current, WC Benton(1991), "Vendor selection criteria and methods", *European Journal of Operational Research* , 50, 2-18
- 9) ME Bross, G Zhao, (204), "Supplier selection process in emerging markets -The Case Study of Volvo Bus Corporation in China", [M.Sc. Thesis], 2004, School of Economics and Commercial Law Göteborg University.
- 10) TL Saaty, *The Analytic Hierarchy Process*, 1980, McGraw-Hill, NY.
- 11) AC Pan(1989), "Allocation of order quantity among suppliers," *International Journal Purchasing and Materials Management*, Vol. 25, No. 3, 36-39.
- 12) AT Almeida(2007), "Multicriteria decision model for outsourcing contracts selection based on utility function and ELECTRE method," *Computers & Operations Research*, Vol. 34, 3569-3574.
- 13) A Zouggari, L Benyoucef, V Jain(2009), "A knowledge-based discrete event simulation approach for supplier selection with order allocation," 2009 IEEE International Conference on Industrial Engineering and Engineering Management, Hong Kong, 2009, 1673-1678.
- 14) MCY Tam, VMR Tummala, Omega "An application of the AHP in vendor selection of a Telecommunications system", Volume 29, Issue 2, 2001, Pages 171-182.
- 15) Nydick, RL Hill, R Paul (1992) "Using the Analytic Hierarchy Process to Structure the Supplier Selection Procedure", *International Journal of Purchasing & Materials Management*. 28(2), 31-36.
- 16) GW Dickson(1966), "An analysis of vendor selection systems and decisions", *Journal of Purchasing*, Volume 2, Issue 1, 5-17.
- 17) CC Wei, CF Chien, MJJ Wang(2005), "An AHP-based approach to ERP system selection", *International Journal of Production Economics*, Volume 96, Issue 1, 47-62.