

A REVIEW OF SUPPLIER SELECTION METHODS IN MANUFACTURING INDUSTRIES

Farzad Tahriri, Mohammad Rasid Osman, Aidy Ali* and Rosnah Mohd Yusuff

Received: Sept 24, 2007; Revised: Jun 2, 2008; Accepted: Jul 29, 2008

Abstract

In today's highly competitive environment, an effective supplier selection process is very important to the success of any manufacturing organization. In this context, supplier selection represents one of the most important functions to be performed by the purchasing department. Supplier selection is a multi-criterion problem which includes both qualitative and quantitative factors (criteria). A trade-off between these tangible and intangible factors is essential in selecting the best supplier. A number of models and techniques have been developed to deal with selecting and evaluating suppliers. In this paper, different selection methods concerning supplier selection are discussed and the advantages and disadvantages of selection methods, especially the Analytic Hierarchy Process (AHP), are illustrated and compared.

Keywords: Analytic Hierarchy Process (AHP), supplier selection, qualitative and quantitative criteria

Introduction

Supplier selection and evaluation have become one of the major topics in production and operations management literature, especially in advanced manufacturing technologies and environment (Motwani *et al.*, 1999). The main objective of supplier selection process is to reduce purchase risk, maximize overall value to the purchaser, and develop closeness and long-term relationships between buyers and suppliers, which is effective in helping the company to achieve "Just-In-Time" (JIT) production (Li *et al.*, 1997). Additionally, with the increase in use of Total Quality Management

(TQM) and Just-In-Time (JIT) concepts by a wide range of firms, the supplier selection question has become extremely important (Petroni, 2000). Choosing the right method for supplier selection effectively leads to a reduction in purchase risk and increases the number of JIT suppliers and TQM production.

Supplier selection is a multiple criteria decision-making (MCDM) problem which is affected by several conflicting factors. Consequently, a purchasing manager must analyze the trade-off between the several criteria. MCDM techniques support the

Department of Mechanical and Manufacturing Engineering, University of Putra Malaysia, 43400 Serdang, Selangor, Malaysia E-mail: aidy@eng.upm.edu.my

** Corresponding author*

decision-makers (DMs) in evaluating a set of alternatives (Amid *et al.*, 2006). Supplier selection problem has become one of the most important issues for establishing an effective supply chain system. The supplier selection problem in a supply chain system is a group decision according to multiple criteria from which a number of criteria have been considered for supplier selection in previous and present decision models (Chen-Tung *et al.*, 2006). The purchasing manager must know a suitable method, then use the best method from the different types of methods to select the right supplier.

Supplier Selection Methods

Supplier selection methods are the models or approaches used to conduct the selection process (Li *et al.*, 1997). The methods chosen are extremely important to the overall selection process and can have a significant influence on the selection results. It is important to understand why a firm chooses one method (or a combination of different methods) over another. Several well-known selection methods have been developed and classified by numerous scholars over the years. Certain methods have been popular selection choices for years, while other methods have only emerged recently. Usually when a company sets out to develop or choose a supplier selection method, the result is a combination of several different methods with different strengths suited to meet the company's specific selection needs. Therefore, it is important to explore a range of different selection methods and to discuss their different applications.

There are several supplier selection methods available in the literature. Some authors propose linear weighting models in which suppliers are rated on several criteria and in which these ratings are combined into a single score such as the categorical model. The categorical model is a simple method, but it is also the quickest, easiest, and least costly to implement. However, it may be influenced by recent events and usually implies a high level of subjectivity and therefore it is imprecise (Petroni, 2000).

The weighted point model is also easy to implement, flexible, and fairly efficient in the optimization of supplier selection decisions. It is more costly than the categorical method, but tends to be more objective, even though it relies on the buyer's assessment of the supplier performance. Total cost approaches attempt to quantify all costs related to the selection of a vendor in monetary units. This approach includes cost ratio (Timmerman, 1986) and Total Cost of Ownership (TCO) (Ellram, 1990). The cost ratio method is very flexible. It is a complex method that requires a developed cost accounting system. The total cost model is precise, expensive to implement due to its complexity and requires more time and implies the ability to identify the more important elements. Mathematical programming models often consider only the more quantitative criteria; this approach includes the Principal Component Analysis (PCA) and the Artificial Neural Network (ANN).

According to Bello (2003), the PCA method has two advantages that are accessible and capable of handling multiple conflicting attributes. The ANN model saves money and time. The weakness of this model is that it demands specialised software and requires qualified personnel who are expert on this subject. Over the years, researchers have begun to classify and group the individual supplier selection methods into a number of broader categories, with each classification having both advantages and disadvantages.

The Multiple Attribute Utility Theory (MAUT) method has the advantage that it enables purchasing professionals to formulate viable sourcing strategies and is capable of handling multiple conflicting attributes. However, this method is only used for international supplier selection, where the environment is more complicated and risky (Bross and Zhao, 2004).

According to Chen-Tung *et al.* (2006), the Fuzzy logic approach measures for supplier performance evaluation. This approach can help Decision Making (DM) to find out the appropriate ordering from each supplier. Another useful method is the Analytical Hierarchical Process (AHP), a decision-making method developed for prioritizing alternatives when

multiple criteria must be considered and allows the decision maker to structure complex problems in the form of a hierarchy, or a set of integrated levels.

The AHP is relatively simple to use and understand. This method incorporates qualitative and quantitative criteria. A review of the supplier selection literature shows that the AHP method to be one of the most commonly applied methods in practice. AHP is an ideal method for ranking alternatives when multiple criteria and sub-criteria are present in the decision-making process.

The AHP was introduced by (Saaty, 1980). There has been wide discussion about the empirical effectiveness and theoretical validity of this technique. Similar to that of the MAUT, AHP allows the decision-maker to structure complicated problems in the form of a decision hierarchy. The hierarchy usually consists of three different levels, which include goals, criteria, and alternatives.

AHP is often considered as a supplier selection method because it allows decision makers to rank suppliers based on the relative importance of the criteria and the suitability of the suppliers (Saaty, 1980). AHP offers a methodology to rank alternative courses of action based on the decision maker's judgments concerning the importance of the criteria and the extent to which they are met by each alternative. For this reason, AHP is ideally suited for the supplier selection problem. The problem hierarchy lends itself to an analysis based on the impact of a given level on the next higher level. The process begins by

determining the relative importance of the criteria in meeting the goals. Next, the focus shifts to measuring the extent to which the alternatives achieve each of the criteria. Finally, the results of the two analyses are synthesized to compute the relative importance of the alternatives in meeting the goal. Managerial judgments are used to drive the AHP approach (Yusuff *et al.*, 2001).

These judgments are expressed in terms of pair-wise comparisons of items on a given level of the hierarchy with respect to their impact on the next higher level. Pair-wise comparisons express the relative importance of one item versus another in meeting a goal or a criterion. Each of the pair-wise comparisons represents an estimate of the ratio of the weights of the two criteria being compared. Because AHP utilizes a ratio scale for human judgments, the alternatives weights reflect the relative importance of the criteria in achieving the goal of the hierarchy (Maggie and Tummala, 2001).

The use of AHP is increasing with time; since a lot of journals are bringing out special issues, on this topic. Omkarprasad, and Kumar, 2006 have written an excellent review and shown the percentage use of the AHP method during the specified time periods as shown in Figure 1.

The use of the AHP approach offers a number of benefits. One important advantage is its simplicity (Liu and Hai, 2005). AHP can also accommodate uncertainties and subjective information, and allows the application of experience, insight, and intuition in a logical

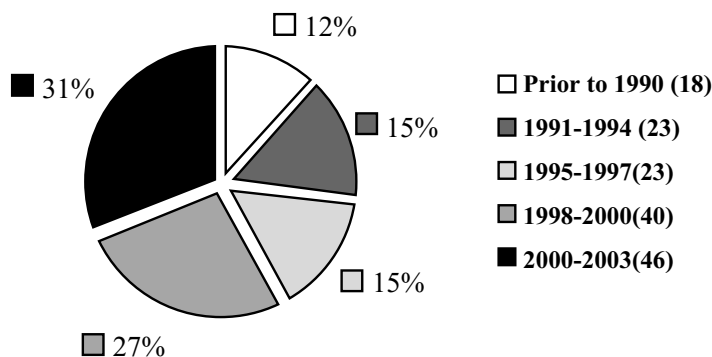


Figure 1. Distribution of review papers on the use of AHP method over the years

manner. It is observed that AHP is being predominantly used in the area of selection and evaluation (Maggie and Tummala, 2001).

Advantages and Disadvantages of the AHP Method

One advantage of AHP is that it illustrates how possible changes in priority at upper levels have an effect on the priority of criteria at lower levels. Moreover, it provides the buyer with an overview of criteria, their function at the lower levels and goals as at the higher levels. A further advantage of AHP is its stability and flexibility regarding changes within and additions to the hierarchy. In addition, the method is able to rank criteria according to the needs of the buyer which also leads to more precise decisions concerning supplier selection. The main advantage of AHP is that the buyer is able to get a good picture of the supplier's performance by using the hierarchy of the criteria and evaluating the suppliers (Omkarprasad and Kumar, 2006). However, AHP also has some weak points. One of these is the complexity of this method which makes its implementation quite inconvenient. Moreover, if more than one person is working on this method, different opinions about the weight of each criterion can complicate matters. AHP also requires data based on experience, knowledge and judgment which are subjective for each decision-maker. A further disadvantage of this method is that it does not consider risks and uncertainties regarding the supplier's performances (Yusuff *et al.*, 2001).

The strength of the AHP method lies in its ability to structure complex, multi-person, multi-attribute, and multi-period problems hierarchically and it is simple to use and to understand. It necessitates the construction of a hierarchy of attributes, sub-attributes, alternatives and so on, which facilitates communication of the problem and the recommended solutions. In addition, the AHP method provides a unique means of quantifying judgmental consistency. AHP does not require preferences independent of its complement (i.e., the preference order of consequences, for any pair of attributes does not depend on the levels at which all other attributes

are placed) as MAUT model.

Some benefits of AHP method provided the follow explanation.

a. The strength of the AHP method lies in its ability to structure a complex, multi person, multi attribute, and multi period problem hierarchically (Saaty, 1980).

b. It is simple to use and understand (Chan, 2003).

c. It necessitates the construction of a hierarchy of attributes, sub attributes, alternatives and so on, which facilitates communication of the problem and recommend solutions (Yusuff *et al.*, 2001).

d. It provides a unique means of quantify judgmental consistency (Chan, 2003).

e. It does not greatly intuition, experience, and theoretical knowledge of the domain expert as expert system (Yusuff *et al.*, 2001).

f. It does not require preferential independent of its complement (i.e. the preference order of consequences, for any pair of attributes does not depend on the levels at which all other attributes are hold) as multi-attribute utility model (Chan, 2003).

AHP provides remarkable versatility and power in structuring and analyzing complex multi-attribute decision-making problems. Figure 2 shows the relationship between the criteria and the methods for supplier selection since 1960. The criteria are classified into 2 groups: quantitative and qualitative. The figure shows that after 2003 more attention has been given to qualitative criteria. After 2003, the changes in the use of qualitative criteria, and the methods in supplier selection have been changed as a consequence. During these years, it was necessary to change measure qualitative and quantitative criteria. Figure 2 shows the variation on the use of quantitative to qualitative criteria during this period and it also clearly shows the mostly used supplier selection methods from 2003 until the present.

The AHP approach, as applied to the supplier selection problem, consists of the following five steps (Nydick and Hill, 1992):

1. Specify the set of criteria for evaluating the supplier's proposals.
2. Obtain the pair-wise comparisons of the

relative importance of the criteria in achieving the goal, and compute the priorities or weights of the criteria based on this information.

3. Obtain measures that describe the extent to which each supplier achieves the criteria.

4. Using the information in step 3, obtain the pair-wise comparisons of the relative importance of the suppliers with respect to the criteria, and compute the corresponding priorities.

5. Using the results of steps 2 and 4, compute the priorities of each

supplier in achieving the goal of the hierarchy. AHP helps to incorporate a group consensus. Generally this consists of a questionnaire for comparison of each element and geometric mean to arrive at a final solution (Omkarprasad and Kumar, 2006). Ghodsupour and O'Brien (1998) studied based on AHP method to conflicts between two tangible and intangible factors, i.e. qualitative and quantitative, in order to choose the best suppliers. Ghodsupour and O'Brien (1998) had integrated AHP and Linear Programming to consider both tangible and intangible factors in choosing the best suppliers and placing the optimum order quantities among them such that by using integrated AHP and LP the total value of purchasing (TVP) becomes maximum. This model can be applied to supplier selection with or without capacity constraints.

According to Ghodsupour and O'Brien (1998); the advantages of this method for

supply selection are:

(1) Both tangible and intangible factors which are very important in supplier selection can be included in a multiple sourcing policy, while existing models can only consider the quantitative factors.

(2) Corporate strategies can be reflected in purchasing activities.

(3) Using real data, the calculation is simplified and the system's consistency is improved.

(4) Using pair-wise comparison reduces dependency of the system on human judgment.

(5) Both weight of criteria and rank of suppliers are determined by one systematic approach (Ghodsupour and O'Brien, 1998).

Handeld *et al.* (2002) studied Environmental criteria to supplier assessment by transforming purchasing into a more strategic function. The authors integrated the environmental issues to make purchasing managers introduce dimensions into their decisions, for which both qualitative and quantitative factors complicate the problem. By applying AHP in environmental criteria to supplier assessment, the authors were able to solve the above problem. This problem causes a gap in the assessment of suppliers concerning the measurements of the environmentally responsible processes and products, which is both in the framework of supplier decision making and the assessment programs. They integrated these two factors together by using

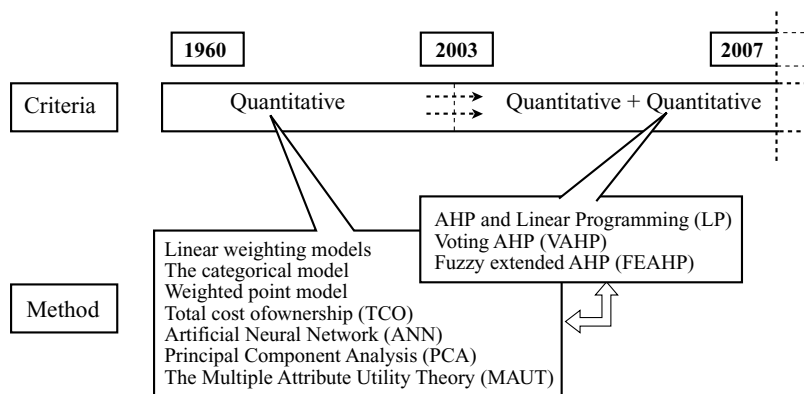


Figure 2. Classification of supplier selection criteria and methods since 1960

AHP system. AHP method may integrate environmental criteria in the sourcing decision process for supplier selection.

Liu and Hai (2005) studied supplier selection by integrating a collaborative purchasing program and came up with a new approach, based on the use of Saaty's (1980) AHP method. This method compares the weighted sum of the selection number of rank votes, after determining the weights in a selected rank.

This system, called voting AHP (VAHP), provides a simpler method than AHP, but does not lose the systematic approach of deriving the weights and sorting performance of suppliers. VAHP allows the purchasing manager to generate non inferior purchasing options and systematically analyze the inherent trade-offs among the relevant criteria. It is expected that in near future this method will be applied effectively to various issues such as: policymaking, business strategies, and performance assessment (Liu and Hai, 2005).

Yahya and Kingsman (1999) used Saaty's AHP method to determine priority in selecting suppliers. The authors applied vendor rating in supplier selection and in deciding how to allocate business, as well as in determining where development effort is applied. This study is performed for a government sponsored entrepreneur development program in Malaysia. This particular Umbrella Scheme of Malaysia's furniture industry was applied using this method. The selection of vendors in Umbrella Scheme Company has to be done not only to ensure benefits to the purchaser customers but also to develop the vendors. The emphasis has to include a mutual benefit. The multiple and conflicting objectives, both getting good quality furniture companies improve their operations, imply that the criteria to use in selecting vendors might be different than that for normal commercial purchasing of goods. Given also the need to identify the strengths and weaknesses of vendors for the development purposes of the scheme, a vendor rating system is essential and cannot be avoided.

Another research based on AHP method unique in one company found out by Tam and Tummala (2001) in empirical study in Telecom-

munication System. This Telecommunication System Company has a long term investment and is directly affected by the vendor selection decision which is a complex multi-person, multi-criteria decision problem. Thus the authors applied AHP to take care of several decision makers to examine the strengths and weaknesses of vendor systems by comparing them with the appropriate criteria and sub-criteria. Time and effort are also reduced in decision making. For easy computation, the results can be transferred to the spread sheet easily.

For Tian Jin Electric Construction Company, Yu and Jing (2004) had developed a new decision model for choosing the optimal supplier combination based on unique company. Yu and Jing (2004) according to previous research by Tam and Tummala (2001), found out through research that trust between suppliers and buyers is the best criterion for selecting optimal supplier which reduces the cost, by using AHP and Linear Programming (LP). The authors established trust for Tian Jin Electric Construction Company. AHP and LP were proposed to consider both tangible and intangible factors leading to the supplier selection under the influence of inter-firm and interpersonal trust. Through research, the authors came up with the fact that quality criteria can be more influential in supplier selection than quantity. Although other criteria such as: cost, quality and delivery were used and focused trust and its importance for supplier selection methodology.

Conclusions

The issues of supplier selection have attracted the interest of researchers since the 1960s, and research studies in this area have increased. A study was conducted to determine what criteria were used in the selection of a firm as a supplier. Most of these criteria during that time were quantitative. During that time the researchers did not give attention to qualitative criteria which had a lower level ranking for the evaluation and the selection of suppliers. Method for DM to measure qualitative criteria such as AHP, Fuzzy etc. was used to select suppliers. Nowadays, qualitative methods received more attention in

decision-making models for selecting the suppliers. Consequently, the researchers will focus on qualitative criteria in the future rather than a combination of both qualitative and quantitative criteria with existing methods such as AHP. Nowadays, AHP and Fuzzy AHP as two precise methods for supplier selection decision-making are believed to be useful for managers due to their simplicity in use. Yet again, it is proven that AHP work well in making decision for many types of companies that involves different types of suppliers. Based on above review, it would be not irrational to suggest that the supplier selection issues need further attention in order to harmonies the combination of qualitative and quantitative criteria to develop the best decision-making models for the selection of the best suppliers.

Acknowledgement

The authors wish to thank the Department of Mechanical and Manufacturing Academic Staff at University of Putra Malaysia for the support.

References

- Amid, A. and Ghodsypour, S.H. (2006). Fuzzy multiobjective linear model for supplier selection in a supply chain. *Production Economics*, 104:394-407.
- Bello, M.J.S. (2003). A case study approach to the supplier selection process, [M.Sc. thesis]. School of Management Systems Engineering, University of the Puerto Rico Mayaguez Campus. p. 73-88.
- Bross, M.E. and Zhao, G. (2004). Supplier selection process in emerging markets - The Case Study of Volvo Bus Corporation in China, [M.Sc. thesis]. School of Economics and Commercial Law Göteborg University.
- Chan, F.T.S. (2003). Interactive selection model for supplier selection process: an analytical hierarchy process approach. *Int. Journal of Production Research*, 41(15):3,549-3,580.
- Chen-Tung, C. and Ching-Torng, L. (2006). A fuzzy approach for supplier evaluation and selection in supply chain management. *Production Economics*, 102:289-301.
- Ellram, L.M. (1990). The supplier selection decision in strategic partnerships. *J. Purch. Mater. Manag.*, 26(4):8-14.
- Ghodsypour, S.H. and O'Brien, C. (1998). A decision support system for supplier selection using an integrated analytical hierarchy process and linear programming. *Int. J. Prod. Econ.*, 56-67: 199-212.
- Handeld, R., Walton, S.V., and Sroufe, R. (2002). Applying environmental criteria to supplier assessment: A study in the application of the Analytical Hierarchy Process. *EJOR* 141:70-87.
- Li, C.C. and Fun, Y.P. (1997). A new measure for supplier performance evaluation. *IIE Transactions*, 29(1):753-758.
- Liu, F.-H.F. and Hai, H.L. (2005). The voting analytic hierarchy process method for selecting supplier. *Int. J. Prod. Econ.* 97 (3):308-317.
- Maggie C.Y.T. and Tummala, V.M.R. (2001). An application of the AHP in vendor selection of a telecommunications system. *Omega*, 29:171-182.
- Motwani, J. and Youssef, M. (1999). Supplier selection in developing countries: a model development. *Emerald*, 10(13):154-162.
- Nydick, J. and Hill, F. (1992). Using the analytic hierarchy process to structure the supplier selection procedure. *Int. J. Purch. Mater. Manag. Review*, 1(1):31-36.
- Omkarprasad, S.V. and Kumar, S. (2006). Analytic hierarchy process: an overview of applications. *EJOR*, 169:1-29.
- Saaty, T.L. (1980). *The Analytic Hierarchy Process*. McGraw-Hill, NY, 287p.
- Petroni, A. (2000). Vendor selection using principal component analysis. *The JSCM*, 1(13):63-69.
- Tam, M.C.Y. and Tummala, V.M.R. (2001). An Application of the AHP in vendor selection of a telecommunications system. *Omega*, 29(2): 171-182.
- Timmerman, M. (1986). An approach to vendor performance evaluation. *The JSCM*, 10 (12):2-8.
- Yahya, S. and Kingsman, B. (1999). Vendor

- rating for an entrepreneur development programme: a case study using the analytic hierarchy process method. *JORS*, 50: 916-930.
- Yusuff, R.D. and Poh Yee, K. (2001). A preliminary study on the potential use of the analytical hierarchical process (AHP) to predict advanced manufacturing technology (AMT) implementation. *Robotics and Computer Integrated Manufacturing*. 17:421-427.
- Yu, X. and Jing, S. (2004). A Decision Model for Supplier Selection Considering Trust. *Chinese Business Review*, 3(6):15-20.