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Full Length Research Paper

Selecting the best supplier using analytic hierarchy process (AHP) method

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The purchasing function of a firm directly affects its competitive ability. Purchasing managers need to periodically evaluate the performance of suppliers in order to retain those who meet their requirements. There are various criteria for supplier selection and evaluation. This report provides a guideline for establishing supplier selection criteria for purchasing activities of University Procurement Department in accordance with some purchasing topics. The analytic hierarchy process (AHP) decision making process functions in terms of the multi-criteria analysis for cost, flexibility, quality, delivery, and variety. The present report provides an accurate and easy classification in supplier attributes that have been prioritized in the model.

Key words: Multi criteria decision-making (MCDM), analytic hierarchy process (AHP), supplier selection, supply chain management (SCM).

INTRODUCTION

Today, in business environment, it became more important to improve the productivity of a firm in global competition. This productivity can be supported in the internal processes of supply chain management (SCM). The most important part of the SCM is the purchasing activity, and the multi-criteria analysis appears to be the right solution for the classification of many purchased goods in the firm as the effort to obtain products at a reasonable cost, in the right quantity, the appropriate quality, at the right time from the right source, is quite crucial for a firm's survival at the market (Simchi-Levi and Kaminsky, 2003). The selection of the inappropriate suppliers could cause important operational and financial problems for the purchasing company. On the other hand, selecting the right suppliers reduces the purchasing cost, quality problems, and long-lead times and definitely improves corporate competitiveness (Vokurka and Fliedner, 1998; Meade and Sarkis, 1999; Humphreys et al., 2007). Furthermore, suppliers have a direct and significant impact on the quality, cost and leadtime of new products and technologies needed to meet new and emerging market demands (Bolstorff and Rosenbaum, 2007).More recently, with emergence of the concept of SCM, more and more scholars and practitioners have realized that supplier selection and management was a vehicle that can be used to increase the competitiveness of the entire supply chain (Lee et al., 2001).

As such, many researchers such as Thanaraksakul and Phruksaphanrat (2009) have concluded that supplier selection and evaluation is one of the most critical activities in purchasing or procurement process (Bayazit et al., 2006). This evaluation process consists of 4 stages; defining objective, formulating the selection criteria, qualifying the suitable alternatives, and final selection. To qualify the prospective suppliers, the effective defining of selection criteria is necessary (Weber et al., 1991; Droge et al., 1991). Beyond the high significance on the product cost and partners relationship, it has considerable impacts on the buyer's corporate competencies (Sarkis and Talluri, 2002; Ha and Krishnan, 2008).

In this study, a simple method for supplier evaluation and a selection based on cost, quality, flexibility, delivery, and variety are used in the analytic hierarchy process (AHP) analysis for the University Procurement Department. The model quantifies five multiple criteria in AHP to combine them into one global variable for decision-making. A numerical example is also presented to better illustrate the model.

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LITERATURE REVIEW

Ho et al. (2010) has just realized the most recent review on supplier selection, they councluded that the contemporary supply management is to maintain long term partnership with suppliers, and use fewer but reliable suppliers. Therefore, choosing the right suppliers involves much more than scanning a series of price list, and choices will depend on a wide range of factors which involve both quantitative and qualitative. Extensive multi-criteria decision making approaches have been proposed for supplier selection, such as the analytic hierarchy process (AHP), analytic network process (ANP), case-based reasoning (CBR), data envelopment analysis (DEA), fuzzy set theory, genetic algorithm (GA), mathematical programming, simple multi-attribute rating technique (SMART), and their hybrids.

Though many proposals are discussed to develop analytical approaches for evaluating various suppliers, the analytical application for supplier selection is limited for the review of supplier selection problems; it is possible to refer to Weber et al. (1991), Partovi et al. (1990) Degraeve et al. (2000), and De Boer et al. (2001). There are basically two stages in the global supplier selection process. In first stage, the decision variables, critical for the selection process should be identified and in the second stage, a specific decision making technique should be analyzed in order to discuss the preferences of alternative suppliers based on the criteria that will be discussed subsequently. In general, most of the researchers have identified cost, quality and service as their primary-basic decision criteria. From another perspective, there are few other subjective factors to be considered in supplier selection such as; cultural compatibility, long-term plan, financial stability, the compatibility of top management, honesty of the supplier, product range, relationship closeness, conflict resolution, trust and visibility, etc. (Weber and Current, 1993). Many articles which emphasize the impact of just-in-time (JIT) manufacturing strategy on the selection activity have been published.

There is another application for supplier selection called the weighted method (Akarte et al., 2001). The model works with the factors on relevant weight and rates the potential suppliers with respect to weighted factors determined by the procurement department. The decision-makers rate the expected performance of the suppliers by each evaluation criterion under subjective judgement. The supplier performance ratings are multiplied by their respective importance weights to the yield. Finally, the vendor with the highest summated score is the superior choice. Yet, the model has the disadvantage of assumption in ordinal scale as a cardinal scale.

Muralidharan et al. (2002) proposed a five-step AHP-based model to aid decision makers in rating and selecting suppliers with respect to nine evaluating criteria. People from different functions of the company, such as purchasing, stores, and quality control, were involved in the selection process.

Chan (2003) developed an interactive selection model with AHP to facilitate decision makers in selecting suppliers. The model was so-called because it incorporated a method called chain of interaction, which was deployed to determine the relative importance of evaluating criteria without subjective human judgment. AHP was only applied to generate the overall score for alternative suppliers based on the relative importance ratings.

Chan and Chan (2004) applied AHP to evaluate and select suppliers. The AHP hierarchy consists of six evaluating criteria and 20 sub-factors, of which the relative importance ratings were computed based on the customer requirements.

Liu and Hai (2005) applied AHP to evaluate and select suppliers. Similar to Chan and Chan (2003), the authors did not apply the AHP's pairwise comparison to determine the relative importance ratings among the criteria and sub-factors. Instead, the authors used Noguchi's voting and ranking method, which allowed every manager to vote or to determine the order of criteria instead of the weights (Thanaraksakul and Phruksaphanrat, 2009).

Chan et al. (2007) developed an AHP-based decision making approach to solve the supplier selection problem. Potential suppliers were evaluated based on 14 criteria. A sensitivity analysis using Expert Choice was performed to examine the response of alternatives when the relative importance rating of each criterion was changed.

Hou and Su (2007) developed an AHP-based decision support system for the supplier selection problem in a mass customization environment. Factors from external and internal influences were considered to meet the needs of markets within the global changing environment.

AHP model

Multi criteria decision-making (MCDM) is a modeling and methodological tool for dealing with the complex engineering problems. Multi-attribute decision-making (MADM) is the most well known branch of decision-making. It is a branch of a general class of operations research models that deal with the decision-making problems under the presence of a number of decision making criteria. The MADM approach requires the selection to be made among decision alternatives described by their attributes. MADM problems are assumed to have predetermined, and limited number of decision alternatives. Solving a MADM problem involves sorting and ranking.

The AHP is a well-known method for solving decision-making problems. AHP is one of the most widely used multi-attribute decision-making (MADM) methods. In this

Table 1. The 1-9 scale for AHP.

Importance intensity	Definition	Explanation
1	Equal mportance	Two activities contribute equally to the objective
3	Moderate importance of one over another	Experience and judgement slightly favor one over another
5	Strong importance of one over another	Experience and judgment strongly favor one over another
7	Very strong importance of one over another	Activity is strongly favored and its dominance is demonstrated in practice
9	Extreme importance of one over another	Importance of one over another affirmed on the highest possible order
2, 4, 6, 8	Intermediate values	Used to represent compromise between the priorities listed above

Table 2. Outlined criteria.

Criteria	Definition
Cost	Defined as the summation of net price after discount (if any) for purchased materials by the manager of department.
Quality	Includes the material terms of use suitability, use time and duration. Can be determined considering these sub-criteria.
Payment flexibility (P.F.)	The company attaches the importance to the payment in terms of delay or installment. These are preferred more if available.
Delivery	Important especially for time based companies. Defined sum of time required for the necessary materials and how many days or hours it takes to supply these materials.
Variety	Sometimes the requirements can be changed up to daily conditions, therefore suppliers are able to provide changing demands.
Quality	Includes the material terms of use suitability, use time and duration. Can be determined considering these sub-criteria.

method, the decision-maker (DM) performs pair-wise comparisons, and, the pair-wise comparison matrix and the eigenvector are derived to specify the weights of each parameter in the problem. The weights guide the DM in choosing the superior alternative.

The AHP has a special concern with departure from consistency and the measurement of this departure, and with dependence within, and between, the groups of elements of its structure; it has found its widest applications in multi-criteria decision-making in planning and resource allocation, and in conflict resolution. In its general form, the AHP is a non-linear framework for carrying out both deductive and inductive thinking without the use of syllogisms. This is made possible by taking several factors into consideration simultaneously, allowing for dependence and for feedback and making numerical trade-offs to arrive at a synthesis or conclusion. Scale of measurement for AHP which is proposed by Saaty (1980) is shown in Table 1.

APPLYING THE METHODOLOGY: AN ILLUSTRATIVE PROBLEM

Data and sample

In this study, the real data sets which are sourced from the University Procurement Department are used. According to the outcomes of the meetings handled with the managers, employees of the procurement department, and experts of procurement, 4 main topics, under which more purchasing are done, were determined as stationary, hygiene, equipment and computers. The managerial board of department is to choose the best supplier between 3 suppliers of stationary, hygiene and computers, and 2 suppliers of equipment according to the criteria outlined in Table 2. While investigating the suppliers under these criteria, the suppliers which belong to same topic are compared with each

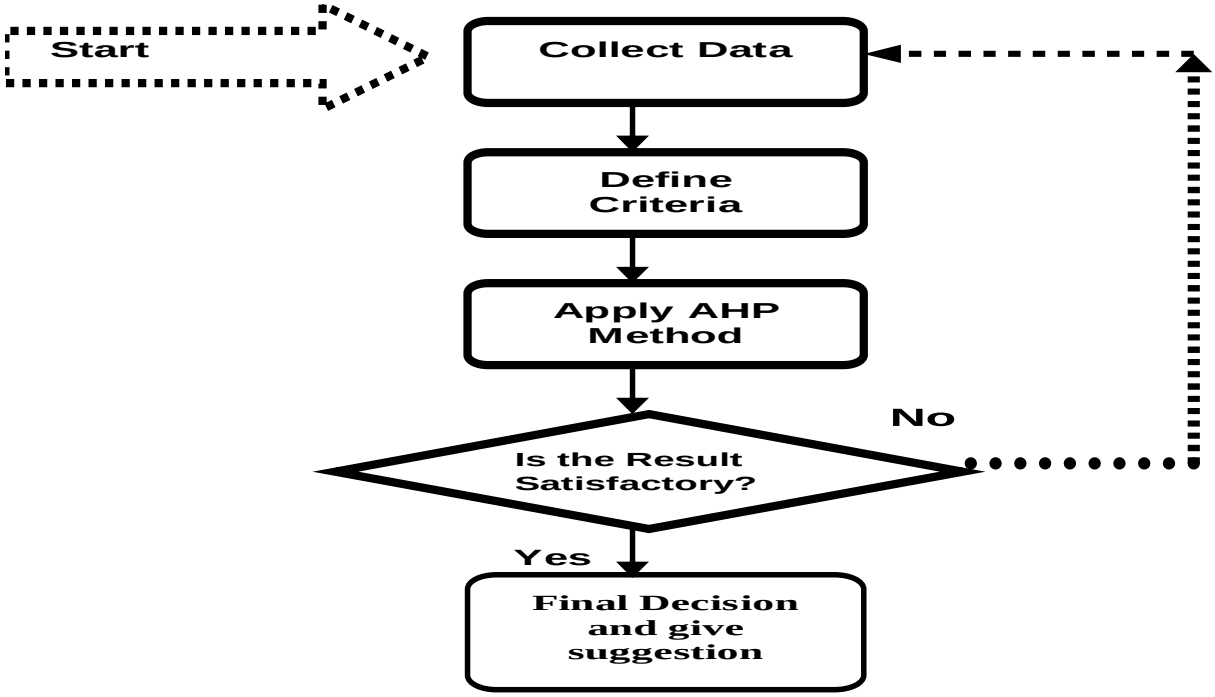

Figure 1. Schematic diagram of the proposed model for case study

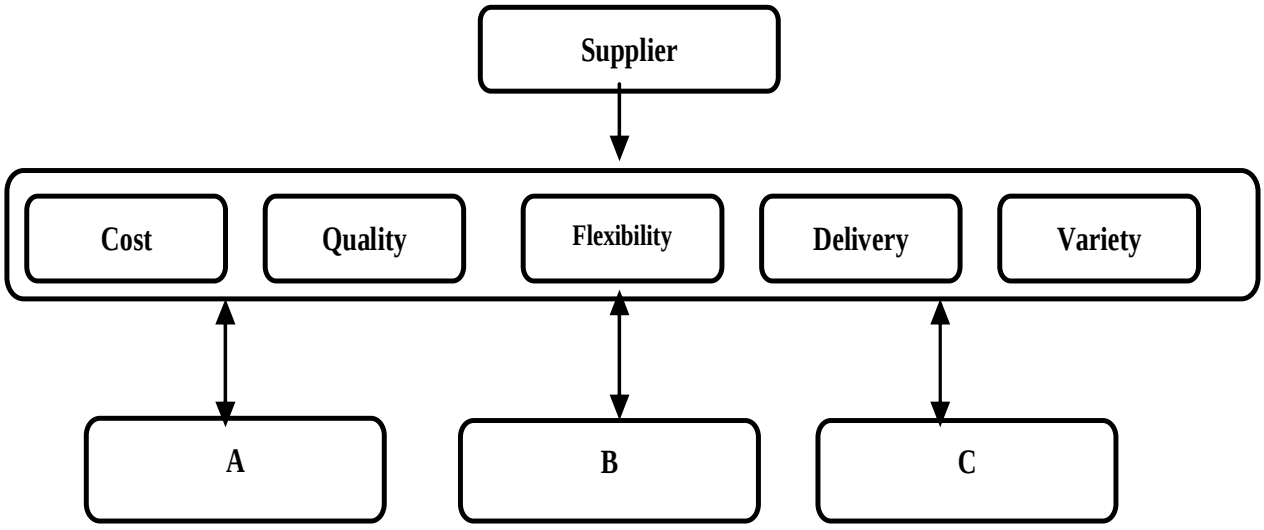

Figure 2. Decomposition of the problem into a hierarchy.

other by using Scale of measurement for AHP. Schematic diagram of the proposed model for case study is shown in Figure 1, and also, a hierarchical categorization of the problem is shown in Figure 2.

Comparison of criteria is outlined for procurement of computer in Table 3. The comparison of the 3 suppliers, which are named as A, B, C under the criteria for procurement of computer by using AHP method whereas, are outlined in Table 4. As seen in Table 4, for computer procurement, supplier A (0.5539) is preferred.

The comparison of criteria is outlined for procurement of equipment in Table 5. While the comparison of the other 2 suppliers, which are named as A and B under criteria for procurement of equipment by using the AHP method, the results are outlined in Table 6. According to the results in Table 6, supplier A (0.7071) is preferred for procurement of equipment.

The comparison of criteria is outlined for the procurement of stationary in Table 7. For the third topic procurement of stationary, when the suppliers named A, B, C are compared under the criteria

Table 3. Comparison of criteria for procurement of computer.

Criteria	Cost	Quality	P.F	Delivery	Variety
Cost	0.38	0.38	0.40	0.37	0.25
Quality	0.38	0.38	0.40	0.37	0.25
P.F	0.13	0.13	0.13	0.21	0.20
Delivery	0.04	0.04	0.03	0.04	0.25
Variety	0.08	0.08	0.03	0.01	0.05
Cost		**A**	**B**	**C**	**Priority vector**
A		0.65	0.56	0.69	0.63
B		0.13	0.11	0.08	0.11
C		0.22	0.33	0.23	0.26
Quality		**A**	**B**	**C**	**Priority vector**
A		0.75	0.64	0.79	0.72
B		0.11	0.09	0.05	0.08
C		0.15	0.27	0.16	0.19
P.F		**A**	**B**	**C**	**Priority vector**
A		0.16	0.15	0.23	0.18
B		0.79	0.76	0.69	0.75
C		0.05	0.08	0.08	0.07
Delivery		**A**	**B**	**C**	**Priority vector**
A		0.08	0.05	0.10	0.07
B		0.38	0.24	0.23	0.28
C		0.54	0.71	0.68	0.64
Variety		**A**	**B**	**C**	**Priority vector**
A		0.68	0.64	0.69	0.67
B		0.10	0.09	0.08	0.09
C		0.23	0.27	0.23	0.24

Table 4. Comparison matrix of the suppliers for procurement of computer according to criteria.

Criteria	Cost	Quality	P.F	Delivery	Variety	
Weights	0.36	0.36	0.16	0.08	0.05	
		Distributive	**Mode**			
A	0.63	0.72	0.18	0.07	0.67	0.5539
B	0.11	0.08	0.75	0.28	0.09	0.2153
C	0.26	0.19	0.07	0.64	0.24	0.2364

As seen in Table 4, for computer procurement supplier A (0.5539) is preferred.

Table 5. Comparison of criteria for procurement of equipment.

Equipment	Cost	Quality	P.F	Delivery	Variety
Cost	0.21	0.16	0.31	0.30	0.44
Quality	0.64	0.48	0.52	0.30	0.19
P.F	0.07	0.10	0.10	0.30	0.19
Delivery	0.04	0.10	0.02	0.06	0.13
Variety	0.03	0.16	0.03	0.03	0.06

Table 5. Contd.

Cost	A	B	Priority vector
A	0.83	0.83	0.83
B	0.17	0.17	0.17
Quality	**A**	**B**	**Priority vector**
A	0.88	0.88	0.88
B	0.12	0.12	0.12
P.F	**A**	**B**	**Priority vector**
A	0.17	0.17	0.17
B	0.83	0.83	0.83
Delivery	**A**	**B**	**Priority vector**
A	0.25	0.25	0.25
B	0.75	0.75	0.75
Variety	**A**	**B**	**Priority vector**
A	0.75	0.75	0.75
B	0.25	0.25	0.25

Table 6. Comparison matrix of the suppliers for procurement of equipment according to criteria.

Criteria	Cost	Quality	P.F	Delivery	Variety	
Weights	0.29	0.43	0.15	0.07	0.06	
		Distributive				
A	0.83	0.88	0.17	0.25	0.75	0.7071
B	0.17	0.13	0.83	0.75	0.25	0.2972

Table 7. Comparison of criteria for procurement of stationary.

Stationary	Cost	Quality	P.F	Delivery	Variety
Cost	0.35	0.35	0.40	0.35	0.16
Quality	0.35	0.35	0.40	0.35	0.16
P.F	0.12	0.12	0.13	0.21	0.26
Delivery	0.07	0.07	0.04	0.07	0.37
Variety	0.12	0.12	0.03	0.01	0.05

Cost	A	B	C	Priority vector
A	0.546	0.71	0.25	0.502
B	0.182	0.23	0.625	0.345
C	0.273	0.047	0.125	0.148
Quality	**A**	**B**	**C**	**Priority vector**
A	0.677	0.635	0.692	0.688
B	0.096	0.09	0.076	0.087
C	0.225	0.272	0.23	0.242
P.F	**A**	**B**	**C**	**Priority vector**
A	0.235	0.2	0.5	0.312
B	0.705	0.602	0.375	0.56
C	0.058	0.2	0.125	0.127
Delivery	**A**	**B**	**C**	**Priority vector**
A	0.652	0.66	0.625	0.645
B	0.217	0.222	0.25	0.229
C	0.13	0.111	0.125	0.122

Table 7. Contd.

Variety	A	B	C	Priority vector
A	0.238	0.714	0.143	0.365
B	0.047	0.142	0.429	0206
C	0.714	0.142	0.429	0.428

Table 8. Comparison matrix of the suppliers for procurement of stationary according to criteria.

Criteria	Cost	Quality	P.F	Delivery	Variety	
Weights	0.32	0.32	0.17	0.12	0.06	
		Distributive	**Mode**			
A	0.502	0.688	0.3116	0.645	0.365	0.53307
B	0.345	0.087	0.56	0.229	0.206	0.27328
C	0.148	0.242	0.127	0.122	0.428	0.18671
Hygiene	**Cost**	**Quality**	**P.F**	**Delivery**	**Variety**	
Cost	0.47	0.67	0.32	0.39	0.14	
Qualıty	0.16	0.22	0.54	0.30	0.43	
P.F.	0.16	0.04	0.11	0.22	0.33	
Delivery	0.05	0.03	0.02	0.04	0.05	
Variety	0.16	0.02	0.02	0.04	0.05	

Table 9. Comparison of criteria for procurement of hygiene.

Cost	A	B	C	Priority vector
A	0.588	0.789	0.33	0.569
B	0.117	0.157	0.5	0.258
C	0.294	0.052	0.166	0.17
Quality	**A**	**B**	**C**	**Priority vector**
A	0.546	0.428	0.6	0.524
B	0.182	0.142	0.099	0.141
C	0.273	0.428	0.3	0.333
P.F.	**A**	**B**	**C**	**Priority vector**
A	0.588	0.333	0.789	0.57
B	0.294	0.166	0.052	0.17
C	0.117	0.5	0.157	0.258
Delivery	**A**	**B**	**C**	**Priority vector**
A	0.166	0.215	0.076	0.152
B	0.5	0.653	0.769	0.64
C	0.333	0.1307	0.153	0.205
Variety	**A**	**B**	**C**	**Priority vector**
A	0.153	0.5	0.227	0.293
B	0.076	0.25	0.454	0.26
C	0.769	0.25	0.454	0.491

by the AHP method, the results are shown in Table 8. The results in Table 8 show that supplier A (0.533) is preferred for procurement of stationary. Comparison of criteria is outlined for the procurement of hygiene in Table 9. For the last Stopic hygiene, made by use of the AHP method, the result of the comparison of 3 alternative suppliers named A, B, C is outlined in Table 10. The results in Table 10 show that supplier A (0.5210) is preferred for the procurement of hygiene.

Table 10. The comparison matrix of the suppliers for procurement of hygiene according to criteria.

Criteria	Cost	Quality	P.F	Delivery	Variety	Score
Weights	0.4	0.33	0.17	0.04	0.06	
A	0.569	0.524	0.57	0.152	0.293	0.52108
B	0.258	0.141	0.17	0.64	0.26	0.21983
C	0.17	0.333	0.258	0.205	0.491	0.25941

Conclusıon

This study proposes AHP as a variable process in the evaluation and selection of suppliers. The decision criteria are cost, quality, delivery, flexibility and variety. The performance of each supplier on each criterion each supplier has been studied by AHP to construct a framework to formalize the evaluation between the conflicting selections criteria associated with various suppliers' offers. This evaluation program can address the act of buying the needs by monitoring and evaluating suppliers on their actual performances with a subjective point of view. It communicates the purchasing priorities to the supplier of the defined topics that is easy to understand. In actual application, managers must carefully select the factors that best represent their competitive priorities, goals and objectives, and also construct pair wise comparison matrices. The results of using AHP can be listed as follows:

i. The maximization of the utilization of time by decreasing the effort of documentation in the department.
ii. The minimization of the purchasing cost and the departmental personnel by the authorization of supplier selection.
iii. As the best supplier groups will be confirmed in the department, the competitive challenge between the suppliers groups (A, B, C) will increase the service quality.

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