

AN AHP APPLICATION IN VENDOR SELECTION

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Abstract: Supplier selection is one of the most crucial activities performed by the organizations because of its strategic importance. A supplier selection problem is a multi-objective problem involving both quantitative and qualitative criteria. Over the years a number of quantitative approaches have been applied to supplier selection problems. Although the Analytic Hierarchy Process (AHP) has previously been implemented in supplier selection problems, in this paper for the first time a comprehensive application of AHP for a real-world case is presented along with sensitivity analysis to choose the best supplier. We proposed an AHP model to choose the best supplier and place the order quantities among them for a construction company.

Keywords: Vendor selection; Analytic Hierarchy Process; Multicriteria Decision Making.

1. Introduction

Strong competitive pressure forces many organizations to provide their products and services faster, cheaper and better than their competitors. Managers have come to realize that they can not do it alone without satisfactory vendors (Handfield and Nichols, 1999). Therefore the

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increasing importance of supplier selection decisions is forcing organizations to rethink their purchasing and evaluation strategies and hence the selection of suppliers has received considerable attention in the purchasing literature (Ellram, 1990; Weber *et. al.*, 1991; Nydick and Hill, 1992; Weber and Current, 1993; Verma and Pullman, 1998; Ghodspour and O'Brien, 1998; Karpak *et. al.*, 2001; Boer *et. al.*, 2001; Park and Krishnan, 2001; Handfield *et. al.*, 2002; Bhutta and Huq, 2002).

Studies over the years have addressed a variety of criteria that are important in vendor selection. The major premise of these studies is that many organizations spend a considerable amount of time evaluating their supply chain partners by the fact that the strategic importance of supplier selection. Ellram (1990) examined the issue of supplier selection with the use of case studies of firms involved in buyer-supplier relationships. She developed some additional factors that should be considered in the selection of supply partners besides quality, cost, on-time delivery, and service. These factors were categorized into four groups: Financial issues, organizational culture and strategy, technology and a group of miscellaneous factors. She also concluded that there is no single model that fits every situation. Weber *et.al.* (1991) reviewed 74 articles which address vendor selection criteria in manufacturing and retail environment published from 1966 to 1991. They provided a comprehensive view of the criteria that might be considered in supplier selection decisions. They showed that quality, delivery and net price have received the great amount of attention. Production facility, geographical location, financial position and capacity generated an intermediate amount of attention. Nydick and Hill (1992) considered four criteria in supplier selection: quality, price, delivery, and service. Research carried out among 139 managers by Verma and Pullman (1998) was designed to study how managers tradeoff among quality, cost, on-time delivery, delivery lead-time and flexibility attributes when choosing a supplier. They indicated that managers perceive quality to be most important supplier attribute, followed by on-time delivery and cost. Park and

Krishnan (2001) examined the supplier selection practices among 78 small business executives and adopted 15 criteria from Ellram's (1990) study: strategic fit, top management compatibility, management attitude/outlook for the future, feeling of trust, compatibility across levels and functions of buyer and supplier firms, supplier's organizational structure and personnel, assessment of current manufacturing facilities/capabilities, assessment of future manufacturing capabilities, supplier's design capabilities, supplier's speed in development, economic performance/financial outlook, financial stability, supplier's safety record, business references, and supplier's customer base. Karpak *et. al.* (2001) considered cost, quality and delivery reliability as vendor selection criteria. Handfield *et.al.* (2002) focused on environmental issues in supplier evaluation. Bhutta and Huq (2002) used four criteria to evaluate suppliers: manufacturing costs, quality, technology, and service.

A number of quantitative approaches have been applied to vendor selection problems such as Total Cost Ownership (TCO), Analytic Hierarchy Process (AHP), linear programming, statistical approaches, etc. The main purpose of this paper is to show how the AHP may be used as a decision analysis tool for supplier selection problems. The AHP has previously been used in supplier selection by e.g. Narasimhan (1983), Nydick and Hill (1992), Barbarasoglu and Yazgac (1997), Bhutta and Huq (2002), and Handfield *et.al.* (2002). Ghodsypour and O'Brien (1998) integrated the AHP and linear programming for supplier selection problem.

In this study for the first time a very comprehensive application of AHP for a real-world case is presented along with sensitivity analysis to choose the best supplier. This paper describes a case study of a construction firm which wants to select the best lime supplier. We proposed an AHP model to choose the best lime supplier and place the optimum order quantities among them. This paper organized in six sections. First, a review of the quantitative approaches to vendor selection problems is presented. The methodology of the study is

explained next. The fourth section introduces the application of the AHP. The sensitivity analysis is presented in the fifth section. Finally overall conclusion is described in section six.

2. Existing Vendor Selection Methods

A number of studies have been devoted to examining vendor selection methods. The common conclusion of these studies is that the multiobjective nature of supplier selection decisions (Karpak *et.al.*, 2001; Nydick and Hill, 1992; Ghodsypour and O'Brien, 1998; Boer *et.al.*, 2001). Weber *et.al.* (1991) reviewed the quantitative approaches to vendor selection problems. According to this study, linear weighting models, mathematical programming models and statistical/probabilistic approaches have been the most utilized approaches. Nydick and Hill (1992) showed how the AHP can be used to structure the supplier selection process. Weber and Current (1993) developed a multiobjective programming approach to assist the purchasing manager in making vendor selection decisions. Ghodsypour and O'Brien (1998) proposed an integration of an AHP and linear programming model in choosing the best supplier. Boer *et.al.* (2001) presented a review of decision methods reported in the literature for supporting the supplier selection process. They showed that several suitable Operations Research methods such as data envelopment analysis, total cost approaches, linear programming, linear weighting models, statistical methods, artificial-intelligence-based models have been used so far in the purchasing literature. Karpak *et.al.* (2001) implemented the Visual Interactive Goal programming (VIG) in a multiple-replenishment purchasing problem. Bhutta and Huq (2002) presented two approaches related to supplier selection decision, AHP and TCO and provided a comparison. Handfield *et.al.* (2002) proposed an AHP model that included relevant environmental criteria in supplier selection decision.

3. Methodology Background

In many existing decision models for supplier selection only quantitative criteria are considered. However, a vendor selection problem is a multi-objective problem, encompassing

many quantitative as well as qualitative factors. Since the AHP is capable of dealing with these kind of decision problems, the AHP was selected as a decision analysis tool and *Expert Choice*® was selected as the software. In this section the AHP and the research carried out at AKG Inc. are explained.

3.1. Analytic Hierarchy Process

The AHP is designed to solve complex multi-criteria decision problems. It is based on the innate human ability to make sound judgments about small problems. It facilitates decision making by organizing perceptions, feelings, judgments, and memories into a framework that exhibits the forces that influence a decision. The AHP is implemented in the software of *Expert Choice*® and it has been applied in a variety of decisions and planning projects in nearly 20 countries (Saaty, 2001).

In AHP a problem is structured as a hierarchy. Once the hierarchy has been constructed, the decision-maker begins the prioritization procedure to determine the relative importance of the elements in each level. Prioritization involves eliciting judgments in response to questions about the dominance of one element over another with respect to a property.

The scale used for comparisons in AHP enables the decision-maker to incorporate experience and knowledge intuitively and indicate how many times an element dominates another with respect to the criterion (Millet, 1997b). The decision-maker can express his preference between each pair of elements verbally as *equally important*, *moderately more important*, *strongly more important*, *very strongly more important*, and *extremely more important*. These descriptive preferences would then be translated into numerical values 1,3,5,7,9 respectively with 2,4,6, and 8 as intermediate values for comparisons between two successive qualitative judgments. Reciprocals of these values are used for the corresponding transposed judgments. The table below shows the comparison scale used by AHP.

Table 1. The fundamental scale

Intensity of Importance	Definition	Explanation
1	Equal Importance	Two activities contribute equally to the objective
3	Moderate Importance	Experience and judgment slightly favor one activity over another
5	Strong Importance	Experience and judgment strongly favor one activity over another
7	Very strong Importance	An activity is favored very strongly over another; its dominance demonstrated in practice
9	Extreme importance	The evidence favoring one activity over another is of the highest possible order of affirmation
2,4,6,8	For compromise between the above values	Sometimes one needs to interpolate a compromise judgment numerically because there is no good word to describe it.

Finally, all the comparisons are synthesized to rank the alternatives. The output of AHP is a prioritized ranking of the decision alternatives based on the overall preferences expressed by the decision maker. Sensitivity analysis is used to investigate the impact of changing the priorities of the criteria on the final outcome.

3.2. The Research

In this study we selected the best lime supplier for AKG Construction Inc., which manufactures construction materials. As one of the construction materials, the company started to produce 285 thousand cubic meters autoclaved aerated concrete (AAC) a year in 1999. AKG primarily sells bag products, concrete blocks, glass blocks, and limestone-building products. AAC is a structural, insulating building material made of a combination of cement, lime, gypsum, water, and expansion agent. It is used in a wide range of building construction with residential, commercial and industrial buildings being common applications. AAC is an economical, easy to use, environmentally friendly, energy efficient, cellular, and lightweight material. It consists of basic materials that are widely available. One of those raw materials is lime. The company currently purchases lime from three suppliers. Since managing multiple relationships within a supply chain is a challenging task, the selection of lime supplier became a very important issue for AKG Inc. They wanted to select

the best lime supplier and place the order quantities among them considering various criteria. We ran an AHP study on the problem because supplier selection problems deal with a relatively large number of attributes within a hierarchical framework. We met with the managers of the company for several hours to decide on the best alternative. A team of AKG decision-maker comprised of quality control manager, production manager, operations manager, purchasing manager, sales manager, plant manager, and marketing manager. First, the AHP methodology was presented to the decision-making team since the decision-making team was not familiar with the idea. Then we formulated the model and decided the criteria. Initially 89 criteria were identified. However, decision-making team has gone through some initial evaluation of the factors that eliminates insignificant ones to the supplier selection problem and considers 64 factors as the primary ones. Also, three suppliers are identified as the decision alternatives: Akyuz, Bastas, and Kirsehir. Finally, we ended up with a six-level hierarchy and the following criteria for evaluating the decision were identified:

-Logistical Performance: The decision makers identified three major criteria in selecting best lime supplier. Great importance is given to the supplier's *logistical performance*, because supplier performance affects total firm performance. The decision makers categorized *logistical performance* into two criteria: *Delivery performance* and *Cost analysis*. Since orders or material releases sent to a supplier have a quantity and a material due date, supplier's performance in lead-time requirements (on-time delivery) and providing exact quantity has an important role in supplier selection. Therefore, *delivery performance* decomposed into two criteria, which are *delivery quantity* and *lead-time requirements*. Besides the delivery performance, the decision makers decided that cost features of the products the supplier provides should be considered in the supplier selection process. Hence price, terms of payments and credit, and supplier's willingness to help the company find ways to reduce purchase cost is involved under *cost analysis* category.

-Commercial Structure: The decision makers considered commercial structure of the supplier as one of the main criteria. *Commercial structure* is divided into six categories: *Communication systems*, *technical capability*, *personnel capabilities*, *cost structure*, *organizational structure*, and *performance history*. *Communications systems* deal with the way supplier manage the relationship with the buyer. The willingness of supplier's employees to contribute to supply chain objectives (*willingness of employees*) and ease of contact with the supplier (*ease of contact*) helps to maintain a positive relationship with the supplier. The decision making team decided that supplier's technical capability must be evaluated. Ability of the vendor to provide technical support (*technical support*) and responsiveness of the vendor to changes in purchase quantities and due dates (*responsiveness*) are considered as the secondary sub-criteria under *technical capability*. The decision making team believed that the supplier evaluation process also requires an assessment of personnel capabilities. The second category labeled *personnel capabilities* includes three criteria: The overall skills and abilities of the workforce especially with regard to the level of education and training received (*overall skills*), the degree to which employees support the company's continuous improvement (*support*), and highly experienced employees (*experience*) are key factors in selecting the suppliers. Evaluating a supplier's cost structure involves providing detailed cost data by the supplier (*total costs*), an assessment of financial condition and stability (*financial capability*), and market share of the supplier (*market share*). *Organizational structure* is considered one of the critical factors in selecting the best lime supplier by the decision-maker team of AKG. It is divided into three criteria. First criterion named *long-term relationship* addresses supplier's willingness to develop longer-term relationships. *Reliability/trust* refers acting and meeting performance expectations reliably. Developing a trusting relationship with the suppliers is one of the critical elements that will result important benefits for both firms. The third criterion, *management capability*, includes management's commitment, overall professional ability, and willingness to develop a closer working relationship with the buyer.

The decision-making team found *performance history* important in selecting suppliers. It relates to the supplier's reputation for performance. Past experience with the supplier (*past performance*) and business references provided by the supplier (*business references*) are involved under performance history.

-Production: Production capability of the supplier (*production*) is considered as one of the three main criteria. *Production* is then divided into seven categories: *Product specifications*, *material specifications*, *inventory policy*, *equipment*, *process capability*, *production capacity* and *quality management systems*. Physical and chemical characteristics of the product are included under product specifications. *Physical characteristics* is categorized into three sub-criteria: storage requirements of the product provided by the supplier (*storage*), pH level of the product (*pH level*), and article size of the product (*article size*). *Chemical characteristics* subdivided into hydration level of lime (*hydration*), degree of burn (*degree of burn*), processibility of lime (*processibility*) and proportion of calcium oxide (proportion of *CaO*). Specifications of the raw materials used by the supplier in lime production involved three criteria: The purity of calcareous rock (*purity of calcareous*), magnitude of the calcareous rock reservoir (*magnitude*), and quality of coal used in lime production by the supplier (*quality of coal*). Size of available warehouse facility (*size of available facility*), availability of exclusive warehousing (*exclusive warehousing*), and humidity level of supplier's warehousing (*humidity level*) were considered as the sub-criteria for *inventory policy* criterion. Equipment used by the supplier is also considered to evaluate lime suppliers. Quality of equipment used to manufacture the product and production technology being used by supplier are involved for *equipment* sub-criterion. The decision-making team decided that the partner's process capability must be considered in selecting suppliers. The fifth category labeled process capability includes three criteria: Ability to develop process technology (*process technology*), supplier's future process capability (*future*) and the ability to meet current and expected future production requirements (continuous in production). Supplier's

production capacity is also included as a main sub-criterion. *Quality management systems* is mentioned as important in the supplier selection. Quality certifications the supplier has received (*certification*), the overall skills and experience of quality control personnel (*personnel*), quality control tools being used by the partner (*quality tools*), defect rates of the supplier (*defect rate*), and quality control inspection methods (*inspection*) used by the supplier are included under quality management systems.

4. Application of the AHP in supplier selection

4.1. Structuring the Hierarchy

The goal is to choose the best lime supplier for AKG Construction Company. We placed this goal at the top of the hierarchy. The hierarchy descends from the more general criteria in the second level to sub-criteria in the third level to tertiary sub-criteria in the fourth level on to the alternatives at the bottom or fifth level. General criteria level involved three major criteria: *Logistical performance*, *commercial structure* and *production*. We located *delivery performance* and *cost analysis* under *logistical performance* criterion in the third level of the hierarchy. Each of these in turn needed further decomposition into specific items in the fourth level. For example, *delivery performance* decomposed into two criteria: *delivery quantity* and *lead-time*. We also located *communication systems*, *technical capability*, *personnel capabilities*, *cost structure*, *organizational structure*, and *performance history* under *commercial structure* in the third level of the hierarchy. We thought decomposition was necessary for all these six sub-criteria. For example, we included *willingness of employees* and *ease of contact* for *communication systems* in the fourth level of the hierarchy. The seven sub-criteria were included for *production* in the third level. These are *product specifications*, *material specifications*, *inventory policy*, *equipment*, *process capabilities*, *production capacity*, and *quality management systems*. Each of these in turn needed further decomposition into specific items. As an example, *equipment* decomposed into *quality of equipment* and *process technology*. The decision-making team considered three lime

suppliers for the decision alternatives, and located them on the bottom level of the hierarchy. These are Akyuz, Bastas, and Kirsehir. Figure 1 shows a hierarchical representation of the selecting best lime supplier decision-making model.

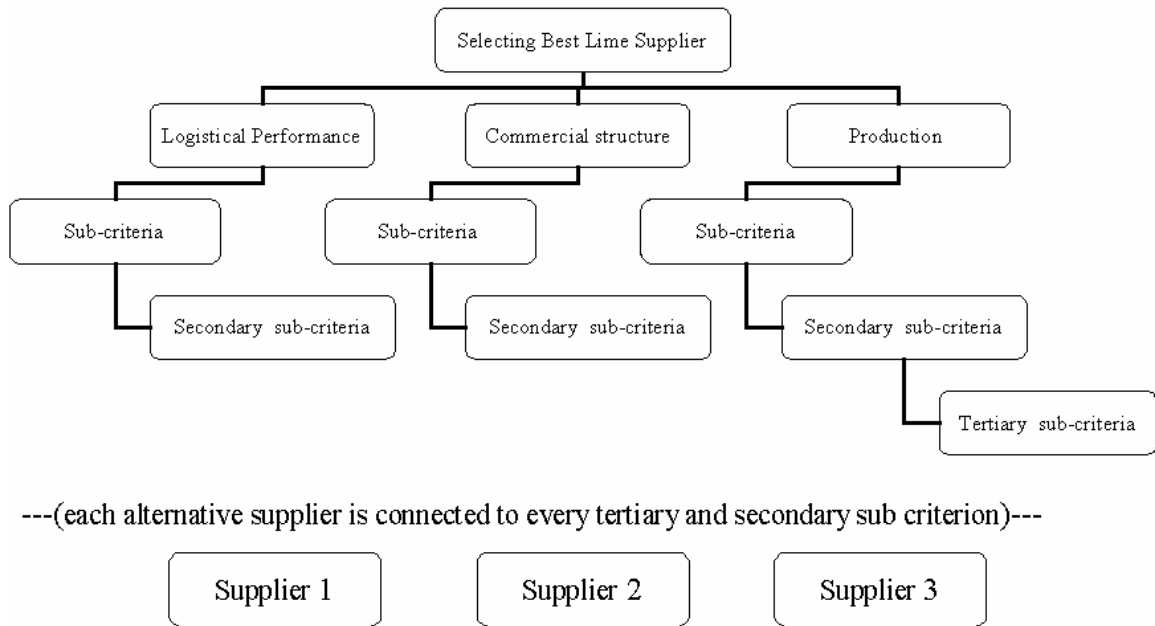


Fig. 1. A hierarchical representation of the AHP model

4.2. Performing Pairwise Comparisons

After constructing the hierarchy, pairwise comparisons were performed systematically to include all the combinations of criteria/sub-criteria/secondary sub-criteria/ tertiary sub-criteria/alternatives relationships. We compared the criteria and sub-criteria according to their relative importance with respect to the parent element in the adjacent upper level. Prior to our study, it is hoped that we would be able to go through pairwise comparisons together with the decision makers. It was not possible due to the differences among the schedule of the managers. Hence, 191 questions questionnaires including all possible pairwise comparison

combinations were distributed to the decision makers. They first made all the pairwise comparisons using semantic terms from the fundamental scale and then translated them to the corresponding numbers, separately. The questions to ask when comparing two criteria being compared, which is considered more important by the decision-maker selecting the best supplier, and how much more important is it with respect to selection of the best supplier. After performing all pairwise comparisons by the decision-makers, we aggregated individual judgments using the geometric mean as Saaty suggested (Saaty, 1990). The judgments were based upon the gathered information through the questionnaires. The results are then combined by applying the geometric mean.

Expert Choice® provides various options for comparing criteria/sub-criteria/tertiary sub-criteria/alternatives: Numerical, verbal and graphical. Numerical options where the decision makers can enter numerical values between 1 and 9; verbal option where semantic terms can be used; and graphical option where the decision makers can make comparisons by contrasting the graphical bars. Graphical multiple bars and graphical pairwise comparisons are the two sub options under graphical option. As the name implies graphical multiple bars evaluate all criteria/sub-criteria/alternatives simultaneously whereas in graphical pairwise comparison option, decision-makers compare criteria/sub-criteria/alternatives two at a time. Direct estimation is where the user simply produces a set of values reflecting the relative preference for the compared elements. Millet (1997a) evaluated different comparison modes and found that direct estimation, and numerical pairwise comparison methods are dominated by verbal comparison, graphical pairwise comparison and graphical multiple bars based on perceived ease of use and accuracy criteria. Prior to our study, the decision-making team needed some guidance regarding which comparison mode should be chosen. Under our guidance graphical pairwise comparison mode which evaluates pairwise comparisons in a continuous scale was the most appealing to the decision-making team.

We have first entered the judgments provided through the questionnaires for three major criteria in level 2. *Production* is the most important factor of selecting the best lime supplier with a priority of 0.555. *Logistical Performance* is also a major factor with an importance priority of 0.364. Figure 2 shows the pairwise comparison matrix for the major criteria.

	Logistical Performance	Commercial Structure	Production
Logistical Performance		4.718	0.620
Commercial structure			0.153



Fig. 2. Comparing major criteria-Preferences and weights of major criteria

Then we evaluated *logistical performance* criteria. As an example, for *logistical performance* criterion *delivery performance* is considered more important over *cost analysis* by 0.190. Figure 3 shows the judgments obtained and importance matrix for *logistical performance*.

<i>Logistical Performance</i>	Delivery	Cost analysis	Priorities
Delivery performance		0.190	0.159
Cost analysis			0.841



Fig. 3. Comparing criteria for logistical performance

As shown in Figure 4, *cost analysis* received the highest priority, 0.841. Under *delivery performance* criterion, *lead-time* turned out to be the most important one, 0.767. Under *cost analysis*, not surprisingly price received the highest priority, 0.766.

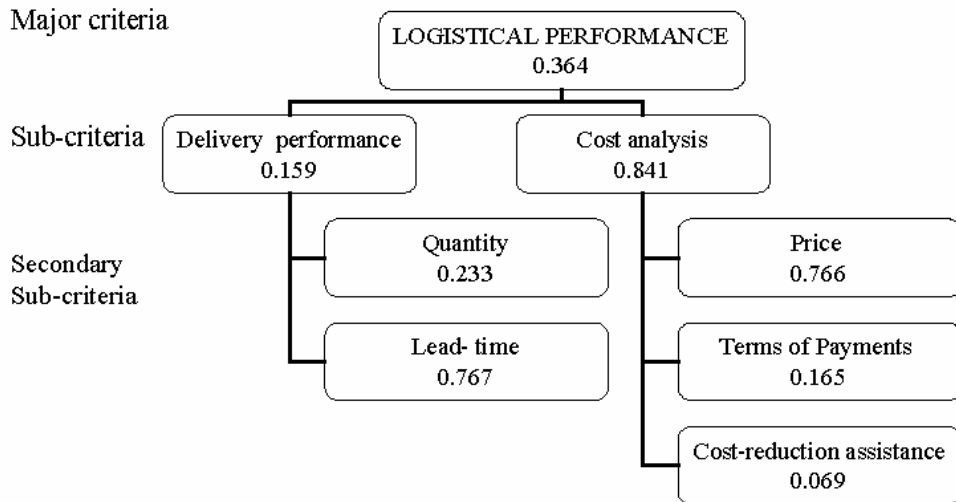


Fig. 4. Priorities of logistical performance criteria

Then we have entered the judgments for *commercial structure* to set the priorities for its all sub-criteria and secondary sub criteria in terms of importance of each in contributing to the overall goal. The priorities of *commercial structure* criteria are shown in figure 5. It reveals that, *technical capability* is the most important with the priority of 0.345 whereas the priority of *organizational structure* is 0.156.

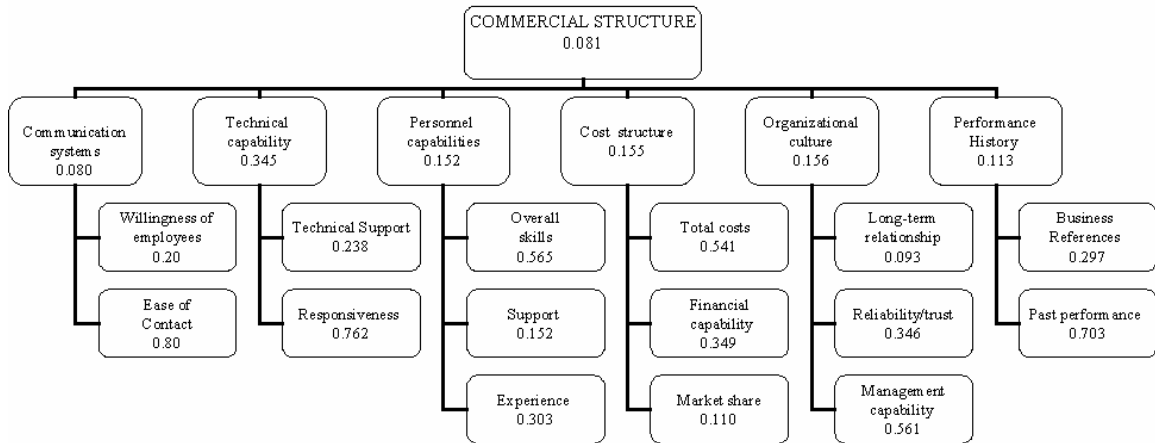


Fig. 5. Priorities of commercial structure criteria

When we have entered the judgments for *production* criterion, *product specifications* turned out to be the most important criterion among the seven sub-criteria, with a priority score of 0.317. The priorities of production criteria are shown in figure 6.

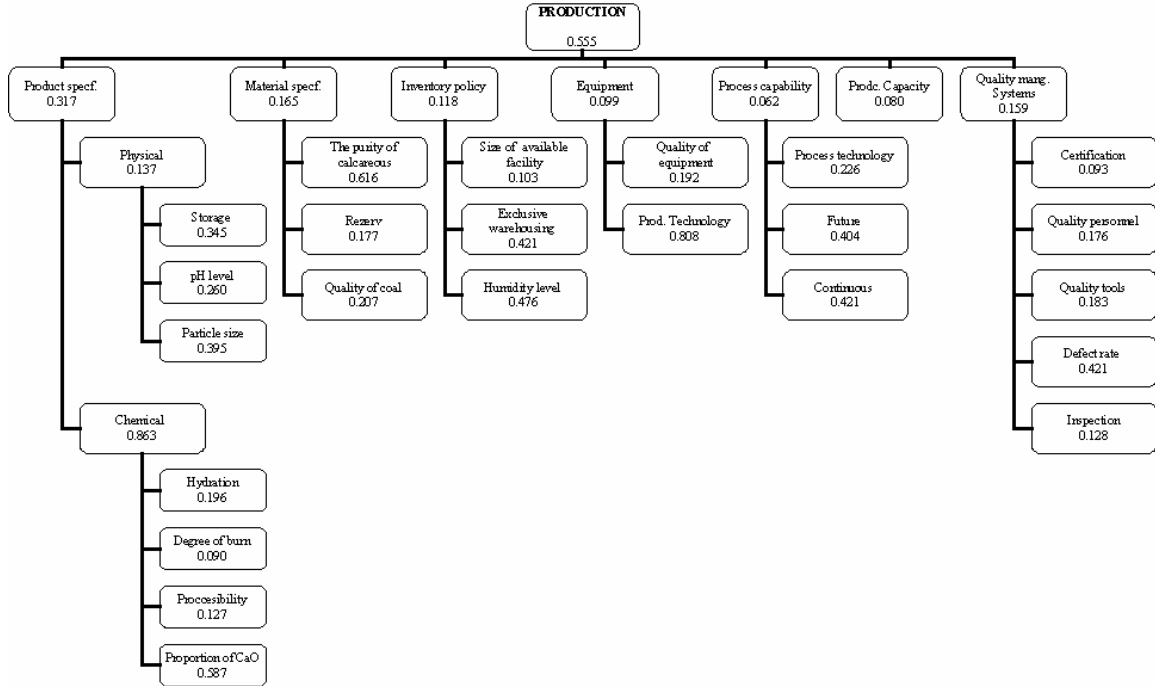


Fig. 6. Priorities of production criteria

Finally we compared each pair of alternative with respect to each criterion. In comparing the three suppliers, we asked which supplier decision-making team preferred with respect to each of the main criterion in level 2, each sub-criterion in level 3, each secondary sub-criterion in level 4 and each tertiary sub criterion in level 5. For example, for the sub criterion *delivery quantity* (located on the left-most branch under *delivery performance*), we obtained a matrix of paired comparisons (Fig 7) in which supplier 1 (Akyuz) is preferred over supplier 2 (Bastas) and supplier 3 (Kirsehir) by 6.804 and 4.708, respectively and supplier 2 is preferred

by 0.195 over supplier 3. Akyuz appears superior to the other two alternatives with respect to *delivery quantity*. As a result of it, Akyuz came out as the top choice with a preference rating of 0.686, followed by Kirsehir.

<i>Delivery Quantity</i>	Akyuz	Bastas	Kirsehir
Akyuz		6.804	4.708
Bastas			0.195



Fig. 7. Comparing alternatives based on delivery quantity

4.3. Synthesizing the Results

Expert Choice provides two ways of synthesizing the local priorities of the alternatives using the global priorities of their parent criteria: the distributive mode and the ideal mode. In the distributive mode the weight of a criterion reflects the importance that the decision maker attaches to the dominance of each alternative relative to all other alternatives under that criterion. In our case, the distributive mode would be the way to synthesize the results. After deriving the local priorities for the criteria and the alternatives through pairwise comparisons, the priorities of the criteria are synthesized to calculate the overall priorities for the decision alternatives. As shown in figure 8, *Kirsehir* turns out to be the most preferable supplier among the three alternatives, with an overall priority score of 0.409. The suppliers are ranked according to their overall priorities, as follows: Kirsehir, Akyuz, and Bastas, indicating that Kirsehir is the best lime supplier.

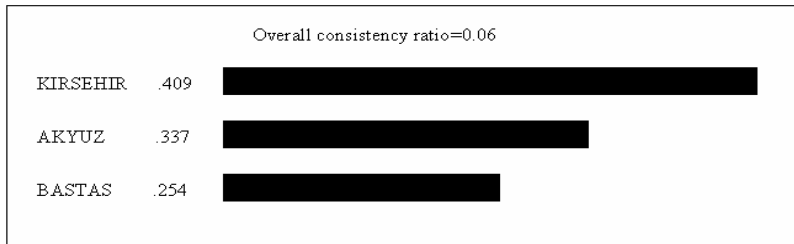


Fig. 8. Overall Results

5. Sensitivity Analysis

A series of sensitivity analyses were conducted to investigate the impact of changing the priority of the criteria on the suppliers' ranking. First, *Dynamic sensitivity of Expert Choice*[®] was performed. *Dynamic sensitivity analysis* is used to dynamically change the priorities of the criteria to determine how these changes affect the priorities of the alternative choices (Saaty, 2001). We investigated the impact of changing the priority of three main criteria on overall results. As shown in Figures 9-11, the results indicate that the suppliers' ratings are not sensitive to changes in the importance of the *commercial structure*, *production* and *logistical performance* criteria. When the importance of *logistical performance* is increased from 0.364 to 0.650, Akyuz is the best supplier. We performed a second sensitivity analysis where the relative importance of *commercial structure* was increased from 0.081 to 0.460. In this analysis, overall rank of the final outcome was preserved. In the third scenario, when the importance of *production* is decreased from 0.555 to 0.072, suppliers' ratings do not change although the superiority of the best alternative is changed from 0.409 to 0.346. We can conclude that these results are not sensitive even in changes *logistical performance* importance rating since it is quite unlikely.

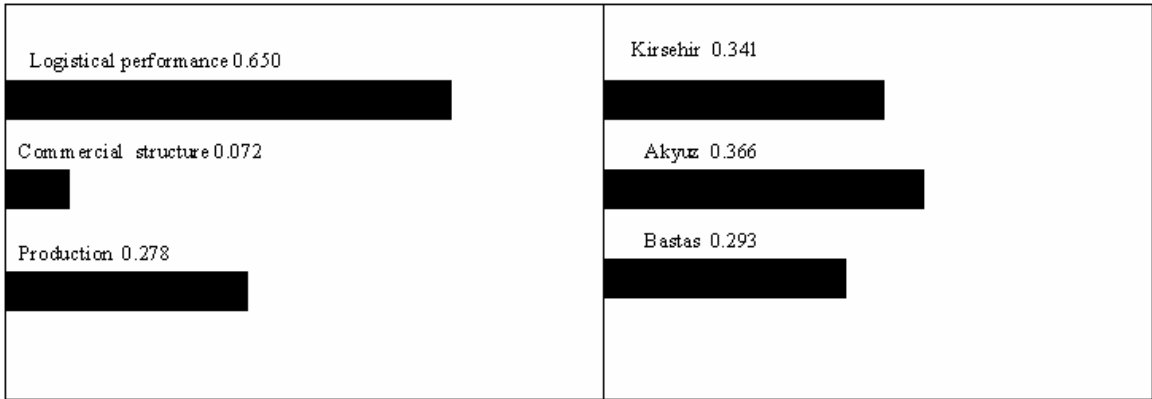


Fig. 9. The first scenario



Fig. 10. The second scenario

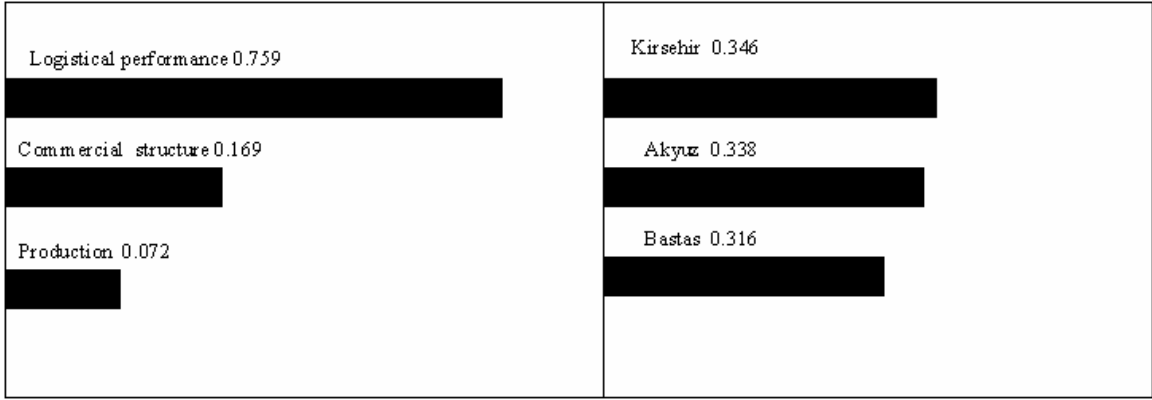


Fig. 11. The third scenario

Second, we changed the priorities of the sub-criteria using *Performance* sensitivity analysis of *Expert Choice*®. The results of the sensitivity analyses indicated that when we changed the importance of the sub-criteria under two main criteria, *commercial structure* and *production*,

the suppliers' rating do not change for all priorities. Kirsehir appears superior to the other two suppliers in terms of *commercial structure* criteria whereas Akyuz appears superior to Bastas. When we decreased and increased the importance of all the criteria, the results indicated that Kirsehir is the best alternative for all priorities. For example, when the importance of *technical capability* was increased up to 0.700, all three suppliers maintained their rank. When the importance of *cost structure* was increased from 0.155 to 0.750, suppliers' ranking did not change. Similarly, Kirsehir appears superior to the other two suppliers in terms of *production* criteria whereas Akyuz appears superior to Bastas. We changed the importance of the sub-criteria to investigate its impact on overall results. Even making extreme assumptions do not change the final outcome. As an example, we increased the importance of *quality management systems* up to 0.65; *process capability* up to 0.78; *equipment* up to 0.62; *material specifications* up to 0.72. In all these analyses suppliers maintained their rank.

Changing priorities of sub-criteria under *logistical performance* reverses the ranks of the alternatives. When we increased the importance of *delivery performance* up to 0.296, Akyuz became the best alternative, with an overall priority score of 0.384 while the overall priority of Kirsehir is decreased from 0.409 to 0.320. Bastas is still preserved as the third alternative, although its preference rating is increased up to 0.254 as shown in Fig. 12.

As a result of the sensitivity analyses, we found out that the outcome of our analysis is very robust and Kirsehir is the best supplier for AKG Inc.

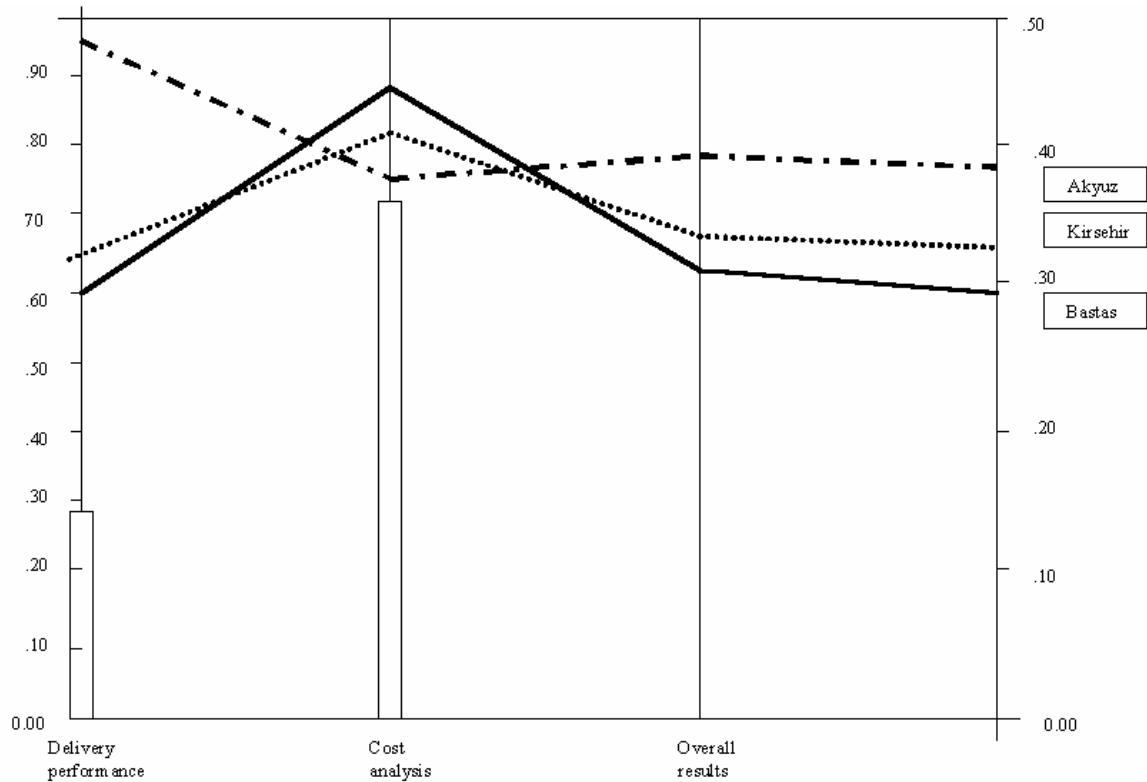


Fig. 12. Performance sensitivity analysis for logistical performance sub-criteria

6. Conclusion

When an organization is confronted with choosing the best vendor to deliver a good or service, the decision can often be very complex. Vendor selection problems are multi-objective problems which have many qualitative and quantitative concerns. This paper has presented the AHP as a decision analysis tool in supplier selection problems. We proposed a comprehensive AHP model to select the best supplier for a construction company. The AHP models a decision making framework using a hierarchical relationship among decision levels. It is capable of handling multiple criteria and enabled us to incorporate 64 both qualitative and quantitative factors, when assessing the vendors. We concluded that Kirsehir is the best supplier with an overall priority score of 0.409.

Current vendor selection decisions are group decisions, and involve both quantitative and qualitative criteria. AHP can accommodate group decisions. Managers can collaborate in

setting priorities and software supports the arranging of individual judgments into final priorities in cases where consensus is not achieved by group members.

As Handfield *et. al.* (2002) pointed out one major weakness of the application oriented AHP literature is that it tends to focus on the mechanics of AHP, instead of theoretical and practical implications associated with implementing the methodology. Though it is one of the most extensively used Multiple Criteria Decision Analysis methodology, our literature search indicated that most studies found out the best solution and ignored sensitivity analysis. The sensitivity analysis is very important for practical decision making, sometimes even as important as finding out the best solution.

We conducted sensitivity analysis to see how robust the final outcome is. We found no matter how much we increase or decrease the priorities of two main criteria (*commercial structure* and *production*) and their sub-criteria, the overall rank of the outcome was preserved although these experiments changed the magnitudes of the superiority of the best alternative. Sensitivity analysis showed that our outcome is insensitive even to the changes in the importance of *logistical performance* criterion though rank order of the alternatives changed when we changed the importance rating from .36 to .64.

Actual process of conducting this analysis helped the decision making team prioritize the criteria in a manner otherwise might not be possible. The team was far more confident with their decision since this study showed them even if the importance of certain criteria changes overall ranking does not change though the degree of preference rating is strengthened or weakened.

Bounded rationality and limited cognitive processes make it really impossible for the decision maker to adequately consider all of the factors involved in a complex screening decision. Without decision support methodologies like AHP, managers might base their decisions on only a subset of important criteria while not understanding their relative importance and interactions.

In general, because decision-makers fail to rank correctly the relative accuracy of elicitation methods, there seems to be a need to direct decision-makers toward better choice of techniques. In this study, the *expert team* presented the relative accuracy and perceived ease of use of each of the comparison methods provided by *Expert Choice* to the *decision-making team* and let them choose which they preferred to use. Among the non-dominated elicitation methods, the decision-makers did not select graphical multiple bars because they understood that it would have low accuracy and they eliminated verbal pairwise comparisons because of the difficulty of translating their judgments to words. The *decision-making team* thus selected the graphical pairwise comparison mode as their preferred way to transmit their judgments

There are some limitations of the approach. AHP assumes linear independence of criteria and alternatives. If there is dependence among the criteria, Analytic Network Process (ANP) (Saaty, 2001) is more appropriate yet ANP requires far more comparisons which may be formidable in practical decision environment. This is a new area of research to explore.

We were able to acquire the cooperation of the decision making team to structure the model, and solve it. We attribute our success mainly ease of use of AHP and the existence of easy-to-use commercial software (*Expert Choice*).

We needed a methodology well supported with a well developed-software conducive to real life applications easily understandable by the managers. AHP is appropriate whenever a goal is clearly stated and a set of relevant criteria and alternatives are available. When there are quite a few criteria involved, AHP is among very few multiple criteria approach capable of handling so many criteria, especially if some of the criteria are qualitative. With its *Expert Choice* software AHP enables sensitivity analysis of the results which is very important in practical decision making. This study showed the researchers that the AHP can be used to manage complex problems in vendor selection.

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