Supplier Selection Using Analytic Hierarchy Process: An Application From Turkey

Betül Özkan, Hüseyin Başlıgil, Nergis Şahin

***Abstract*—Decision making is one of the most important activities in companies. Making the right decisions have an important effect on companies' profit and success. In this paper our purpose is to choose the best supplier for computer and printer purchasing for General Directorate of Land Registry. We use Analytic Hierarchy Process (AHP) for selection methodology. First of all, we determine our main and sub-criteria. We have 4 main criteria and 16 sub-criteria. Our potential suppliers are A, B and C. Then we apply AHP on our problem and finally we determined the best supplier.**

***Index Terms*— AHP, computer and printer purchasing, decision making, supplier selection**

I. INTRODUCTION

Decision making is one of the most important activities in business. Managers need reliable and true forecasts for their decisions. Doing this they should consider scientific criteria. In general, a decision making problem is selecting the most appropriate alternative according to at least one goal or criteria from the alternatives cluster [1].

Decision makers' interest about the supplier selection process has been continuously growing because reliable suppliers enable the reduction of inventory costs and the improvement of product quality [2]. The selection of a supplier for partnership is perhaps the most important step in creating a successful alliance. The selection of an appropriate supplier is an important factor affecting eventual buyer–supplier relationship. If the process is done correctly, a higher quality, longer lasting relationship is more attainable [3].

Supplier selection is defined in as the ''process of finding the suppliers being able to provide the buyer with the right quality products and/or services at the right price, at the right quantities and at the right time [2].

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To choose the right supplier, different methods can be used. In this paper we used AHP to determine the best supplier. In literature, there some studies that use AHP for supplier selection. These studies can be summarized below [4]:

Akarte et al.[5] developed a web-based AHP system to evaluate the casting suppliers with respect to 18 criteria. In the system, suppliers had to register, and then input their casting specifications. To evaluate the suppliers, buyers had to determine the relative importance weightings for the criteria based on the casting specifications, and then assigned the performance rating for each criterion using a pairwise comparison. Muralidharan et al. [6] 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 [7] 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 [8] 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 [9] applied AHP to evaluate and select suppliers. Similar to Chan [7] 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. Chan et al. [10]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 [11]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.

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II. ANALYTIC HIERARCHY PROCESS (AHP)

AHP, developed by Saaty, addresses how to determine the relative importance of a set of activities in a multi-criteria decision problem. The process makes it possible to incorporate judgments on intangible qualitative criteria alongside tangible quantitative criteria. The AHP method is based on three principles: first, structure of the model; second, comparative judgment of the alternatives and the criteria; third, synthesis of the priorities[12].

In the first step, a complex decision problem is structured as a hierarchy. AHP initially breaks down a complex multi-criteria decision-making problem into a hierarchy of interrelated decision criteria, decision alternatives. With the AHP, the objectives, criteria and alternatives are arranged in a hierarchical structure similar to a family tree. A hierarchy has at least three levels: overall goal of the problem at the top, multiple criteria that define alternatives in the middle, and decision alternatives at the bottom [12]. The second step is the comparison of the alternatives and the criteria. Once the problem has been decomposed and the hierarchy is constructed, prioritization procedure starts in order to determine the relative importance of the criteria within each level. The pairwise judgment starts from the second level and finishes in the lowest level, alternatives. In each level, the criteria are compared pairwise according to their levels of influence and based on the specified criteria in the higher level. In AHP, multiple pairwise comparisons are based on a standardized comparison scale of nine levels. Table I shows the comparison scale. Let C = {Cj |j = 1, 2,...., n} be the set of criteria. The result of the pairwise comparison on n criteria can be summarized in an (n_n) evaluation matrix A in which every element aij (i,j = 1,2,..., n) is the quotient of weights of the criteria, as shown [12].

$$A=\begin{bmatrix} a_{11} & \dots & a_{12} & \dots & a_{1n} \\ \vdots & & \vdots & & \\ a_{21} & \dots & a_{22} & \dots & a_{2n} \\ \vdots & & \vdots & & \\ a_{n1} & \dots & a_{n2} & \dots & a_{nn} \end{bmatrix} \qquad a_{ii-1},\ a_{ji}=1/a_{ij},\ a_{ij}\neq 0$$

At the last step, the mathematical process commences to normalize and find the relative weights for each matrix. The relative weights are given by the right eigenvector (w) corresponding to the largest Eigen value λ_{max} as:

$A_w = \lambda_{max} W$

If the pairwise comparisons are completely consistent, the matrix A has rank 1 and $\lambda_{max} = n$. In this case; weights can be obtained by normalizing any of the rows or columns of A. It should be noted that the quality of the output of the AHP is strictly related to the consistency of the pairwise comparison judgments. The consistency is defined by the relation between the entries of A : $a_{ij} * a_{jk} = a_{ik}$. The consistency index CI is: $CI = (\lambda_{max} - n)/(n-1)$

The final consistency ratio (CR), usage of which let someone to conclude whether the evaluations are sufficiently consistent, is calculated as the ratio of the CI and the random index (RI)[12].

CR=CI/RI

The consistency ratio should be less than 0.1.

TABLE I
COMPARISON SCALE (AMIRI, 2010)

Definition	**Intensely of Importance**
Equally important	1
Moderately more important	3
Strongly more important	5
Very strong more important	7
Extremely more important	9
Intermediate more important	2,4,6,8

III. SUPPLIER SELECTION WITH AHP

In this paper, we selected the best supplier for General Directorate of Land Registry. They should buy 2000 computers and 500 printers annually and have to decide on the best supplier. So they decided to determine the best supplier by using AHP. There are 4 main criteria, 16 sub-criteria and 3 potential suppliers: A, B and C.

Hierarchical structure of the problem is shown in Fig. 1. The main criteria are; *General and organizational structure of the firm, Production capability, Service quality and Price*. The main criteria and their sub-criteria are explained below.

General and organizational structure of the firm

- *Employees number and quality:* The number of the well-qualified employees should be high, because the products are distributed to different areas all over the country.
- *Sector experience:* It would be better that the potential supplier firm have worked with different public concerns like General Directorate of Land Registry before.
- *References:* It shows the customer satisfaction degree of the supplier while working in similar sectors.
- *Communication capability*: Having strong communication while solving the problem and between other suppliers, it occurs a trust. And it is expected having a strong communication between customer an the firm in marketing and handling process.
- *Service adequacy:* The supplier should have a service infrastructure that is integrated and has a good knowledge and experience and can solve the problems quickly.
- *Capital:* It is preferred that the supplier is in good economic condition. The firm can choose the supplier with a big capital while purchasing some complex products.

Production capability

- *Delivery date appropriateness*: The supplier should deliver the products at the expected quality and at the time that is specified in the arrangement.

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- *Material appropriateness*: The materials that will be used in production should have in good quality and some standards.

- *Technological knowledge*: It is expected that the supplier can meet customers requirements using the new technology.

- *Material lead time*: It shows the power of the communication between the domestic and oversea suppliers. The lead time should be short.

Service quality

- *Packaging and carrying capability*: The material should be delivered to the desired place at the right time perfectly.

-*Flexibility:* It shows the quick response to the changes related to the material.

- *Sale and service network*: It is expected that the material can be supplied from the nearest location in- and after the agreement time. The firm has to have common authorized service network.

-*Customer satisfaction*: The product quality, the use of product, solving the problem and the relationship between the customers are all related to the customer satisfaction.

- *Research and development activities*: These are activities that are done for improving the product quality.

Price

This is one of the most important criteria. Generally the cheapest one will be preferred. But the cheapest one is not always the best.

The evaluation of the suppliers is made by experts. The experts answers the surveys and for evaluation they used Saaty's 1-9 scale. Every expert answered the survey individually and then the geometrical average was calculated and a single value was found.

First of all the pairwise comparisons are made for the main and sub-criteria. And the consistency rates are calculated. All the consistency rates are less than 0.1. The weights of the main and sub-criteria are found and then these weights are multiplied. And the final weights are found. Then the sub criteria are compared to the alternative suppliers. Table II shows the pairwise comparison matrix of the general and organizational structure of the firm's sub criteria. After the AHP methodology is applied on the problem, the best supplier is determined. Table III shows the results.

According to AHP results in Table IV, C is the best supplier.

TABLE II
PAIRWISE COMPARISON MATRIX OF THE GENERAL AND ORGANIZATIONAL STRUCTURE OF THE FIRM

General and organizational structure of the firm	**Communication capability**	**Employees number and capability**	**References**	**Sector experience**	**Capital**	**Service adequacy**	**Weights**
Communication capability	**1**	0.4368	0.6694	0.8736	1.4422	0.6934	**0.1316**
Employees number and quality		**1**	0.8434	0.5503	0.4642	1.5874	**0.1662**
References			**1**	1.1006	1.1447	0.6934	**0.1678**
Sector experience				**1**	0.6934	1.4422	**0.1803**
Capital					**1**	0.5503	**0.1748**
Service adequacy						**1**	**0.1793**
C.R. =0.0739							

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TABLE III
THE WEIGHTS OF CRITERIA

Criteria	**Subcriteria**	**Weight**
Price (0.1562)		
Service quality (0.3561)	R&D activities	0.1174
	Packaging and carrying capability	0.072
	Flexibility	0.2229
	Sale and service network	0.2533
	Customer satisfaction	0.3344
Production capability (0.2138)	Delivery date appropriateness	0.1059
	Material appropriateness	0.2225
	Equipment situation	0.2799
	Technological knowledge	0.2581
	Material lead time	0.1336
General and organizational structure (0.274)	Employees number and quality	0.1662
	Sector experience	0.1803
	References	0.1678
	Communication capability	0.1316
	Service adequacy	0.1793
	Capital	0.1748

TABLE IV
AHP RESULTS

Potential suppliers	Points
A	0.326
B	0.214
C	0.460

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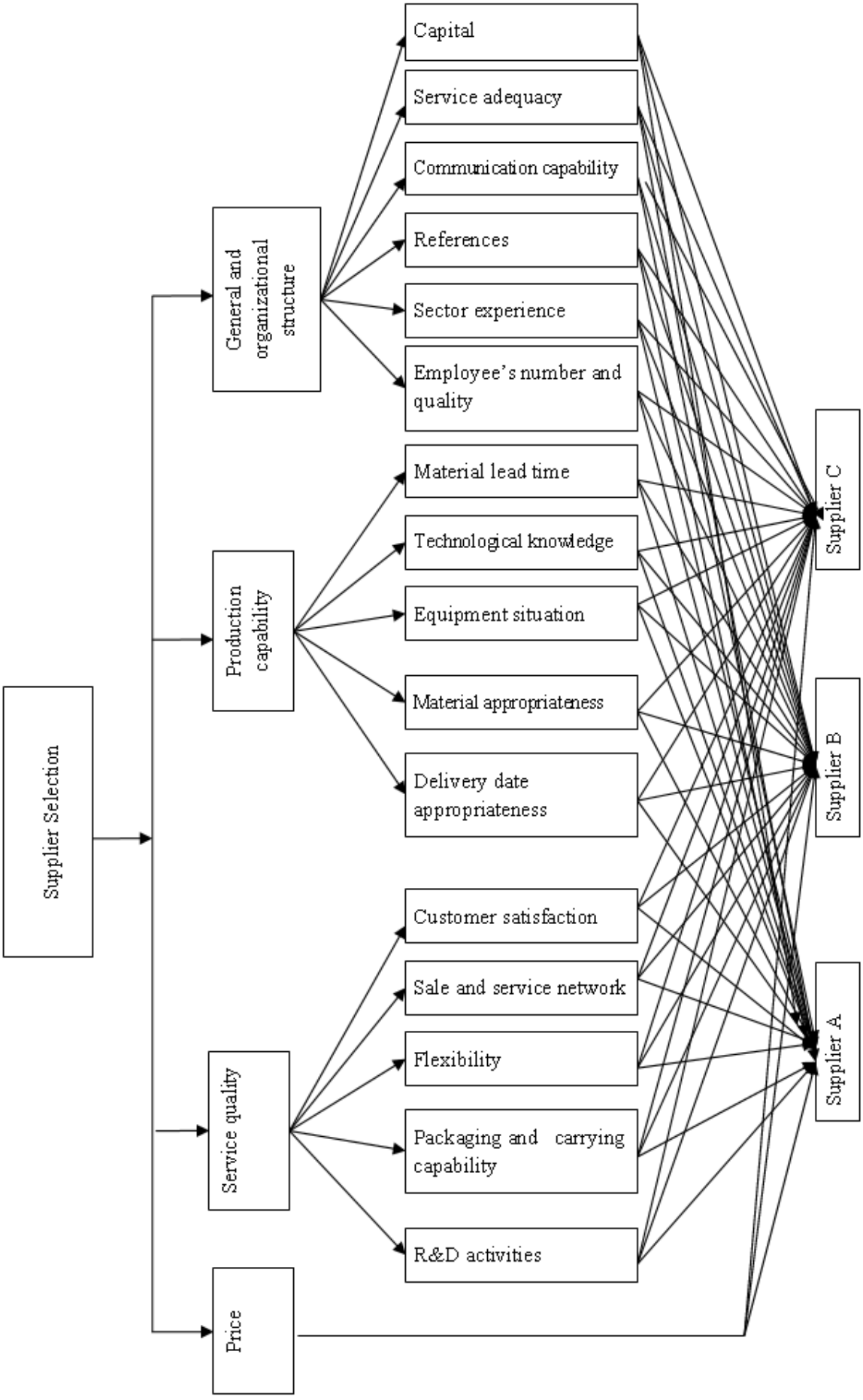

Fig. 1 Hierarchical structure

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IV. RESULTS

Since the criteria are both qualitative and quantitative for our case, AHP is used to evaluate decision process. According to AHP's results, the criterion *service quality* is determined as the most important criterion and the criterion *packaging and carrying capability* is determined as the least important sub-criterion. The ranking of criteria is determined Service quality- General and organizational structure- Production capability- Price from the most important to the least important.

In this paper, AHP methodology is used to determine the best supplier for purchasing computer and printers in General Directorate of Land Registry. According to obtained results, the alternative C is determined as the best supplier alternative, while A is determined as second best alternative and B is the worst alternative.

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