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An Analytic Hierarchy Process (AHP) Approach to a Real World Supplier Selection Problem: A Case Study of Carglass Turkey

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Abstract
Purpose: The main purpose of this study is to solve a real world supplier selection problem of Carglass Turkey.
Design/Methodology/Approach: This problem includes both tangible and intangible criteria therefore analytic hierarchy process (AHP) is accepted as the methodology. In this study, we took three main criteria as cost, availability and quality, additionally six sub-criteria as product price, transportation costs, quality assessment, technical capability, business improvement and management approach and four suppliers into account. During this study, a strict cooperation with Carglass Turkey's Supply Chain Management Team (SCMT) is ensured and maintained.
Findings: According to the calculated weights, availability emerged as the most important criteria and followed by cost and quality. These criteria also gave dominance to the selected supplier among other alternatives. All results with interpretations were presented to SCMT as a report. Implementation of the outcome was carried out by SCMT accordingly.
Originality/Value: In this study we implemented AHP to a real world supplier selection problem. The results that we obtained were considered acceptable and feasible by the decision maker.

Keyword: Analytic hierarchy process (AHP); Multi-criteria decision making (MCDM); Real-world problem; Supply chain management (SCM); Supplier selection

Paper Type: Case study

Introduction

In today's vying environment companies should meet customer needs completely and in a timely manner in order to compete with their rivals. Furthermore, due to developments in technology and global market circumstances, customers now have an instant access to a wide range of product and service alternatives. Along with the attributes such as quality and cost, rapid accessibility has become a prioritizing factor for the customers.

Thus, it can be stated that being agile is crucial for the companies that follow customer oriented approaches. In order to reach the state of readiness, making right decisions and choices regarding suppliers is essential and this will definitely render an enterprise discernible in above mentioned global competition area. Therefore supply chain excellence is a significant characteristic of competitiveness in most industries globally. Supply chain management mainly offers an effective use and harmonious interaction of the processes from customer to supplier (Setak et al., 2012). At this point, the decisions made by companies become especially critical. Yet either in manufacturing or service businesses, regardless from the concentration, effective supply chain management can lessen purchasing costs, boost customer satisfaction, provide faster product presentation and make positive contribution to competitive ability (Liao & Kao, 2009). In some situations that a supplier also appears to be a competitor, well planned supply chain management may also secure the companies' position in above stated highly competitive environment.

As being discussed in numerous studies, the main consensus of scholars is that one of the key issues in supply chain management is the selection of supplier (Deng et al., 2013; Wu & Barnes, 2011; Huang & Keskar, 2007). In accordance with this, today's dynamic state of quality management and increased variety of production concepts points out the supplier selection matter as a critical issue for companies (Muralidharan et al., 2002). Therefore it can be said that decision makers' particularity is comprehensible and somehow essential while selecting suppliers.

Supplier selection is picking up the competent business partner that ensures providing required quality products and services with an acceptable cost, at sufficient quantities and on time (Sonmez, 2006). Procedure primarily begins with the formation of conditions or circumstances that requires a selection of the supplier. This is naturally followed by the decision of the organizations to start the selection process. The search for a suitable supplier proceeds with determination and evaluation of different aspects, which are generally, defined as supplier selection criteria. These criteria may present tangible and/or intangible features. It is obvious that prominence of these criteria is related with the distinctive features of the company. As each company expected to have its own typical characteristics, structures, backgrounds and needs it's advised that the supplier selection criteria must be determined according to these features (Chen & Chao, 2012). Determining the appropriate criteria is followed by choosing a best supplier. As a multi-criteria decision making (MCDM) problem various different methods has been used to date in supplier selection and these methods have been presented in a research recently (Chai et al., 2013). In this study, Carglass Turkey's real world supplier selection problem is handled. As it was a MCDM problem and the determined criteria were both in tangible and intangible function, analytic hierarchy process (AHP) was accepted as the main methodology.

This study divided into four sections: In Section 1, the concepts of supply chain management (SCM) and outline of supplier selection problem is explained. In Section 2, a brief review of AHP method and its applications are presented. In Section 3, the real world study, selection of the best supplier for Carglass Turkey along with explanation of the model, components, analysis applied and results are given. Section 4 includes the evaluation of the outcome.

AHP and Its Applications

AHP was developed by Saaty in 1976 (Saaty, 2000). It has been one of the most widely used multi-criteria decision making tool to model real world decision problems. In compliance with the subjectivity factor in real world problems, this method takes both

tangible and intangible criteria into account (Erdogmus et al., 2006). Another advantage of this method is the convenient usage of hierarchies to structure complex multi-period, multi-person and multi-criteria problems, since the steps of the solution includes configuring these hierarchies and synthesizing outcomes of judgments (Yusuff et al., 2001). It can be said that this type of hierarchical visualization facilitates the contribution of decision-makers and may lead them to reassess their judgments in accordance with the development of the decision process. Thus a state of consensus can also be built among several decision-makers. In general AHP consists of four steps. The first step of AHP is the determination of main and sub-criteria in accordance with the decision problem. AHP methodology continues with conversion of the decision problem into hierarchies (Wind & Saaty, 1980). The hierarchical structure can be generated and presented in many forms. Nevertheless a general illustration of a hierarchical presentation which consists of ultimate goal, criteria and alternatives is shown below in Figure 1.

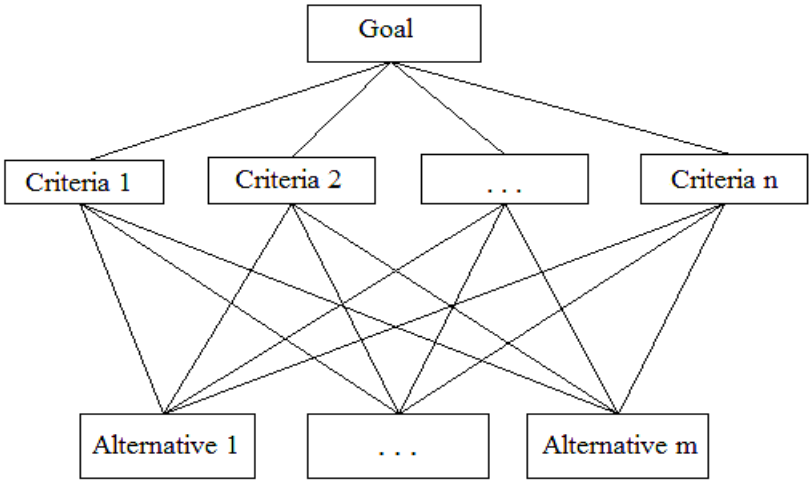

Figure 1: General structure of the hierarchy (Saaty, 2000)

Second step is subsequently followed by collecting data. In this step, data are collected through pairwise comparisons which are performed by the decision-maker. These comparisons are made by using the scale of relative importance which ranges the values from 1 to 9 and presented in Table 1.

Table 1: Fundamental scale used in AHP (Saaty, 2000)

Intensity of Importance	Definition	Explanation
1	Equal Importance	Two activities contribute equally to the objective
2	Weak	--
3	Moderate Importance	Experince and judgment slightly favour one activity over other
4	Moderate Plus	--
5	Strong Importance	Experince and judgment strongly favour one activity over other
6	Strong Plus	--
7	Very strong	An activity is favoured very strongly over another
8	Very, very strong	--
9	Extreme Importance	The evidence favouring one activity over another is of highest possible order of affirmation

Grounds of these pairwise comparisons are to take (i) every sub-criteria into account for each alternative, (ii) every main criteria into account for each sub-criteria, (iii) the goal into account for each main criteria (Aras et al., 2004).

As a result, pairwise comparison matrices are obtained by these comparisons. Afterwards, inconsistency ratios for every matrix are checked in order to determine the misevaluation of comparisons. Inconsistency ratios are generally acceptable up to the limit of 0.10, while some scholars offer a limit up to 0.20 (Cox, 2000; Soma, 2003). If all matrices are consistent, the process can proceed to the next step. If not, inconsistent matrices should be reassessed in order to provide consistency for all matrices. Concerning the above explanations, the third step includes synthesis of these judgments in order to determine an overall priority among alternatives and criteria (Korpelaa et al., 1998). In the fourth step the best decision is acquired through this synthesis.

Many researches have been published which include applications of AHP in different fields such as planning, selecting the best alternative, resource allocations, resolving conflicts, optimization problems, etc. (Vargas, 1990). This can be seen through studies that presents collections and reviews of the applications of AHP (Boer et al., 2001; Sonmez, 2006; Vaidya & Kumar, 2006; Ho, 2008; Bruno et al., 2011; Wu & Barnes, 2011; Subramanian & Ramanathan, 2012). AHP is also one of the most utilized methodologies to solve the supplier selection problems. In accordance with the main concentration of this study as a real world problem, a compilation of some studies that have applications of AHP and integrated AHP in real world supplier selection problems are mentioned below in Table 2.

Table 2: AHP-based applications to real world supplier selection problems

Industries	Applications
General electronics	Chen et al. (2007), Gencer et al. (2007), Che et al. (2008), Lee (2009), Lee et al. (2009), Levary (2008), Yang et al. (2008), Wu et al. (2009)
Home appliances	Sevkli et al. (2003), Zaim et al. (2003), Demirtas et al. (2007), Demirtas et al. (2008), Sevkli et al. (2008), Kilincci et al. (2012)
Automotive/tyre	Noorul Haq et al. (2006)
Semiconductor industry	Yu et al. (2008)
Food industry	Cebi et al. (2003), Bottani et al. (2005)
Telecommunication	Onut et al. (2008)
Manufacturating	Ozgen et al. (2008), Tahriri et al. (2008), Asamoah et al. (2012), Ramanathan (2013), Verma et al. (2013)
Logistics	Buyukozkan et al. (2008)
Commercial tools	Schoenherr et al. (2008)

As it can be seen from the Table 2, there are several studies in various industries including AHP-based solutions to real world supplier selection problems. In this study a real world supplier selection problem in auto glass industry is handled.

A Case Study of Carglass Turkey

The main motivation behind this study is solving Carglass Turkey's real world problem of selecting the best supplier. Carglass Turkey operates in vehicle glass repair and replacement and serves more than 110.000 customers ever year with 12 branches and 198 franchises. Apart from Carglass Turkey, including world's majority brands such as Carglass Europe, O'Brien Australia and Safelite Unites States of America is owned by Belron Inc. which operates in 28 countries for 8 million customers.

As one of the pioneers in its line of business, Carglass Turkey faced a supplier selection problem recently. This was a strategic decision problem which is considered to effect Carglass Turkey's competitiveness in above mentioned arduous environment. In addition, this problem includes both tangible and intangible criteria therefore AHP is accepted as the methodology to solve this real world supplier selection problem. The process followed to solve this problem is shown in Figure 2.

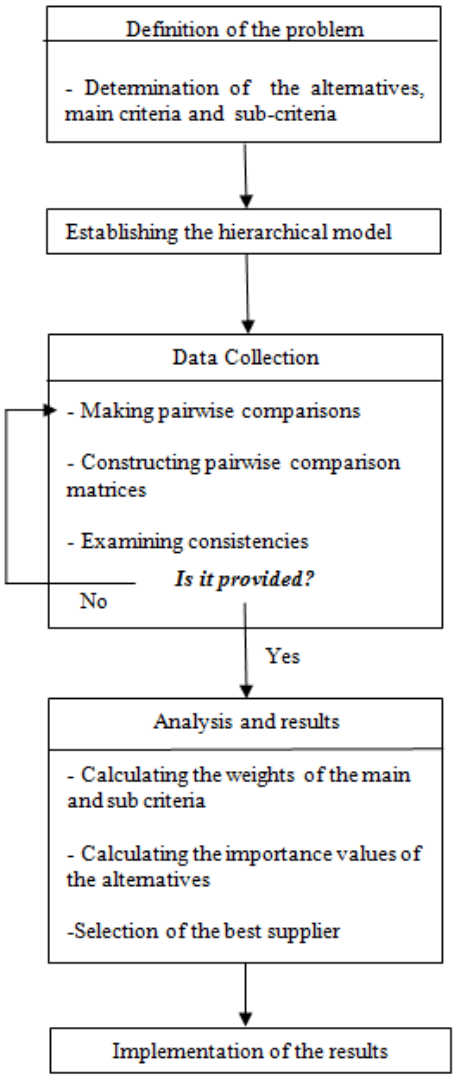

Figure 2: Solution process of Carglass Turkey's supplier selection problem

The process followed in this study consists of six steps which are shown in Figure 2. These steps are explained below respectively.

The first step of this solution process is the definition of the problem. In this step, all of the components (alternatives, main and sub-criteria) of Carglass Turkey's supplier selection problem are defined clearly. In order to determine these components, a meeting was held with Supply Chain Management Team (SCMT) of Carglass Turkey. This team consists of a supply chain manager and two specialists. In this meeting, we were informed that there are four suppliers which are also competitors of Carglass Turkey. These suppliers were renamed as A, B, C and D respectively in accordance with the request of the company regarding their confidentiality policy. According to SCMT, each of these four suppliers has different characteristic advantages which changes from the aspect of one criteria to another. Therefore, several criteria have been taken into account with essential literature review. As a result, 40+ criteria were presented to SCMT. Finally, three main criteria which are also stated as Belron Inc.'s essential supplier evaluation principals, are selected by SCMT. These main criteria are *cost*, *availability* and *quality*.

Cost can be defined as financial outcome of business relations related with purchase. According to SCMT, *product price* and *transportation costs* are pointed as critical cost related criteria, therefore these were taken as sub-criteria.

Availability simply means the accessible sources of products for which SCMT did not state any sub-criteria.

The last criteria *quality* is the level of sufficient business interactions. The sub-criteria that have been stated by SCMT are: *Quality assessment* by which quality will be improved and maintained; *technical capability* which means the ability to control field related skills (Chan & Chan, 2010); *business improvement* which ensures future developments in accordance with changing customer needs; *management approach* which includes strategic management and applying new methods.

The second step is establishing the hierarchical model. In this step, we hierarchically modeled the supplier selection problem of Carglass Turkey. This hierarchical model is shown below in Figure 3:

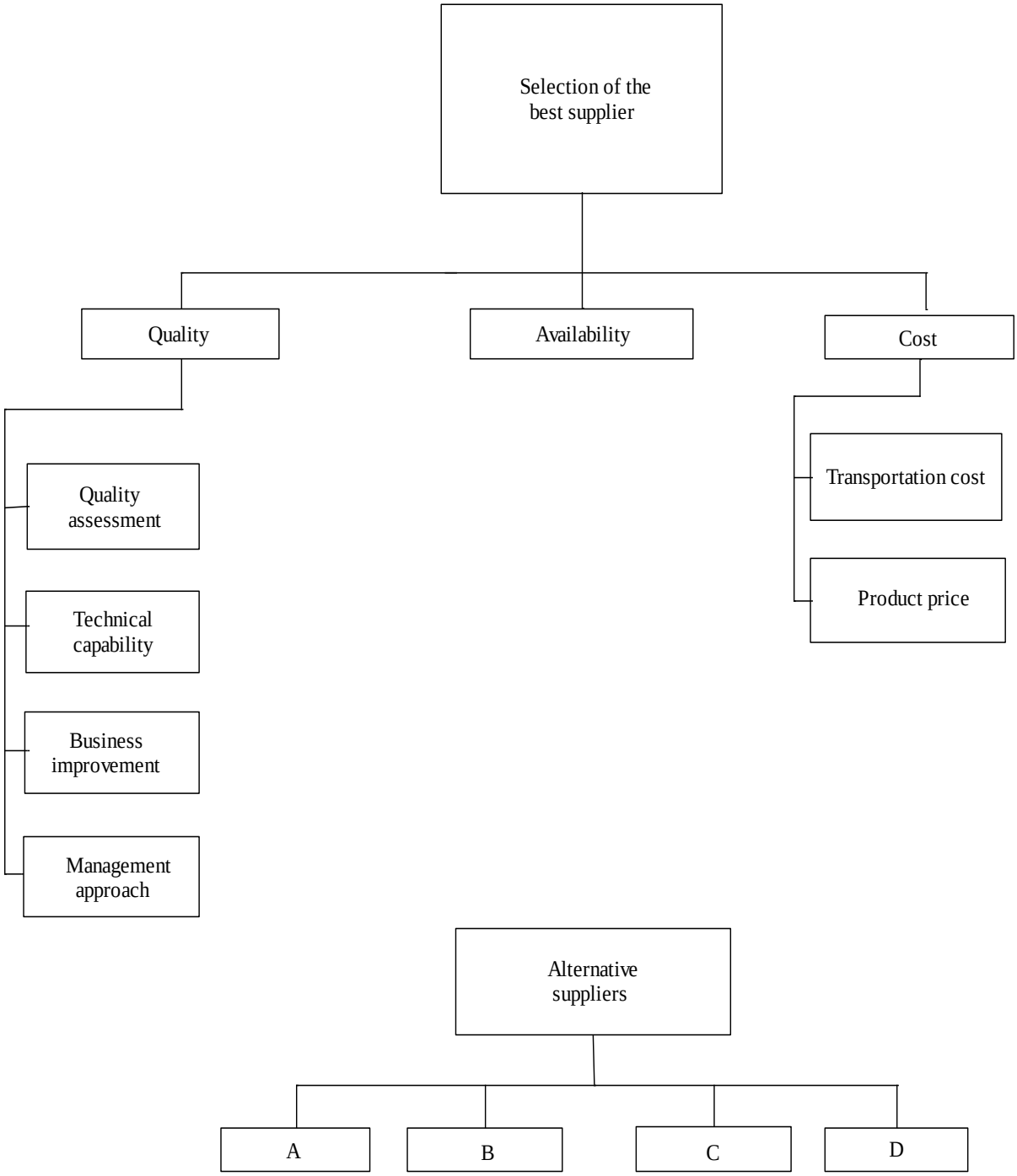

Figure 3: Hierarchical model of Carglass Turkey's selection of the best supplier problem

After establishing the hierarchical model data were collected by pairwise comparisons. These comparisons were performed in a meeting with SCMT. In this meeting, each comparison was evaluated by using the scale in Table 1 (see Section 2) and finalized singly as a collective judgment of SCMT.

After carrying out all comparisons, pairwise comparison matrices were obtained. As an example, the pairwise comparison matrix which includes judgments of SCMT regarding main criteria is given below in Table 3.

Table 3: Pairwise comparison matrix of the main criteria

	Cost	Availability	Quality
Cost	1	1/3	2
Availability	3	1	4
Quality	1/2	1/4	1

According to this matrix, *availability* is three times as important as *cost* which means *availability* has moderate importance over *cost*. Also, *availability* is four times as important as *quality* which means *availability* has moderate plus importance over *quality*. In addition *cost* is two times as important as *quality* which means *cost* has weak importance over *quality*. Following the acquisition of matrices, inconsistency ratios were checked. In this study the inconsistency ratios are 0, 0.07 and 0.08 for main criteria, 0.09, 0.04 and 0.07 for sub-criteria. For this reason, no reassessments were made.

The analysis step of the process consists of calculating the weights of both criteria, alternatives and selection of the best supplier. In this study, Expert Choice 11 software was used for all the analyses. Firstly, relative weights of all criteria were calculated and presented in Figure 4:

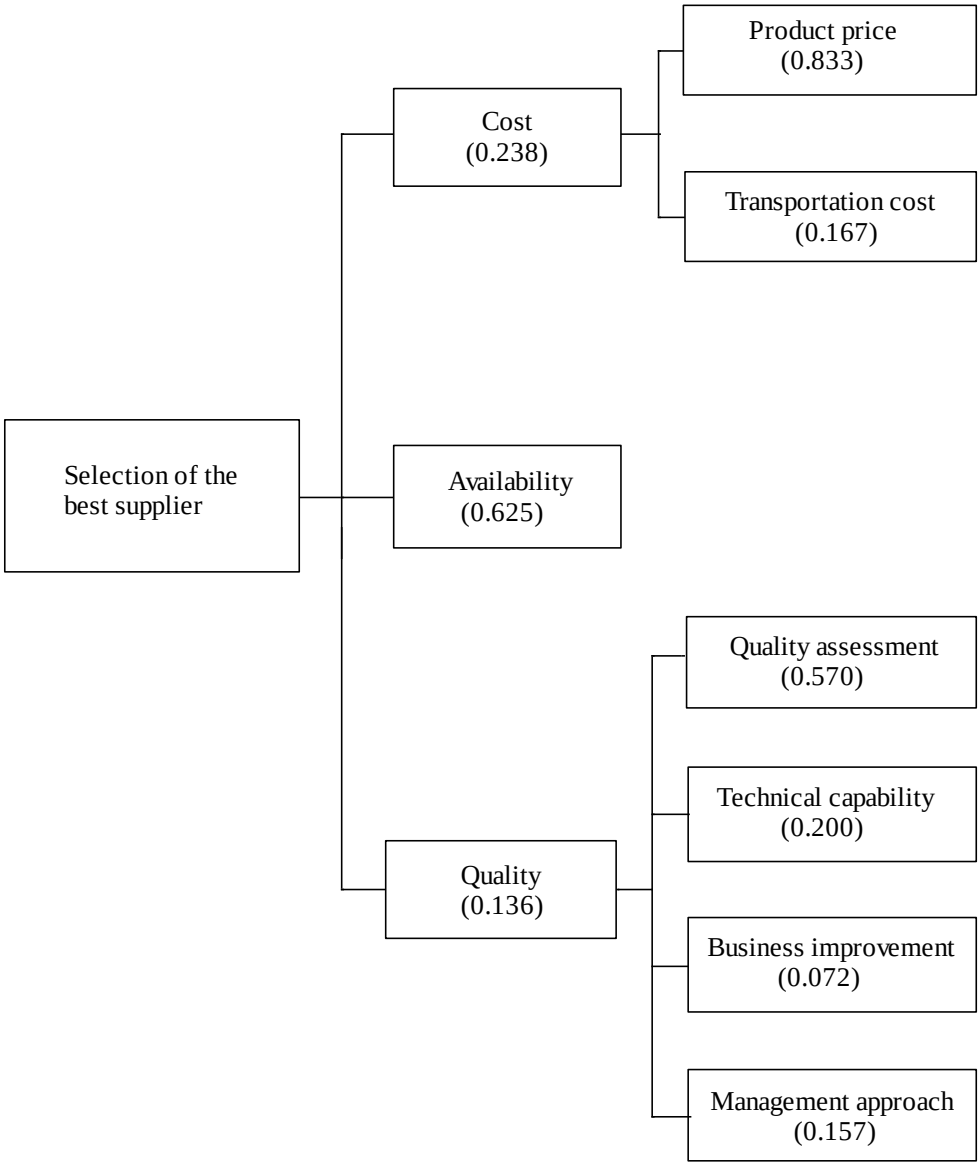

Figure 4: Relative weights of main and sub-criteria

Based on the results that are shown in Figure 4, *availability* is the core criteria for selection of the best supplier for Carglass Turkey. *Cost* and *quality* follow this criteria respectively. With a quick glance to sub-criteria weights; (i) for *cost*, *product price* is more important than *transportation cost* and (ii) for *quality*, *quality assessment* has dominance over *technical capability*, *management approach* and *business improvement*. Before selection of the best supplier, validation of these results was checked in a meeting with SCMT. In this meeting, relative weights of all criteria were evaluated. According to the evaluation of main criteria, SCMT approved the validity of the importance order. Because, logically a broken glass needs to be fixed by repairing and/or replacing instantly; therefore *availability* happens to be the most important criteria for an emergency solution. For this reason *availability* seems to be the dominant criteria in selection of the best supplier. SCMT also approved the importance order of *cost*'s sub-criteria. "*Product price has the power to boost competition of supplier market in order to be the best supplier*" SCMT mentions. Similarly the order of *quality*'s sub-criteria is accepted by SCMT, because it is compatible with company policy.

This step continues with calculating the importance values of supplier alternatives. These values are presented in Table 4:

Table 4: Importance values & ranks for alternative suppliers

Alternatives	Importance Values	Rank
A	**0.438**	**1**
C	0.259	2
D	0.198	3
B	0.105	4

As it can be seen in Table 3, Supplier A has the highest importance value among all alternative suppliers.
The last step of the process is the implementation of the results. In this step, all results with their interpretations have been presented to SCMT in a meeting. Consequently Supplier-A suggested as the best supplier and approved by SCMT accordingly.

Discussions and Conclusions

In nowadays competitive business environment, supply chain management (SCM) attracts a significant attention. Regardless from the business concentration, companies can take advantage from the benefits of efficient management of supply chains. As a crucial issue of supply chain management, supplier selection process will display contradictions regarding intentions. These intentions may consist of emergency solutions to the customer needs, keeping an efficient business in terms of quality and maintaining this delicate relationship in a highly vying environment. Because of these, a supplier selection problem can present a complex situation as it also includes tangible/intangible factors. Therefore AHP appears to be one of the most convenient methods for complex decision problems due to its simple concept and acceptable feasibility.

In this study, AHP is used to solve Carglass Turkey's real world supplier selection problem. The process in Figure 2, which consists of five steps was followed accordingly to solve this problem. Firstly, the problem was defined including main/sub criteria and alternatives. In compliance with these components, the hierarchical model was established which is given in Figure 3. Pairwise comparisons were performed and related matrices were obtained. In order to determine if there were any misevaluations, inconsistency ratios for every matrix were examined. As all matrices were consistent, we calculated the relative weights of all criteria. These weights were presented in Figure 4. According to Figure 4, *availability* is the criteria that has highest importance value. *Availability* is followed by *cost* and *quality*. Concerning the sub-criteria weights, *product price* has dominance over *transportation costs* and similarly *quality assessment* is much more important than *technical capability* and *business improvement*. Finally, the importance values of suppliers were calculated. These importance values were presented in Table 3. Consequently, the superiority on the most significant criteria, *availability*, put *Supplier A* forward among other suppliers. It can be clearly seen that one specific criteria appeared to have the ability to give dominance to the supplier among others in this study.
In accordance with our outcomes which were acquired in this study, a report has been presented to SCMT. After several discussions, SCMT approved the validity of all results. In conclusion, SCMT accepted *Supplier A* as the best supplier.

The limitation in this study is that it was performed in one particular area which is auto glass industry. Therefore the main and sub-criteria were presented to SCMT in accordance with their branch. As a general problem which may occur in several industries, the criteria for a supplier selection problem should be determined in compliance with the related branch.

On the contribution aspect of this study, it has two significant values added to the literature: Firstly, to handle a real world supplier selection problem, secondly and more importantly to offer an implementable solution to this problem. Thereby, this study will guide researchers as well as executives who are experiencing a decision problem similar to this field and offer a valid solution.

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