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THE ANALYTIC HIERARCHY PROCESS METHOD TO DESIGN STRATEGIC DECISION MAKING FOR THE EFFECTIVE ASSESSMENT OF SUPPLIER SELECTION IN CONSTRUCTION INDUSTRY

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ABSTRACT

Purpose - Endemic uncertainty of the environment within a limited time framework tend to complicate the decision-making process. This study aims to analyze the selection of the optimal supplier that meets the necessary criteria such as product features, supplier features, and delivery conditions.

Methodology - Increasing market pressure in the construction industry compels companies to make quick and good decisions conducting strategic analyses. In this regard, information asymmetry is a crucial concept that requires managers to use different models during the decision-making process not only for their own benefit but also for the sake of all stakeholders. Analytic Hierarchy Process Method is used to evaluate suppliers' characteristics that tend to consist of numerous interdependent variables and complex relationships.

Findings - Supplier A has relatively better product features and supplier features. Addressing fundamental issues in supplier selection has been increasingly gaining ground in the construction industry in order to maintain a competitive advantage in regard to both cost and time efficiency as well as sustainability.

Conclusion - Companies operate in an environment where decisions are ought to be handled in a rather holistic way. When managers are about to make robust decisions, they are ultimately obliged to feel responsible to both the company and various groups of stakeholders. Overall, decision-making is of vital importance for corporates both in a macro perspective due to existing ecological concerns and also in a micro perspective in terms of sustainability.

Keywords: Analytic Hierarchy Process, strategy, decision-making, supplier selection, construction industry.
JEL Codes: M00, M10, M19

1. INTRODUCTION

The research conducted in this study aims to explore and subsequently overcome problems and deficiencies that are associated with the multi-criteria nature of the corporate environment. A number of methods can be used in order to evaluate multiple variables. Generally speaking, companies operate in an environment where mutual effects shape their strategies. Companies are required to assess concepts, strategies and progressive stages of positive growth.

This article examines the application of the AHP method in terms of the supplier selection process in the Turkish construction industry. There seems to be a rather strong and complex competitive structure in the industry. The use of the fuzzy AHP method in the Turkish construction industry may both shorten and also simplify this complicated and generally tangled process of choosing the right supplier. In addition to that, this study also aims to provide a general view of top management structures of the construction companies that have been examined in an empirical study based on the application of the AHP method in terms of the supplier selection process and favorable approaches in order to devise a nifty as well as accurate scheme throughout the decision-making mechanisms. The characteristics of supplier capabilities have also been analyzed in this comparative study. Studies conducted on modeling and simulation so far offer some useful tools for decision-makers.

Businesses around the world are forced to evaluate and also benchmark all the criteria they often encounter. This has a huge impact on the decision-making process in terms of the prioritization of variables by eliminating some possible alternatives. In general, financial parameters tend to be important determinants that can be seen in comparison tables

based on the supplier selection process. The demands of end-users as well as owners on issues such as quality and technical performance seem to be increasing on a daily basis. And there are widespread improvements detected in the level of awareness in regard to the environment, society and sustainability. Therefore, not only performing the decision-making process in the construction industry turns out to be a rather challenging process both practically and systematically, but also achieving these business goals ultimately seems to be a rather demanding task. The Fuzzy AHP method stands out as an application of a Multi-Criteria Decision Analysis (MCDA) that offers a solution to the abovementioned challenges in the decision-making process.

To sum up, this article aims to provide a framework to contrive strategic decision-making based on the evaluation of supplier selection in the construction industry. With this in mind, the literature reviews about the supplier characteristics are presented. The third part focuses on the steps of AHP method. And the calculations based on the given criteria can be found in the fourth part. Finally, the findings are shown from a managerial perspective in the conclusion part.

2. SUPPLIER SELECTION CRITERIA AND METHODS

There has been diversified research that tends to evaluate supplier selection criteria. There are also some beneficial literature reviews on different industries to examine. In general, supplier selection criteria can be summarized as follows: product features, supplier features, and delivery conditions.

The supplier selection process has gone through a lot of significant changes over the last two decades. One of the main reasons is the use of improved computer-mediated means of communications that not only encourage distant suppliers to connect with one another, but also enable them to compete with their local rivals more easily. What's more, they facilitate effective communication between companies as well as alternative suppliers, which in return speeds up the entire decision-making process during which faster and more accurate strategic decisions are made. Having a variety of alternatives leads main contractors, end-users, and owners to have higher expectations that suppliers are required to meet. This ultimately affects the supplier selection criteria in that it puts considerable demands on both quality and technical performance. With recent advancements in computer and networking technologies, it is now much easier to have improved technical performance. And due to increasing demand for state-of-the-art quality, there have been difficulties with conventional methods in terms of the supplier selection process.

In Malaysia, the problems faced in regard to construction projects are often due to missing the deadlines which in return often leads to unwanted delays. The main causes of these delays could be listed as: contractor's inadequate planning, inefficient construction management, limited expertise, scarce financial resources, incomplete pay from the customer, machinery, labor supply, equipment, difficulties with subcontractors, communication deficiencies as well as inaccurate planning. To put it in a nutshell, there are six major causes of delays: (1) time, (2) expenses, (3) conflicts, (4) compromises, (5) prosecution, and (6) desertion (Sambasivan and Soon, 2007: 517).

Contractor selection in terms of construction projects is a highly important determinant for the ultimate success. There are six key indicators that have been examined in this study, namely expertise, economic fluctuations, high caliber construction, human workforce, machinery, and tasks at hand (Jabbarzadeh, 2018:125).

The criteria for supplier selection in telecommunications industry are identified based on some critical aspects such as financial, technical as well as operational attributes. Financial attributes include capital expenditure, unit costs, operational expenses, maintenance expenses, and Network Management System (NMS) expenses. The technical attributes are, namely technical characteristics, technical dependability, technical efficacy, technical competency, upgrades, technical dismissals, imminent technological advancements, keeping up with global measures, constituency with alternative structures. Operational attributes encompass error recognition, system protection, operational facilities, performance appraisals, as well as flexible invoicing. (Tam and Tummala, 2001:176).

The supplier selection process is regarded as a crucial step by the Purchase Division. Normally, suppliers tend to be chosen based on their capacities in terms of necessary characteristics, delivery conditions, and proposed financial value. Apart from current needs, there are also some future expectations that a decent supplier should be able to meet. It is possible to group these rather critical principles into four major categories, namely self-governing, trustworthy, committed, and driven. Interpretive Structural Modelling (ISM) is an approach that displays interdependence of various factors as well as their degrees of significance during the supplier selection process. It shows that "stance as well as enthusiasm in business" together with "customer care" are equally essential elements just like characteristics, delivery, and application processes. The aforementioned elements are also found to be interdependent. The study may yield a substantial systematic database in terms of the supplier selection process (Mandal and Deshmukh, 1994: 58).

The criteria have been established by interviewing procurement officers in the white goods sector in Turkey. They can be summarized under three main headings: a) suppliers, b) product performance, and c) service performance. The subheadings of suppliers are finances, management and quality systems; product performance, use of manufacturing, other

businesses, end use, service performance as a follow-up customer support, customer satisfaction and professionalism (Kahraman, C., Cebeci, U., & Ulukan, Z., 2003:389).

The initial phase involves assessing the configuration of the design. The ultimate aim of the design is to choose the top supplier. There needs to be a total of four suppliers (named supplier A, B, C and D) along with eleven decision-making elements (characteristics, punctuality, cost, adaptability, time of delivery, capacity of senior executives, performance of employees, operational competence, economic potential, as well as market share) in order to assess the substitutes. Consistent elements should be grouped into two categories: supplier's conduct as well as supplier's capacity. Afterwards, four suppliers should be grouped under the category of substitutes. Hence, we are supposed to have three categories in total in the design, namely supplier's conduct, supplier's capacity, as well as substitutes. It is a basic grid system. Figure 1 displays the general picture related to the ANP design. Interconnections are shown with straight arrows in-between the categories (Bayazıt, 2006: 570).

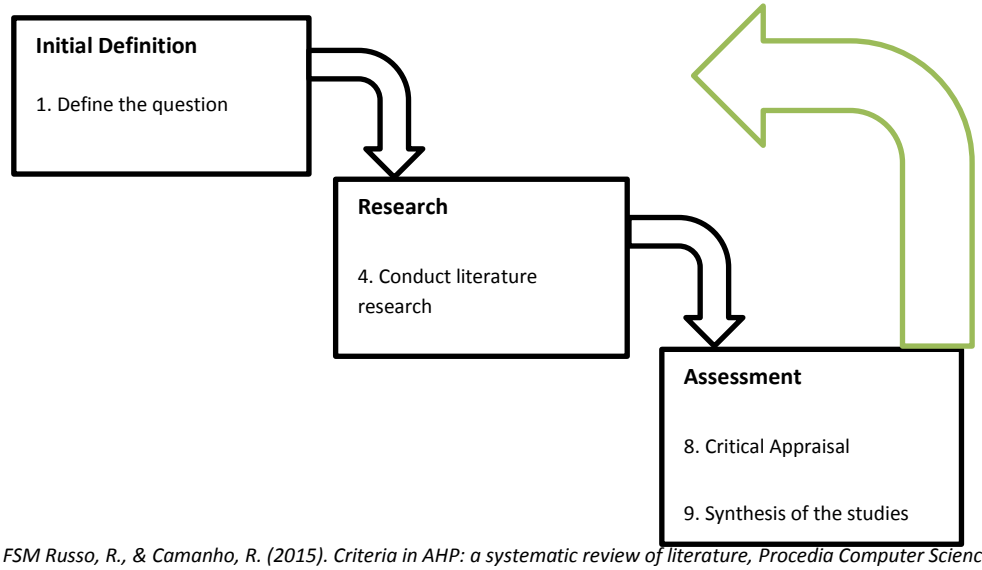
4. ANALYTIC HIERARCHY PROCESS (AHP) METHOD

Various studies in the literature so far have been scrutinized in order to select the most effective criteria. Thence, different indicators have been consolidated to be able to attain the most effective evaluation.

AHP is a technique that evaluates different importance levels of variables for the decision-making process. The decision makers' ability, experience and intuition are also applied in order to simplify the problem-solution process. Both objective and subjective opinions tend to affect the selection process of the variables. There are three levels of this approach in terms of building a hierarchical level comparing relative importance matrices and the measurement of consistency in accepted values. The option with the highest value is preferred over the other alternatives. 1-9 scale is implemented for the measurement. The findings can naturally differ in terms of various multi-criteria decision making models (Ömürbek and Şimşek, 2014: 308-322).

The Analytic Hierarchy Process (AHP) attempts to define the ambiguity (overflow) of the transmitter through diversified alternatives. Numerical comparisons are made as to not only put the alternatives in order according to their targets but also to compare them with one another.

Figure 1: Systemic Review Development Flow



Source: de FSM Russo, R., & Camanho, R. (2015). Criteria in AHP: a systematic review of literature, Procedia Computer Science, 55, 1125.

The Decision Support System (DSS) is integrated into the Analytical Hierarchy Process (AHP) in order to find the best location of the convenience store. The determined components are as follows: (1) hierarchical structure development for fuzzy AHP, (2) weights determination, (3) data collection, as well as (4) decision-making. It aims an accurate and fast decision-making process for top managers (Kuo, R. J., Chi, S. C., & Kao, S. S., 1999: 323).

A two-way comparison is made up of criteria and alternatives, findings of default vectors, scoring and ranking of alternatives. The compliance index and ratios are then calculated.

Alternate comparisons are made for the measurement, in which the numbers from 1 to 9 are made in the form of a matrix.

$$a_{ii} = 1,\ a_{ij} = k,\ a_{ji} = 1/k$$

The column sums in the matrices are found. Each cell is normalized through dividing it by the column sum. The alternatives are graded by averaging each line. This vector shows the extent to which the alternatives meet their criteria. Comparisons of criteria are made using numbers 1-9. The numbers in the matrix are normalized by dividing by the sum of the columns. The priority of the criteria is determined by finding line averages. Each cell is normalized by dividing it by the column sum. The alternatives are graded by averaging each line. This vector shows the extent to which the alternatives meet the criteria. The total scores of the alternatives are multiplied and their grades sorted. The highest score shows the best alternative.

The meaning of numbers 1-9 used in rating is below:

Preference level	Numeric value
Equally important	1
Moderately more level important	3
Strongly more important	5
Very strongly more important	7
Extremely more important	9

Note: 2, 4, 6, 8 represent intermediate values.

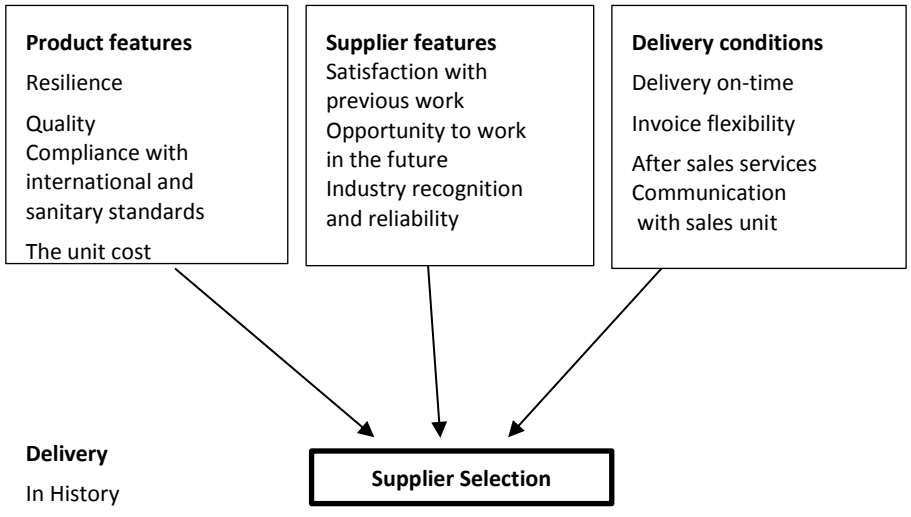
5. RESEARCH MODEL

The best choice is the ultimate goal. In order to achieve this, 4 suppliers will determine the degree of contribution to the three criteria that are to be sorted out. Priority preference rating is made by comparing the alternatives and the criteria.

The decision was based upon the key success factors in the industry. Product features, supplier features and delivery conditions are included in this framework. Product features include resilience, quality, compliance with international and sanitary standards and the unit cost. Supplier features encompass satisfaction without previous work, opportunity to work in the future, industry recognition and reliability. Delivery conditions embody delivery on-time, invoice flexibility, after sales services and communication with sales unit.

There are interrelated determinants which offer a multi-criteria model for accurate decisions when it comes to selecting strategies, procedures as well as processes in regard to corporates.

Figure 2: Interpretive Structural Model (ISM) for Supplier Selection Criteria



Research has been conducted to come to a final decision comparing 4 suppliers. Three important criteria have been designed in order to choose the top supplier according to their levels.

- Alternatives

- ✓ Supplier A
- ✓ Supplier B
- ✓ Supplier C

- ✓ Supplier D

The criteria for supplier comparison are:

- Product features

- ✓ Resilience
- ✓ Quality
- ✓ Compliance with international and sanitary standards
- ✓ The unit cost

- Supplier features

- ✓ Satisfaction with previous work
- ✓ Opportunity to work in the future
- ✓ Industry recognition and reliability

- Delivery conditions

- ✓ Delivery on-time
- ✓ Invoice flexibility
- ✓ After sales services
- ✓ Communication with sales unit

6. SUPPLIER EVALUATION BY USING AHP

The purpose, criteria and sub-criteria were the key elements to be determined first. Afterwards, binary comparisons were evaluated for each and every criterion. Finally, all the ratios in the matrices were graded.

The results based on the ranking of the suppliers indicate that Supplier D is the best alternative in terms of product features, supplier features, and delivery conditions.

Table 1: AHP Process Normalization Table for Product Features

Product Features	Supplier A	Supplier B	Supplier C	Supplier D	Total	Percentage
Supplier A	1,00	3,44	3,67	4,56	12,67	0,47
Supplier B	0,37	1,00	2,02	3,22	6,61	0,24
Supplier C	0,54	1,14	1,00	2,56	5,23	0,19
Supplier D	0,26	0,68	0,79	1,00	2,73	0,10

Supplier A is the most preferred one in terms of product features. In every industry, the product specifications are regarded as important elements. Yet, regulations in construction projects tend to be strictly defined, so it is necessary to provide the necessary conditions without risking people's lives. Since quality is also one of the crucial factors in the construction industry, performance and flexibility (the ability to adapt existing details/conditions to current projects/conditions easily) of the materials have a rather increasing importance as suppliers prefer to have complex and state-of-the-art buildings/projects. In that respect, these features could turn out to be more important than price and other conditions at times.

The term quality could be defined as the supplier's capability to satisfy the quality requirements on a regular basis. The elements that the term quality encompasses are product standards, dependability, efficiency, supplier's quality consciousness, quality analysis tools, and so on (Mandal and Deshmukh, 1994: 58).

Manufacturing efficiency as well as competence are two crucial factors that embody some elements such as supplier's conditions of production, volume maximization, limited financial means, physical conditions, and so on (Mandal and Deshmukh, 1994: 58).

The term net price stands for the value of the goods when all discounts are subtracted from and transportation as well as warranty expenses are added to the price (Mandal and Deshmukh, 1994: 58).

Table 2: AHP Process Normalization Table for Supplier Features

Supplier Features	Supplier A	Supplier B	Supplier C	Supplier D	Total	Percentage
Supplier A	1,00	3,33	4,00	4,78	13,11	0,47

Supplier B	0,46	1,00	2,43	3,11	7,00	0,25
Supplier C	0,30	0,83	1,00	3,17	5,30	0,19
Supplier D	0,25	0,37	0,64	1,00	2,26	0,08

Supplier A is the most preferred one in terms of the supplier features. Supplier capabilities are of crucial importance in terms of building solid strategic corporate partnerships, fostering a long-term rapport as well as acquiring products in bulk quantities.

Financial conditions stand for the supplier's liquid assets, financial competence, solvency ratios as well as credit rating.

Technical conditions, on the other hand, stand for technical workforce, manufacturing mechanics, research and development assistance, and so on.

Administration as well as supervision stand for the supplier's organizational coordination, task allocation, targets as well as aspirations, and so on (Mandal and Deshmukh, 1994: 58).

Table 3: AHP Process Normalization Table for Delivery Conditions

Delivery Conditions	**Supplier A**	**Supplier B**	**Supplier C**	**Supplier D**	**Total**	**Percentage**
Supplier A	1,00	2,28	2,67	3,72	9,67	0,39
Supplier B	0,86	1,00	2,94	3,00	7,81	0,32
Supplier C	0,40	0,54	1,00	2,36	4,29	0,17
Supplier D	0,48	0,41	0,92	1,00	2,80	0,11

Supplier A is the most preferred one in terms of the delivery conditions. It offers the possibility of working together again by means of the long-term structure of the construction projects.

Transportation as well as communications stand for the supplier's geographic position as well as its means of information exchange.

The term after-sales stands for the supplier's capabilities in terms of providing effective customer care as well as spare parts when needed.

Attitude as well as enthusiasm stand for the supplier's stance towards customer values in terms of satisfying the customers' needs and wants.

Workplace relationships stand for analyzing not only interpersonal relationships that place in a plant but also necessary personnel files as well as records.

Delivery stands for a number of elements such as the supplier's capability in terms of meeting shipment deadlines, flexibility as well as dependability of logistics network, lead time, and so on (Mandal and Deshmukh, 1994: 58).

Finally, aggregating all of these factors, the overall scores and percentages are calculated.

Table 4: Weighting Supplier Alternatives

	Product Features	**Supplier Features**	**Delivery Conditions**	**Total**	**Percentage**
Supplier A	0,47	0,47	0,39	1,33	0,44
Supplier B	0,24	0,25	0,32	0,81	0,27
Supplier C	0,19	0,19	0,17	0,55	0,18
Supplier D	0,10	0,08	0,11	0,29	0,09

According to these calculations, Supplier A is the most preferred one when all the criteria are considered. The total weights show the priority values which demonstrate that Supplier A is the most strategically advantageous one. Supplier B and Supplier C follow Supplier A. Lastly, Supplier D does not seem to be preferred much.

7. CONCLUSION

Companies aim to create added value and product efficiency throughout all the processes in the supply chain starting from the first stage that includes manufacturing items using raw materials till the last stage where the end product is finalized and put at customer's disposal. It is true to say that supply chain system is of pivotal importance in every step of the way. Thus, in some cases it becomes a valuable partner to companies. In a way, it creates a win-win relationship in a highly competitive environment. This attaches great significance to the supplier selection process and decision-making.

There seems to be five highly critical forces in this competitive environment, namely the supplier, buyer, potential entrants and substitute products. The implication of industry analysis examines not only the attractiveness but also foundations of competition as well as profitability. Industry structure is required to be analyzed in a both quantitative and qualitative fashion. The bargaining power of buyers heavily depends on the proportion of the buyer's price sensitivity, barriers to entry, and buyer's changing expenditures. All of these issues need to be analyzed closely and in a holistic view in order to determine the right strategies (Porter, 2008: 29).Dağdeviren and Yüksel (2010:1013) indicate that the existence of substitute products tend to have a serious effect on the supplier's power. Actually, corporates seem to be in the control of only some of the indicators. Sarkis and Dvahale (2015:177) add the concept of the Triple Bottom Line (profit, people and planet) approach to supplier selection metrics in terms of sustainability due to the rising pressure on the stakeholders of the corporate environment.

This study aims to assess supplier selection process by using Analytic Hierarchy Process (AHP) integrated with the whole environment of the firm. In the construction industry, in some cases such as for some specific projects, supplier selection seems to affect companies' approach which may lead to accepting new business partners. Additionally, in some other cases, depending on the business competence of companies, the supplier company and the parent company may be willing to participate in certain frameworks. Despite the efforts to turn these partnerships into long-term alliances, they usually remain as individual short-term projects (Gadde & Dubois, 2010: 254). In cases where the partnership definitely is out of the question for a variety of reasons, it has been observed that the entire staff is often transferred to the parent company. The use of AHP or similar methods in today's construction world, where the supplier and proper material selection tend to be of vital importance, is thought to be more advantageous in terms of corporate competitiveness and more efficient use of intensive working time for both employees and managers thanks to its rapid and widespread use with various technological developments.

Agility and a flexible supply chain are fundamental determinants in terms of accomplishing tasks in a highly uncertain environment such as the construction industry. Supply chain flexibility determines two key antecedents, namely sourcing and supplier flexibility. Network coordinators balance both supplier flexibility and sourcing flexibility through appropriate use of three different categories: framework agreement suppliers, approved suppliers and preferred suppliers. All of these categories seem to have different opportunities to offer. Framework agreement suppliers, for example, ensure high levels of supplier flexibility. Whereas, approved suppliers provide higher levels of sourcing flexibility. As for preferred suppliers, they offer moderate levels of suppliers and sourcing flexibility (Gosling, et al., 2010:20).

Delay is another very important factor that affects business performance in the industry. Accordingly, there has been plenty of research on this issue. Approval drawings, insufficient early planning as well as sluggishness of the owners' decision-making mechanisms come at the top of the list of causes based on delays in the United Arab Emirates construction industry (Faridi and El-Sayegh, 2006:1167).

There are strategic, organizational, technological, cultural and individual barriers determined in adopting Knowledge Management (KM) in the Supply Chain (SC) as it can be seen in a case study in which some solutions are presented to an Indian hydraulic valve production company. AHP and fuzzy TOPSIS were the methods implemented in order to determine the high ranking solutions. The first one was Positive Leadership in terms of KM adoption in the SC. Constructing reliable cooperation in order to have a better level of information exchange within the SC came second on the list. Consolidating cultural attachment as well as interaction amongst the SC members came third. Therefore, in the case of the Indian company, they are ought to put these solutions into action on priority basis and remain in a stepwise fashion based on these rankings (Patil and Kant, 2014: 691).

The study shows that Supplier A is more preferred than the other alternatives. And yet, there were two major limitations in the study: time and the sampling group. The purchasing experts were the only selected individuals in the construction companies to be questioned in Istanbul. Even so, they all happen to be decision makers. The suggestion for further studies is that a broader sampling group should yield a broader range of results. The expansion of the criteria as well as differences in weighting could also be of a better opportunity for researchers in the future.

The opportunity of a broader sampling assures not only the consistency of evaluations made by the decision-makers but also the reduction of subjectivity in terms of reaching solutions. Nine experts involved were the direct decision-makers in

terms of procurement activities in a manufacturing operation based on selecting the best suppliers to be evaluated amongst 4 suppliers.

There are many determinants such as changes in weather conditions as well as governmental laws and regulations all of which seem to affect the project completion date. Exceeding the allotted time and cost may naturally cause problems with the contractors.

All criteria have been evaluated on an equal basis. Yet, the weight of these criteria may also vary on a project basis. Product performance criterion is regarded as another substantial element, especially in terms of architectural or specific projects/constructions where the priority of the cost criteria of the products is reduced. The supplier criterion also loses priority accordingly, along with the reduced cost of the product selection. On the other hand, it can be said that the supplier criteria gain weight in projects/constructions realized in different geographical/market conditions. The project differences tend to influence the importance of the factors weighting. For example, in some cases, cost seems to be of crucial significance in situations where products are equal.

Aslan and Çınar (2012: 955) draw attention to the intensity of high rivalry amongst suppliers. And yet, they can often provide a competitive advantage in terms of balancing the quality and the price.

A company's strategies in regard to resource allocation are ought to be structured through globalization and localization. They should also encompass risk assessment results that include currency instabilities, changes in politics, market fluctuations not only in the county but also worldwide (Kahraman, C., Cebeci, U., & Ulukan, Z., 2003: 383).

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