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Analysis of Supplier Selection Process with Multi Criteria Decision Making Techniques; Example of an Airline Company[1]

Şeyma BOZKURT UZAN[2]

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Abstract: Decision making is at the heart of the managerial processes of many businesses. Problems such as the disclosure of the work to be done, the timing of the work, who will do the work, the determination of the resources to be used, require decisions to be determined in advance. If there were restrictions on the use of resources that were difficult to access and limited, there would be no major decision-making problem for the whole world. As the number of objectives increases, decision-making processes become more difficult. The management of decision-making processes is the most important task of the managers and the main objective in all business management is to make optimum decisions and make the most accurate decisions. In this study, multi-criteria decision making (MCDM) and logistics issues are handled together. The universe of the study consisted of all airline companies in Turkey. The sample of the study consisted of Turkey's leading national airline. The data of the study was collected with "Saaty scale". The scale was mutually evaluated by the decision-making group. In the research, a mixed research model was used in which qualitative and quantitative methods were used together. As a result of this research, after determining the weight of the criteria with DEMATEL, the selection of the airline information technology department software company, it is determined that the first supplier will be the best choice by using MOORA and ARAS method.
Keywords: Multi criteria decision making, DEMATEL, MOORA, ARAS , Supplier selection, Airway

Çok Kriterli Karar Verme Teknikleri ile Tedarikçi Seçim Süreci Analizi; Bir Havayolu Şirketi Örneği

Öz:*İşletmelerin birçoğunun yönetimsel süreçlerinin temelinde karar verme yer almaktadır. Yapılacak olan işin açıklanması, işin zamanlaması, işi kimlerin yapacağı, kullanılacak kaynakların belirlenmesi gibi sorunlar, kararların önceden belirlenmesini gerektirmektedir. Ulaşımı zor ve sınırlı olan bazı kaynaklar için kullanım kısıtlılığı olsaydı, tüm dünya için önemli bir karar verme sorunu olmazdı. Amaçların sayısı arttıkça karar verme süreçleri zorlaşmaktadır. Karar verme*

[1]Bu çalışma, Prof. Dr. Umman Tuğba Şimşek Gürsoy danışmanlığında İstanbul Üniversitesi Sosyal Bilimler Enstitüsünde yürütülen Bir Havayolu Şirketinde IT Departmanı Yazılım Şirketi Seçimi başlıklı doktora çalışmasından türetilmiştir.

[2]Dr. Öğr. Üyesi, İstanbul Gelişim Üniversitesi, İktisadi İdari ve Sosyal Bilimler Fakültesi, Yönetim Bilişim Sistemleri, https://orcid.org/0000-0003-3527-3730

süreçlerinin idaresi yöneticilerin en önemli görevidir ve tüm işletme yönetimlerinde ulaşılmak istenen ana hedef optimum kararlar alarak, alınan kararların en doğru şekilde gerçekleştirilmesidir. Bu çalışmada, çok kriterli karar verme (ÇKKV) ve lojistik konuları birlikte ele alınmaktadır. Araştırmanın evrenini Türkiye'de bulunan tüm havayolu şirketleri oluşturmaktadır. Araştırmanın örneklemini ise Türkiye'nin önde gelen milli havayolu şirketi oluşturmaktadır. Araştırmanın verileri "Saaty ölçeği" ile toplanmıştır. Ölçek, karar verici grup tarafından kriterlerin önem derecelerinin karşılıklı olarak değerlendirilmiştir. Araştırmada nitel ve nicel yöntemlerin bir arada kullanıldığı karma araştırma modeli kullanılmıştır. Bu araştırmanın sonucunda havayolu şirketi bilgi teknoloji departmanı yazılım şirketi seçimi DEMATEL ile kriterlerin ağırlıkları belirlendikten sonra, MOORA ve ARAS yöntemi kullanılarak birinci tedarikçi firmanın en iyi seçim olacağı saptanmıştır.

***Anahtar Kelimeler**: Çok kriterli karar verme, DEMATEL, MOORA, ARAS, Tedarikçi seçimi, Havayolu*

GENİŞLETİLMİŞ ÖZET

Çalışmanın Amacı: Bu çalışmanın amacı Türkiye'deki bir havayolu şirketinin IT departmanında yer alan bir tedarikçi seçim sürecinin değerlendirilmesinin Çok Kriterli Karar Verme (ÇKKV) Teknikleri ile gerçekleştirmektir.

Araştırma Soruları: Tedarikçi seçim süreci ÇKKV teknikleriyle nasıl değerlendirilmektedir?

Bir ÇKKV problemi nasıl ilerlemektedir?

Karar verme süreçlerinde ÇKKV teknikleri nasıl kullanılmaktadır?

Literatür Araştırması: ÇKKV ile ilgili farklı alanlarda literatür taraması çalışmaları mevcuttur. Karaoğlan'ın çalışmasında (2016), bir otelin fotoğrafçılık hizmetleri için dış kaynak kullanımı ile ilgili seçim problemi incelenmiştir. Kriter ağırlıkları ve kriterler arasındaki ilişkilerin belirlenmesinde DEMATEL yöntemi kullanılmıştır.

Karaoğlan ve Şahin'in çalışmasında (2016), satın alma sürecindeki kriterlerin ağırlıkları ve ilişkilerinin belirlenmesinde DEMATEL yöntemini kullanılmıştır.

Gandhi vd. çalışmasında (2016), yeşil tedarik zinciri yönetiminin uygulanmasıyla ilgili başarı faktörlerinin, Hindistan imalat sanayi açısından değerlendirmeyi amaçlamaktadır. Öncelikle çalışmada 24 başarı faktörü tanımlanmıştır. Daha sonra, bu başarı faktörlerini değerlendirmek için AHP ve DEMATEL yaklaşımını bir arada kullanılarak yapısal bir model geliştirilmiştir.

Raghuvanshi ve diğerlerinin çalışmasında (2017), kadın girişimciliğinin önündeki engelleri kriterleri açıkladıktan sonra, aralarındaki ilişkiyi araştırmıştır. Kriterler arasındaki sebep-sonuç ilişkisine dayanan bir çerçeve önerilmiştir. Bu araştırma için DEMATEL tekniği kullanılmıştır. Bu çalışmada analiz 14 engelden beşini nedensel olarak tanımlamaktadır. Bunlar şunlardır: eğitim eksikliği, deneyim ve eğitim olanakları; mekansal hareketlilik ve aile desteğinin eksikliği; kurumsal destek eksikliği; girişimcilik yönetimi eksikliği; ve finansal kaynakların elde edilmesinde yaşanan sorunlar.

Mangla'ın çalışması (2018), literatür taraması ile tedarik zinciri sürdürülebilirliğini geliştirmek için Endüstri 4.0 girişimlerinin 18 temel zorluğunu ortaya koymaktadır.

Yöntem: Bu çalışma kapsamında havayolu sektöründe faaliyet gösteren bir işletme analize dahil edilmiştir ve tedarikçi seçim problemi ele alınmıştır.

Analizin ilk aşamasında karar verici kişi veya kişiler seçilmiştir. Türkiye'de faaliyet gösteren havayolu şirketi çalışanlarından IT departmanından beş uzmana bu anketler yaptırılmıştır. Anket sonuçları değerlendirilirken ÇKKV teknikleri kullanılmıştır.

Bu çalışmada faydalanılan işletmenin tedarikçi seçim süreci değerlendirilirken ÇKKV teknikleri kullanılmıştır. Bu teknikler arasından DEMATEL, MOORA ve ARAS teknikleri kullanılarak uygulama gerçekleştirilmiştir. DEMATEL ile kriterlerin ağırlıkları belirlendikten sonra, MOORA ve ARAS yöntemleriyle tedarikçi seçim süreci gerçekleştirilmiştir.

Sonuç ve Değerlendirme: Tüm alanlarda parametrelerin çeşitliliği nedeniyle karar verme süreci gitgide zorlaşmaktadır. Ayrıca karar vericilerin tercihleri de bu süreci karmaşık hale getirmektedir. Yapılan çalışmalarda, bir ÇKKV probleminde birden fazla yöntem kullanıldığı görülmektedir. Bu çalışmada, tedarikçi seçiminde ÇKKV yöntemleri arasından DEMATEL, MOORA ve ARAS yöntemleri kullanılarak bir analiz geçekleştirilmiştir. Araştırmada birçok karar verme yöntemi uygulanmıştır. Bunun sebebi, tek veya iki karar verme yöntemi uygulandığında ortaya çıkabilecek sonuçların yanıltıcı olabilme ihtimali ile karşılaşılabilmesidir.

Öncelikle ÇKKV teknikleri ile ilgili teorik bilgiler verilmiş, daha sonra anketlerden elde edilen bilgiler DEMATEL yöntemi kullanılarak Excel'de çözümlenmiştir. Son aşamada ise tedarikçi seçimi için MOORA ve ARAS yöntemleri Excel'de çözümlenmiştir. İki farklı yöntem ele alınarak seçim sonucunda farklılık olup olmadığına dikkat çekilmiştir. MOORA yönteminde kriter ağırlıklarına yer vermeden analiz gerçekleştirildiğinde 4. Firmanın seçildiği görülmüştür. ARAS yönteminde ise DEMATEL ile hesaplanan kriter ağırlıkları kullanılmıştır ve seçimin yine 40. Firma olduğuna karar verilmiştir. Bu çalışma ile literatürde sınırlı sayıda olan konulara değinilmiştir. Ayrıca yapılan çalışma, alanında çalışmak isteyen araştırmacılar için bir kaynak oluşturmaktadır.

Bu çalışma araştırmacılar için tedarikçi seçim sürecine rehber olabilecek bir çalışma olarak değerlendirilebilmektedir. DEMATEL ile çalışma sayısı sınırlı olduğundan, DEMATEL ile analiz süreci ÇKKV alanında çalışmak isteyen araştırmacılar için iyi bir örnek olabilecektir.

Introduction

Technology and information are renewing themselves constantly in the recent times. Information which was used frequently and which was leading to the right path each time in the past, may not be leading to the desired target today, if it is not valid anymore. The most important point to make progress in

case the desired target is not reached or a negative situation is faced, is to be able to make a fast decision based on the correct information. Therefore all sectors must follow up the correct information and integrate decision-making strategies into their companies. The most important step of this integration is directly proportional with a person's decision making skills. The options with the best profit should be predicted among the others and decision-making strategies should be developed within these predictions, keeping up with the developments.

Decision-making is the choice among various alternatives. It is a type of skill which must be used while making correct decisions. The most important factor for senior executives of a company in developing their decision-making skill is the increase of their decision values.(Koç and Topaloğlu, 2010)

All choices, together with their obvious effects, have numerous effects that are unnoticed but that cannot be explained numerically. Analyzing these effects, examining which of the choices shall bring the most contribution, is exhausting and time consuming for decision-maker. In general, decision-maker is using his/her instinct to assess the factors. (Yuluğkural, 2001)

Decision-making is one of the basic functions of the corporations in management processes. Multi-criteria decision-making is used, in cases where the choices and alternatives are numerous. Multi-criteria decision-making is enabling the assessment of several dimensions that are included in decision-making processes. Decision-makers are aiming to reach the optimum result.

Air transport also develops constantly, increasing the market share of companies. Along with freight or goods transportation, human transportation can also be done through software and developed robotic processes. Thus, airline companies can use multi-criteria decision making techniques related to the sector while reaching the standards of service delivery. In this study, three MCDM techniques stand out. DEMATEL, MOORA and ARAS methods, which are among the multi criteria decision making techniques, have been applied. Each of these mentioned methods can contain separate decision making processes. While criterion weights are determined with DEMATEL methods, supplier selection is analyzed with MOORA and ARAS.

The purpose of the study is to investigate how an airline can apply to the IT department software company selection. limitations of the study: There is only limited data on an airline in Turkey. The importance of the study, many studies on the subject can be seen in the literature. Unlike the studies in the literature, the IT company selection process of the IT department in the airline company was evaluated with MCDM. The work done is important in this aspect. The assumption of the study is expressed as follows; IT department software company selection process in an airline company is more efficient with the applied MCDM techniques.

1. Airline Transport

Airline transport is defined by the first article of the Regulation on Commercial Aviation Administrations of the Turkish Civil Aviation Act with

number 2920 which is enacted in 1983. The code defined airline transport as carrying passengers, cargos and males in exchange of a fee by all kind of aircrafts. The codes of the United States of America (USA) defines the airline transportation as; transportation of humans, articles or males by an aircraft, in exchange of a fee or a rent, by an airline transporter which is open to the general public.

Airline transport is a technical and complex service. The services are provided by staff trained for this domain. Airline transportation is one of the sectors which follow up developing technology closely. People who are improving themselves have huge impact on the actual position of airline transportation. Widespread use of automated machines in airline transportation sector, not decreasing the importance of human factor, however increased the need of people who are improving themselves. Staff support is required in all kinds of planning of airline administrations in order to not face any disconnection between those plans. Accordingly, good planning of human resources is providing success for airline transportation companies in medium and long-term. (Küçükönal and Korul, 2002)

2. Multi-Criteria Decision-Making

Decision-making analysis can be explained by various ways. Decision-making can be explained as to make the most appropriate choice. Detailing this definition, decision-making is to make the optimum choice among numerous alternatives. During decision-making analysis a choice is made among various different options. Several problems may occur while making a choice. Each incident has several aspects and the choice is made taking into consideration all of them. Decision-making is the choice decision made by the individuals within an enterprise for their work domains. Enterprises play a very important role for a country's economy. One of the basic functions each enterprise uses to reach its targets is the decision-making process (Timor, 2011).

Multiple criteria decision-making (MCDM) is a powerful tool widely used for evaluating problems containing multi- ple, usually conflicting criteria (Erkayman, et al., 2012). In multi-criteria decision-making analyses, decision-maker is comparing and assessing various alternatives in different quantities and under different titles. Eventually, the optimum value is chosen among the others. In multi-criteria decision-making methods, the problems are solved by using the weight of the criteria. The alternatives and the criteria are determined during the first phase of the analysis.

Then the weight of each criterion is determined. After having conducted the correlation analysis between criteria and alternatives by determined criterion weight, optimum alternative is chosen. Finally sensitivity analysis is carried out and the result proposals and evaluations are revealed.

MCDM methods are used in analyses when in a solution process there are various criteria which are different from each other and which are unrelated.

MCDM methods are encountered in each phases of a person's life. Decision-making exists in each and every function of enterprises. Such as in costs, accounting, management, human resources and marketing. Synchronized solution is mentioned in MCDM methods. The fact that several criteria and alternatives are functioning in a synchronized way, while they are evaluated jointly, brings MCDM methods fore. (Baysal and Tecim, 2006).

Table 1 shows the evaluations that are revealed when some multi-criteria decision-making technics and numerical values are taken into consideration.

Table 1. *Some Multi-Criteria Decision-Making Technics*

MCDM Technics	Computing period	Simplicity	Mathematical Operations	Reliability	Data Type
AHP	Very long	Complicated	Maximum	Weak	Mixed
TOPSIS	Medium Level	Medium Level	Medium Level	Medium	Numerical
VIKOR	Short	Simple	Medium Level	Medium	Numerical
MOORA	Very short	Very simple	Minimum	Good	Numerical
ARAS	Medium Level	Medium Level	Medium Level	Medium	Numerical
ELECTRE	Long	Medium Level	Medium Level	Medium	Mixed
PROMETHEE	Long	Medium Level	Medium Level	Medium	Mixed

Source: (Brauers, et al., 2012)

2.1. Literature Review

There are several literature review studies on different domains related with the MCDM. The study of Karaoğlan (2016) examined choice problem related with the outsource use for a hotel's photography services. DEMATEL method is used to determine the relations between criterion weights and criteria.

The study of Karaoğlan and Şahin (2016) used DEMATEL method to determine the weight of the criteria and their relations during purchase process.

Mangla's (2018) study reveals 18 basic difficulties of Industry 4.0 initiatives to develop supply chain sustainability through literature review.

The study of Raghuvanshi et al. (2017) after having explained the obstacles emerging before female entrepreneurship, researched their interrelations. A frame based on the cause and effect relation between the criteria is proposed. DEMATEL technique is used for this research. The analysis defines causatively five of the 14 obstacles for this study. They are: lack of education, experience and education opportunities; spatial mobility and lack of familial support; lack of corporate support; lack of entrepreneurship management; and problems faced in acquiring financial resources.

Gandhi et al. (2016) aims by his study to evaluate with regard to Indian production industry, success factors related to the application of supply chain management. Primarily 24 success factors are defined in the study. Then a structural model is developed using together AHP and DEMARTEL approaches to evaluate these success factors.

2.2. DEMATEL Method

DEMATEL method is the most appropriate one if the study works with data having complex and interpenetrating structures. It is developed between the years of 1972 and1976 by "Battelle Memorial Institute Geneva", "Science and Human Relations" program (Gabus and Fontela, 1972; Fontela and Gabus, 1974, 1976).

One of the most important profits of the method is that it includes cause and effect relations. The method provides huge help in solving stirring and complex relations. It examines in the best way, during each phases of the analysis, all criteria, criteria relations, types and interactions, as well as the alternatives. During the analysis dominant criteria define the cause criteria and non-dominant criteria define effect criteria (Karaoğlan and Şahin, 2016)

Determining criterion weights with DEMATEL Method

The functions relating to DEMATEL method to be used in determining criterion weights are presented here below in order: (Karaoğlan and Şahin, 2016)

1st Step; After the determination of the criteria by decision-makers, a survey has been conducted to determine the weight of the criterion. The survey includes dual comparisons and has used 1-9 comparison scale created by Thomas Saaty. This scale is provided on Table 2.

Table 2. *Importance Level Table used in Comparisons*

Importance Grade	Description
1	Equally important
3	Adequately important
5	Strongly important
7	Very strongly important
9	Absolutely more important
2, 4, 6, 8	Interim values

Source: (Subramanian and Ramanathan, 2012)

2nd Step; Following performed evaluations, the arithmetic mean of the grades is calculated. Then these values are placed in the matrix and an asymmetric matrix having "1" as diagonals. This matrix is called direct relation matrix (X).

3rd Step: Then as shown on the equation, maximum value of the sum of each column and row and the obtained value is called "s". Then each element of the matrix is divided with "s" value and normalized direct relation matrix (C) is created.

4rd Step: Direct relation matrix (C) is deducted from unit matrix, its reciprocal is taken and is multiplied again with C matrix. Eventually total relation matrix (F) is obtained.

$F = C + C2 + C3 + \cdots + C9 = C\ (I - C)$-1

5th Step: For this step, to determine affecting and affected factor groups and to compute net effect levels, after having determined total relation matrix (F),

the total of the columns and rows are computed (Çınar, 2013; Karaoğlan, 2016). Obtained levels shows for each criterion:

For the total of each rows (Di), the criterion affecting other criteria directly or indirectly,

For the total of each column (Ri) the total affection of the criterion from other criteria directly or indirectly.

For each criterion Di + Ri sent and received total effect value,

For each criterion Di - Ri total effect made by the criterion on the system.

Di + Ri shows the importance of the criterion within the system.

If the value of the Di - Ri is positive, it is defined as affecting, and if it is negative it is defined as affected.

6th Step: In this step, after having determined the threshold value of the matrix (Total Relation Matrix Mean), effect directed scatter chart is created. Criteria over threshold value are defined as effecting and its effect direction is shown with an arrow. Any situation that affects the criterion itself, is also shown on the diagram. Arrows are created from effecting to affected ones. Threshold value can be determined by experts. In cases where this is not applicable, it can be determined by computing total relation matrix' (F) mean.

7th Step: To obtain criterion weights, the sum of the Di+Ri square and the Di-Ri square is taken under a square root. Then, each weight is divided to the sum of the weights. Eventually weights of the criterion are found.

2.3. MOORA Method

MOORA method is developed by Brauers and Zavadskas. The method has a vast area of use. The criteria are creating an easy to use calculation algorithm taking into consideration the maximization and minimization (Karakaş and Kırmızı, 2019).

MOORA method includes more than one approach during solution process. When the literature is reviewed, it is seen that there are resources where both methods are used, as well as solutions that are performed with one approach only.

In some of the resources MOORA method is applied mostly in two sections as proportion method and reference point approach. In some of the analyses both methods are used, while in some resources it is seen that the listing is performed by using only one of the methods. The method starts by writing in matrix the data created by the alternatives and the criteria (aims) and it follows.

MOORA which is a multi-objective optimization based on ratio analysis, has different versions such as MOORA-ratio MOORA-reference point, MOORA-Importance Coefficient, MOORA-Full Product Form and MULTIMOORA. (Yıldırım et al., 2013)

2.4. ARAS Method

ARAS method is developed by Turskis, Z. and Zavadskas, E. K. as a new method in solving MCDM problems. The classical approach for MCDM methods

is to be focused on subjective sorting. Various MCDM methods which can be seen in the literature are computed as to relative distances to ideal positive and ideal negative solution or are comparing existing solutions' utility function values with the ideal positive alternative solution value. For ARAS method, utility function values of the alternatives which are included in the analysis, are compared with the utility function value of the optimal alternative which is added by the researcher to the decision problem. For example; for a decision problem where the most proper score of the criterion is 100, instead of computing it as 100% as it is the case for existing methods that are obtained by all alternatives from this criterion, it is computed as 80% (0.80).

As per ARAS method, the utility function that is used to determine the relative efficiency of a prospective alternative in a project is directly proportional with relative effects of the criteria weights and values. ARAS method helps to determine the performance of the alternative and reveals the proportional similarity of each alternative with regard to the ideal alternative (Dadelo et al., 2012). For example, when the optimal value of a criterion is 10, but however the maximum score obtained during evaluation of the alternatives is supposed to be 9, the optimality value of the criterion being computed as 1.0 for other MCDM methods, shall be 0.9 for ARAS method. Accordingly it is said that ARAS method is the most proper method for the purpose of proportional graduation among other MCDM methods.

3. Supplier Selection

Companies whose suppliers are prone to distribution risks have a common question to ask. How do firms obtain better performance than others if similar suppliers are affected by fisruptions? (Cavalcante, et al., 2019)

Traditional approach is focused on the price, flexibility and quality for the performance evaluation in choosing a supplier. As an addition to these parameters, as purchase process becomes more complicated due to the surrounding and social pressures in sustainability supply chain., it bears a crucial importance. It is obvious that social aspect must be a focus point in supply chain and that there is still a lot to do on the subject (Mani et al., 2014).

Nowadays, industrial enterprises are producing products, using several parts. The increase of the features of the products produced by enterprises, increased also the number and the types of the parts used in production. It is not less costly for the enterprises to produce themselves all the parts they are using for production. That's why enterprises outsource some of the parts which are necessary during production. The enterprises providing production parts for producing enterprises are called suppliers. Supplier Choosing; is a process which includes criteria such as cost, quality, performance, technology, etc. (ISO 9000, 2000).

The main purpose of supplied evaluation process is to maximize the total value for the purchasing enterprise, by reducing purchase risks. Purchasing

enterprise must choose suppliers with who it can develop a long-term business relation. Suppliers must continuously improve themselves in order to meet the actual and future needs and expectations of the enterprise. Although shared evaluation criteria are used in choosing suppliers and evaluating chosen suppliers, some differences are seen in evaluation methods, as the needs and wishes of enterprises are different.

4. Analysis of Decision Problem

In this study, the airline company information technologies department aims to reveal how the selection of software companies is determined by multi-criteria decision making techniques. The universe of the study consisted of all airline companies in Turkey. The sample of the study consisted of a leading position in the national airline of Turkey.

In the research, supplier selection was made by using the actual data received from the airline company. It is the selection of the company that will write a new mobile application desired during the supplier selection process.

MCDM methods were used in supplier selection process analysis. Among these methods, application was carried out using DEMATEL, MOORA and ARAS techniques.

There is no unique answer for "what is the best enterprise system?" There are many important criteria which determine the suitable system for a company (Erkayman, et al., 2012). After determining the decision-making group within the scope of the study, in the face-to-face meeting with the group members, the criteria determined by the experts and within the scope of the literature review were presented. The criteria set used in the study consists of two main and fifteen sub criteria. These criteria are described in detail below:

- Institutional Competence Level: It indicates whether the company meets the criteria determined according to the prepared technical specifications.
- Domain Expertise: It refers to the level of expertise of the company in the area to receive service.
  - ✓ Company Age: It refers to the number of years the firm has been operating.
  - ✓ Mobile application development turnover: It indicates how much turnover the company has achieved for mobile application.
  - ✓ Mobile application % turnover: It indicates how much turnover the company has achieved from mobile application. If the rate is high, it can be said that the company is an expert on mobile.
  - ✓ A wealth of platorm developed mobile application: It refers to the richness of software platforms used in the infrastructure of the company.
  - ✓ Total number of mobile staff: The ratio of the total number of staff in the company to the number of mobile staff.
- References: It is a parameter that is used to understand the place and value of the company in the market with the things that the company has worked

before, the businesses it works with, the activities carried out between the companies.

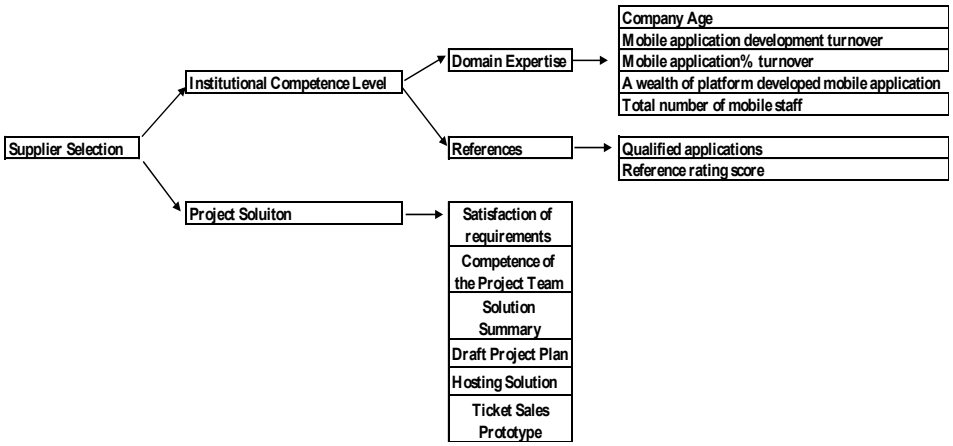
- ✓ Qualified Applications: It refers to the evaluation of the practices that the firm has made for the companies it has worked for before.
- ✓ Reference rating score: It refers to the results of the evaluation letters obtained from the companies that are its customers, describing the company. For example; expresses the degree of mobile application satisfaction written by the company before.

- Project Solution: It refers to the extent to which the company performs the technically desired job (mobile application).
- Satisfaction ofRequirements Affordability: It refers to the level of meeting the firm's desired requirements. For example; security requirements, display properties requirements, compliance with technical specifications.
- Competence of the Project Team: Refers to the company's team promotion.
- Solution Summary: It refers to the technical solutions of the requirements of the company in the technical specification.
- Draft Project Plan: It refers to the plan with all the details of the project in detail along with the technical specification of the company.
- Hosting Solution: It refers to the environment in which the firm will store information about the applications it prepares.
- Ticket Sales Prototype: It refers to the development of the prototype in relation to the ticket sales function. Mobile applications of many airlines are designed close to each other. The company examines these applications and expresses its suitability for the required technical specification.

After the weights were determined with DEMATEL, supplier selection analysis was performed using MOORA and ARAS methods.

Figure 1, which shows the hierarchical structure of the decision problem, is modeled with the help of the Expert Choice program.

Figure 1. *Hierarchical Structure of Decision Problem*



4.1. Determination of Criterion Weights with DEMATEL

The arithmetic mean of the scores given by the experts was obtained from the Direct Relationship Matrix shown in the Table. By the values placed in the diagonal matrix, and '1' are obtained in an asymmetric matrix. The resulting matrix is called the direct correlation matrix (X). The geometric mean of each survey score entered was determined. In line with these values, weights of the main criteria were calculated first.

Table 3. *Direct Relationship Matrix (X)*

Direct Relationship Matrix			
	Institutional Competence Level	**Project Solution**	**TOTAL**
Institutional Competence Level	1	0,129	1,129
Project Solution	7,765	1	**8,765**
TOTAL	8,765	1,129	

Table 4. *Normalized Direct Relationship Matrix (C)*

Normalized Direct Relationship		
	Institutional Competence Level	**Project Solution**
Institutional Competence Level	0,114	0,015
Project Solution	0,886	0,114

According to Normalized Direct Relationship Matrix, the maximum value of the row totals of the matrix and the maximum value of the column totals of the matrix represent the Project Solution criterion. The value of this criterion is determined as 8,765 value as "s value". The maximum value (s) is divided by each element of the matrix to form a normalized direct relationship matrix (C).

Table 5. *Total Relationship Matrix*

	Institutional Competence Level	**Project Solution**	**Di**
Institutional Competence Level	0,129	0,015	0,144
Project Solution	7,765	0,129	7,893
Ri	7,893	0,144	

The total relationship matrix is obtained by the operation $F = C + C2 + C3 + \cdots + C9 = C\ (I - C)$-1.

Table 6. *Affected and Affecting Factor Groups*

	D	**R**	**D+R**	**D-R**
Institutional Competence Level	0,144	7,893	8,037	-7,750
Project Solution	7,893	0,144	8,037	7,750

Table 7. *Criterion Weights Table*

	SQRT(D/R)^2/(D.R)^2	Criteria Weight	Criteria Priorities
Institutional Competence Level	0,0160	0,0003	2
Project Solution	48,4259	0,9997	1
Total	48,4420		

In the last step, Table 7 shows the criteria weights and criteria priorities obtained by using DEMATEL method based on expert opinions. When the importance of the criteria calculated using the DEMATEL method is considered, the Institutional Competence Level criterion was excluded from the analysis due to the low percentage of the Project Solution criterion, which is 99.97%. Therefore, the weights of the sub-criteria of the Project Solution criterion were calculated in the following steps.

Table 8. *Direct Relationship Matrix*

Direct Relationship Matrix								
	Satisfaction of requirements	Competence of the Project	Solution Summary	Draft Project Plan	Hosting Solution	Ticket Sales Prototype	TOTAL	MAX
Satisfaction of requiremen	1	3,471	6,518	3,497	5,502	2,516	22,503	22,503
Technical Competence of	0,288	1	4,555	1,813	5,387	2,631	15,673	
Technical Solution Summ	0,153	0,220	1	1,016	3,314	1,821	7,524	
Draft Project Plan	0,286	0,552	0,985	1	1,380	1,401	5,603	
Hosting Solution	0,182	0,186	0,302	0,725	1	0,549	2,943	
Ticket Sales Prototype	0,397	0,380	0,549	1,821	1,821	1	5,968	
TOTAL	2,307	5,808	13,908	9,871	18,403	9,918		
MAX	18,403							

Table 9. *Normalized Direct Relationship*

Direct Relationship Matrix	Satisfaction of requirements	Technical Competence of the Project Team	Technical Solution Summary	Draft Project Plan	Hosting Solution	Ticket Sales Prototype
Satisfaction of requirements	1	3,471251715	6,517506371	3,49659201	5,50156321	2,51589265
Technical Competence of the Project Team	0,28808052	1	4,554610199	1,81322298	5,38684661	2,63071687
Technical Solution Summary	0,153432915	0,219557757	1	1,01551128	3,31445402	1,8205642
Draft Project Plan	0,28599276	0,551504151	0,984725646	1	1,37972966	1,40113103
Hosting Solution	0,18176652	0,185637363	0,301708817	0,72477966	1	0,54928027
Ticket Sales Prototype	0,397473239	0,380124525	0,549280272	1,8205642	1,8205642	1

The maximum value of the row totals and column totals of the matrix is 22,503. This value belongs to the “satisfaction of requirements” criteria and it is determined as “s value”.

Table 10. *Total Relationship Matrix*

Total Relationship Matrix							
	Satisfaction of requirements	Technical Competence of the Project Team	Technical Solution Summary	Draft Project Plan	Hosting Solution	Ticket Sales Prototype	Di
Satisfaction of requirements	0,047	0,182	0,408	0,184	0,324	0,126	1,270
Technical Competence of the Project Team	0,013	0,047	0,254	0,088	0,315	0,132	0,848
Technical Solution Summary	0,007	0,010	0,047	0,047	0,173	0,088	0,371
Draft Project Plan	0,013	0,025	0,046	0,047	0,065	0,066	0,262
Hosting Solution	0,008	0,008	0,014	0,033	0,047	0,025	0,135
Ticket Sales Prototype	0,018	0,017	0,025	0,088	0,088	0,047	0,283
Ri	0,105	0,289	0,792	0,487	1,011	0,484	

Table 11. *Affected and Affecting Factor Groups*

	D	R	D+R	D-R
Satisfaction of requirements	1,270	0,105	1,375	1,165
Technical Competence of the Project Team	0,848	0,289	1,137	0,559
Technical Solution Summary	0,371	0,792	1,164	-0,421
Draft Project Plan	0,262	0,487	0,749	-0,225
Hosting Solution	0,135	1,011	1,146	-0,876
Ticket Sales Prototype	0,283	0,484	0,767	-0,201

Table 12.*Criterion Weights Table*

	SQRT(D/R)^2/(D.R)^2	**Criteria Weight**	**Criteria Priorities**
Satisfaction of requirements	1,181	0,082	6
Technical Competence of the Project Team	2,036	0,141	4
Technical Solution Summary	2,763	0,192	3
Draft Project Plan	3,332	0,231	2
Hosting Solution	1,308	0,091	5
Ticket Sales Prototype	3,807	0,264	1
TOTAL	14,427		

Considering the importance of the sub-criteria calculated using the DEMATEL method, Ticket Sale Prototype has the highest importance with 26.4%. Draft Project Plan criterion, which is in the second place, can be said to have similar values with 23.1% Ticket Sale Prototype criterion. The third place of the Technical Solution Summary criterion was 19.2%, the fourth was the Technical Competence of the Project Team criterion, 14.1%, the fifth was the Solution Solution criterion, 9.1%, and the last was 8.2% by Satisfaction of Requirements criterion.

4.2. Supplier Selection with MOORA

After the weights of the criteria were determined by DEMATEL method, the supplier selection was made by MOORA method by using the weights of the criteria obtained with DEMATEL and the solution steps in Excel are explained below.

Table 13. *Decision Matrix*

	Satisfaction of requirements	Technical Competence of the Project Team	Technical Solution Summary	Draft Project Plan	Hosting Solution	Ticket Sales Prototype
1	88	47	20	50	70	90
2	97	28	0	60	80	55
3	82	54	85	40	80	45
4	87	42	80	54	76	79
45	87	40	52	58	77	90
46	95	54	83	55	75	74
47	88	42	60	51	79	60
48	82	30	54	60	74	64
49	84	38	61	54	76	51
50	87	43	74	53	74	73

Table 14. *Normalized Matrix*

	Satisfaction of requirements	Technical Competence of the Project Team	Technical Solution Summary	Draft Project Plan	Hosting Solution	Ticket Sales Prototype
1	7744	2209	400	2500	4900	8100
2	9409	784	0	3600	6400	3025
3	6724	2916	7225	1600	6400	2025
4	7569	1764	6400	2916	5776	6241
5	7921	1024	196	2304	5329	7569
45	7569	1600	2704	3364	5929	8100
46	9025	2916	6889	3025	5625	5476
47	7744	1764	3600	2601	6241	3600
48	6724	900	2916	3600	5476	4096
49	7056	1444	3721	2916	5776	2601
50	7569	1849	5476	2809	5476	5329
Sum of Squares	401086	98853	146684	126779	281623	227575
SQRTof Total	633,31351	314,40897	382,99347	356,06039	530,68164	477,04822

The decision matrix shown in Table 13 is normalized. To perform this operation, each cell value is squared.

Table 15. *Sorting*

	MAX	MAX	MAX	MAX	MAX	MAX		
	Satisfaction of requirement	Technical Competence of the Project	Technical Solution Summary	Draft Project Plan	Hosting Solution	Ticket Sales Prototype	y*i	Ratio Method Sorting
1	0,138	0,155	0,054	0,140	0,131	0,182	0,80	31
2	0,152	0,092	0,000	0,168	0,150	0,111	0,67	49
3	0,129	0,178	0,230	0,112	0,150	0,091	0,89	12
4	0,148	0,175	0,227	0,126	0,141	0,172	0,99	1
5	0,151	0,112	0,046	0,160	0,133	0,099	0,70	45
45	0,134	0,172	0,122	0,143	0,141	0,164	0,87	16
46	0,151	0,135	0,197	0,160	0,146	0,113	0,90	10
47	0,146	0,125	0,038	0,121	0,143	0,127	0,70	46
48	0,129	0,139	0,035	0,118	0,145	0,115	0,68	48
49	0,143	0,175	0,062	0,123	0,135	0,117	0,76	38
50	0,129	0,142	0,095	0,154	0,133	0,103	0,76	37

All cells are recalculated by dividing the values in the decision matrix by the square root values of the sum. Then, a new column opens to calculate yi* values. This value is equal to row totals. In the last step, the Rank formula is used to sort and the process is repeated for the entire column. The 4th company ranked first and the selected supplier was the 4th. During the study, since the simulation technique is used, random numbers are refreshed in each trial and the results change.

4.3. Supplier Selection with ARAS

Supplier selection by ARAS method is performed in Excel and stages are explained.

Table 16. *Decision Matrix*

	MAX	MAX	MAX	MAX	MAX	MAX
Weights	0,082	0,141	0,192	0,231	0,091	0,264
	Satisfaction of requirements	Technical Competence of the Project Team	Technical Solution Summary	Draft Project Plan	Hosting Solution	Ticket Sales Prototype
1	88	47	20	50	70	90
2	97	28	0	60	80	55
3	82	54	85	40	80	45
4	95	38	18	47	70	77
5	95	31	69	42	78	67
45	91	47	46	60	75	58
46	84	34	52	46	79	84
47	90	41	52	52	79	77
48	95	29	83	46	78	57
49	83	29	32	50	74	45
50	96	38	82	60	75	82
MAK/MIN	97	54	85	60	80	90

The decision matrix is formed at the beginning of the supplier selection process. The lines of the decision matrix represent alternatives, while the columns represent criteria.

Table 17. *Beneficiary Transformed Matrix*

	MAX	MAX	MAX	MAX	MAX	MAX
Weights	0,082	0,141	0,192	0,231	0,091	0,264
	Satisfaction of requirements	Technical Competence of the Project Team	Technical Solution Summary	Draft Project Plan	Hosting Solution	Ticket Sales Prototype
1	88	47	20	50	70	90
2	97	28	0	60	80	55
3	82	54	85	40	80	45
4	96	39	8	57	70	77
5	97	39	64	49	80	88
45	86	46	77	46	70	82
46	88	42	39	55	79	90
47	84	38	12	42	74	82
48	83	46	35	56	76	87
49	83	45	21	51	79	63
50	86	46	75	50	76	67
MAX/MIN	97	54	85	60	80	90

In the matrix in Table 17, all the criteria are maximum directional and maximum values are selected from element values.

Table 18. *Normalized Matrix*

	MAX	MAX	MAX	MAX	MAX	MAX
Weights	0,082	0,141	0,192	0,231	0,091	0,264
	Satisfaction of requirements	Technical Competence of the Project Team	Technical Solution Summary	Draft Project Plan	Hosting Solution	Ticket Sales Prototype
1	0,020	0,022	0,009	0,020	0,019	0,027
2	0,022	0,013	0,000	0,024	0,021	0,017
3	0,018	0,025	0,037	0,016	0,021	0,014
4	0,020	0,020	0,003	0,017	0,021	0,016
5	0,019	0,016	0,007	0,024	0,019	0,016
45	0,020	0,022	0,036	0,022	0,021	0,025
46	0,021	0,017	0,029	0,017	0,021	0,020
47	0,021	0,025	0,034	0,018	0,021	0,027
48	0,019	0,018	0,014	0,016	0,019	0,014
49	0,020	0,025	0,028	0,017	0,020	0,026
50	0,021	0,017	0,034	0,020	0,020	0,017
MAK	0,022	0,025	0,037	0,024	0,021	0,027

Table 19. *Weighted Matrix*

	MAX	MAX	MAX	MAX	MAX	MAX
Weights	0,082	0,141	0,192	0,231	0,091	0,264
	Satisfaction of requirements	Technical Competence of the Project Team	Technical Solution Summary	Draft Project Plan	Hosting Solution	Ticket Sales Prototype
1	0,002	0,003	0,002	0,005	0,002	0,007
2	0,002	0,002	0,000	0,006	0,002	0,004
3	0,002	0,004	0,008	0,004	0,002	0,004
4	0,002	0,002	0,006	0,005	0,002	0,006
5	0,002	0,003	0,001	0,004	0,002	0,005
45	0,002	0,003	0,004	0,004	0,002	0,004
46	0,002	0,003	0,001	0,004	0,002	0,004
47	0,002	0,002	0,001	0,005	0,002	0,007
48	0,002	0,003	0,002	0,004	0,002	0,004
49	0,002	0,002	0,008	0,005	0,002	0,004
50	0,002	0,003	0,002	0,005	0,002	0,004
MAX	0,002	0,004	0,008	0,006	0,002	0,007

After the normalized matrix was calculated in ARAS method, the weighted matrix was calculated by multiplying the coefficients of the criteria related to the weights of the elements of the matrix.

Table 20. *Optimum Function, Benefit and Ranking*

	Si	Ki	
OPTIMUM	0,027	1	
1	0,020	0,735	25
2	0,016	0,575	48
3	0,021	0,790	16
4	0,026	0,944	1
5	0,020	0,735	24
45	0,021	0,765	21
46	0,024	0,869	5
47	0,021	0,788	17
48	0,020	0,729	26
49	0,024	0,885	2
50	0,016	0,597	45

After calculating the optimum function of each decision option, the priorities Si and utility Ki values of the decision options were calculated. Then, the most appropriate option was determined by ordering from large to small. The Rank formula was used for sorting and the process was repeated for all columns. When the results were ranked, the 4th alternative was determined as the best choice. During the study, since the simulation technique is used, random numbers are refreshed in each trial and the results change.

Conclusions and Recommendations

In the developing airline industry, the adaptation process to the renewed technologies is one of the most important points. In this study, airline transportation supplier selection process analysis was evaluated. MCDM methods were used to evaluate the supplier selection process.

Due to the diversity of parameters in all areas, the decision-making process is becoming increasingly difficult. In addition, decision-makers' preferences complicate this process. In the studies, it is seen that more than one method is used in an MCDM problem. In this study, an analysis was performed using DEMATEL, MOORA and ARAS methods among MCDM methods in supplier selection. Many decision making methods were applied in the research. The reason for this is that the results may be misleading when one or two decision making methods are applied.

Firstly, theoretical information about MCDM techniques were given, then the information obtained from the questionnaires were analyzed in Excel using DEMATEL method. In the last stage, MOORA and ARAS methods for supplier selection were analyzed in Excel. Two different methods were taken into consideration and whether there was any difference in the selection results. When the analysis was carried out in MOORA method without including criterion weights, it was seen that 4th company was selected. In the ARAS method, the criteria weights calculated with DEMATEL were used and it was decided that the selection was again the 4th company. This study deals with a limited number of issues in the literature. In addition, the study provides a source for researchers who want to work in the field.

Thanks to this study, a study that could be a guide for the supplier selection process was carried out for the researchers. Because the number of studies with DEMATEL is limited, the analysis process with DEMATEL is a good example for the researchers who want to work in the MCDM.

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