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Financial Performance Analysis of Airlines Operating in Europe: CRITIC Based MAUT and MARCOS Methods

Avrupa'da Faaliyet Gösteren Havayolu İşletmelerinin Finansal Performans Analizi: CRITIC Temelli MAUT ve MARCOS Yöntemleri

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ABSTRACT

This paper aims to measure the financial performance of 6 airline operators operating in Europe between the periods of 2019-2021. For performance measurement, 8 financial criteria were used: current ratio, cash ratio, financial leverage ratio, equity multiplier, asset turnover rate, equity turnover rate, return on equity and return on assets ratio. For the analysis of these criteria, the importance levels of the criteria related to the CRITIC method, one of the MCDM methods, were determined. At the same time, with the MAUT and MARCOS methods, the financial performance ranking of the airline enterprises was obtained according to the relevant years. According to the findings of the CRITIC method; It was determined that asset turnover rate in 2019 and financial leverage ratio criteria in 2020 and 2019 were the most important criteria. As a result of the MAUT method, it was concluded that the airline with the best financial performance in 2019, 2020 and 2021 was Air France. According to the findings of the MARCOS method, the airline with the highest financial performance in 2019 was Pegasus Airlines and in 2020 and 2021 it was determined as EasyJet.

Anahtar Kelimeler:

Havayolu İşletmesi,

Finansal Performans

ÇKKV,

CRITIC,

MARCOS

Jel Kodları:

C02, C30, C44

ÖZET

Bu çalışmada Avrupa'da faaliyet gösteren 6 havayolu işletmesinin 2019-2021 dönemleri arasında finansal performans ölçümü yapılması amaçlanmıştır.Performans ölçümü için cari oran, nakit oran, finansal kaldıraç oranı, özsermaye çarpanı, aktif devir hızı, özsermaye devir hızı, özsermaye karlılığı ve aktif karlılık oranı olmak üzere 8 finansal kriter kullanılmıştır. Bu kriterlerin analizi için ÇKKV yöntemlerinden CRITIC yöntemi ile ilgili kriterlerin önem düzeyleri belirlenmiştir. Aynı zamanda MAUT ve MARCOS yöntemleri ile de havayolu işletmelerinin finansal performans sıralaması ilgili yıllara göre elde edilmiştir. CRITIC yöntemi bulgularına göre; 2019 yılında aktif devir hızı, 2020 ve 2019 yıllarında ise finansal kaldıraç oranı kriterlerinin en çok önem arz eden kriterler olduğu belirlenmiştir. MAUT yöntemi sonucunda, 2019,2020 ve 2021 yıllarında en iyi finansal performansa sahip havayolu işletmesinin Air France olduğu sonucuna ulaşılmıştır. MARCOS yöntemi bulgularına göre ise 2019 yılında en yüksek finansal performansa sahip havayolu işletmesi Pegasus Havayolları, 2020 ve 2021 yıllarında EasyJet olarak tespit edilmiştir.

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1. INTRODUCTION

The airline sector is one of the key service sectors that supports the growth of the global economy. Following deregulation, radical changes have occurred in the airline industry with liberalization and globalization. New business models emerged, liberal markets were created, airlines' existing networks were expanded, and flights to new destinations were launched. In this way, the airline industry has become more competitive and airline businesses have been under pressure to respond instantly to the moves of their competitors to survive. It is important for airlines to use their existing capacities and resources more effectively and efficiently to survive in the current situation and gain a competitive advantage (Bakir et al., 2020). Therefore, airlines are looking for ways to improve their operational and financial efficiency in order to maintain their growth and financial sustainability in the long term (Huang et al., 2021).

The aviation sector has faced a serious demand thanks to the important steps taken after the liberalization movements. As a result of the increasing demand, issues such as how to provide appropriate service, adequacy of performance level and competitiveness, etc. have also been raised (Belton & Stewart, 2002). Operators and investors perform various performance measurements in order to observe the extent to which the company can meet the increasing demand and to what extent the demand met increases or decreases the company’s resources.

In general, a preliminary idea can be obtained by looking at company balance sheets, operating income, flight traffic, occupancy rates and passenger numbers. However, it has recently been determined that the airline sector is not only related to financial ratios, operational factors interact with both financial ratios and service quality (Francis et al., 2005). For example; If the airline shows a growth trend, the high occupancy rates for that airline are an indication that the airline has high competitiveness in the sector (Schefczyk, 1993).

Although the aviation sector is a rapidly growing and developing sector, it is the most preferred type of transportation by passengers in direct proportion to the development of technology. In line with the increasing demand, airline operators want to measure financial performance for competition among airlines, strategic plans and track the financial status of companies. Financial values can provide convenience to the decision-maker when companies need to make decisions in risky environments that are possible to live in along with giving investors an idea about them (Koçyiğit, 2009).

Many performance measurement methods have been developed to date. The common feature of each of these methods is to eliminate the deficiencies of the methods applied before them and to ensure that the performance is measured in a more accurate and objective way (Sümerli Sarıgül & Coşkun, 2021). Many businesses prefer financial-based performance measurement models (Sümerli Sarıgül & Özkan, 2020). There are many analysis methods in financial performance evaluation. However, since it can evaluate more than one alternative and criterion simultaneously, MCDM methods were used within the scope of this study. The importance of the financial criteria was determined with the CRITIC method, which is one of the MCDM techniques, and the airline enterprises were ranked in terms of financial performance with MAUT and MARCOS methods.

The next part of the study is a literature search. In the third part, the methods used in the study are introduced and the steps related to the method are included. In the fourth section, the findings of the methods and then the results are included. It is thought that the study will contribute to the literature because it analyzes the airline enterprises operating in Europe and having an important share in the aviation sector with up-to-date methods.

2. LITERATURE REVIEW

Financial valuation has been carried out in almost every sector using the multi-criteria decision-making method. When financial performance studies are examined by using CRITIC, MAUT and MARCOS methods; Öztel and Yavuz (2019) evaluated the financial performance analysis of the textile sector with the CRITIC-based MAUT method. In their article, Yürük & Orhan (2020) investigated the financial ratios of the manufacturing industry sub-sector by using CRITIC and the Entropy-based MAUT method. In his article, Pala (2021) investigated the financial performance of the enterprises in the BIST insurance index with CRITIC and MULTIMOOSRAL techniques. In their study, Gençtürk et al. (2021) analyzed the financial performance of participation banks during the pandemic period with the help of CRITIC and MARCOS methods. In their article, Dwivedi et al. (2021) examined the performance of steel enterprises with MARCOS and CRITIC methods. In their study, Köse et al. (2021) investigated the financial performance of 6 participating banks operating in Turkey using MAUT method. In his article Pala (2021) examined the financial performance of the enterprises traded in the BIST transportation index with IDOCRIW and MARCOS methods. In their research, Koca & Bingöl (2022) analyzed the financial performance of non-life insurance companies using CRITIC and MARCOS methods. Ayaz & Ömürbek (2023) analyzed the impact of the Covid-19 pandemic on the financial performance of logistics companies using CRITIC and PROMETHEE methods.

When the studies evaluating the airline and airport financial performances in the aviation sector are examined, it is possible to come across many studies using MCDM methods. Feng & Wang (2000) surveyed Taiwan's top 5 airlines with a total of 6 main criteria and 22 sub-criteria using financial ratios and efficiency-related ratios.

In the study using TOPSIS and Gray Relationship Analysis, Far Eastern Airlines has the highest performance level. In their study, Chang & Yeh (2001) examined 5 airline companies engaged in domestic transportation in Taiwan with cost, efficiency, service quality, price main criteria and 11 sub-criteria. The analysis was carried out with SAW, WP and TOPSIS methods and Eastern Airline was the best-performing company.

Wang (2008) discussed the financial performance of 3 domestic airlines operating in Taiwan. While determining the importance of financial performance criteria with the Grey Relational analysis method, it determined the ranking of the three airlines with the fuzzy TOPSIS method. As a result of the findings obtained, it was concluded that the A2-coded airline had the best financial performance.

In his article Aydoğan (2011) evaluated 4 companies operating in the Turkish aviation sector according to the criteria of effectiveness, efficiency, risk, quality and professional satisfaction. In this study, AHP and Fuzzy TOPSIS methods were used. According to the findings, it was determined that the No. 4 company showed the best performance as a result of the determined criteria.

In their research, Ömürbek & Kınay (2013) examined the financial performance of two airline companies operating on the Borsa İstanbul and Frankfurt Stock Exchange based on 2012. In this study, where the TOPSIS method was preferred, liquidity, financial structure, profitability and activity rates were used as financial criteria. They found that the financial performance of the airline listed on Borsa Istanbul was higher.

Similarly, Akgün & Temur (2016) examined the financial performance of Turkish Airlines and Pegasus Airlines, which are traded on Borsa Istanbul. The researchers compared the financial data for the years 2010-2015 using the TOPSIS method. According to their findings, they determined that Pegasus Airlines exhibited a more effective financial performance in 2010-2011 and that Turkish Airlines had the highest financial performance in 2012. However, according to another finding, they found that Pegasus Airlines exhibited a more efficient financial performance than Turkish Airlines in 2013-2015 with the entry of Pegasus Airlines into the stock market in 2013.

In his article Köse (2021), with a similar result, analyzed the financial performance of Turkish Airlines and Pegasus Airlines between 2014 and 2019 with the TOPSIS method and determined that Pegasus Airlines was more successful financially. In their research, Kurt & Kablan (2022) discussed the measurement of the financial performance of airline companies traded on Borsa Istanbul and operating in Turkey during the COVID-19 period. As a result of the analyzes made with TOPSIS and MABAC methods, they concluded that the financial performance of the relevant airline companies was adversely affected due to the COVID-19 outbreak.

In their study, Wanke et al. (2015) aimed to examine the financial performance of airline companies operating in Asian countries by considering the periods 2006-2012. In their research using the TOPSIS method, they used the criteria of operating cost, depreciation, salary, total assets, fixed assets, revenues and EBITDA. In the findings obtained, they found that cost structure, type of ownership, market position and distance program offered had significant effects on the efficiency levels of airline operations.

Dinçer et al. (2017) focused on the financial performance of airlines in Africa, North America, Asia Pacific, Europe, Latin America and the Middle East. They used the criteria of growth in profit, liquidity ratio, number of customers, sales performance, number of flights, number of fleets, and profit per employee. In their studies carried out using DEMATEL, AHP and VIKOR methods, they concluded that airlines operating in Europe have higher efficiency in terms of financial performance.

In their research, Avcı & Çınaroğlu (2018) analyzed the financial performance of 5 airline enterprises, including airlines operating in Europe, using AHP and TOPSIS methods. The current ratio, cash ratio, financial leverage ratio, equity multiplier, asset turnover rate, equity turnover rate, return on equity and return on assets criteria were used. As a result of the study, they concluded that Ryanair has the best financial performance in terms of financial performance. Durmaz et al. (2020), which supports this study, examined the financial performance and service quality of the main low-cost airline carriers operating in Europe. As a result of the study using CRITIC, TOPSIS and EDAS methods from MCDM methods, they determined that Ryanair was the airline with the most successful financial performance.

In another study, Barros & Wanke (2015) aimed to measure efficiency by analyzing 29 airlines operating in Africa with TOPSIS and VZA methods. They preferred the criteria of the number of employees, operating cost, passenger revenue, fleet percentage, total destination and passenger revenue/km. In the findings, they revealed that the criteria included in the analysis were the most important variables affecting the efficiency levels in the African airline industry.

Pineda et al. (2018) focused on identifying critical factors for improving airline performance. According to the findings of their research, which prefers DANP and VIKOR methods, they have determined that the highest priority criterion of airline companies is the stock price. The most successful airline in terms of financial performance is Delta Airlines.

Bae et al. (2021) analyzed the factors affecting the financial performance of airline enterprises with FAHP and TOPSIS methods. As a result of the study, they determined that the most important criterion affecting financial performance was gross profit margin and that the airline operating with the most successful financial performance was the airline specified with the A8 code.

Garg & Agrawal (2023) conducted a case study of Indian airlines. They used fuzzy theory and the AHP method in their studies in which they evaluated the key performance indicators including the financial performance of airline enterprises. As a result of the findings obtained, they concluded that indicators related to safety and security are more important and that financial criteria and business-related parameters are in last place.

In their studies, Kaya et al. (2023) carried out airline performance evaluations with the DEA method and performed efficiency measurements. In this context, they examined 35 airlines and found that the airlines with the highest efficiency performance were Aeromexico and Icelandair. According to another finding; they identified the number of wide-body aircraft and the increase in asset return as criteria that adversely affect productivity.

When the studies in the literature are examined, it is thought that the study will contribute to the literature because the study uses CRITIC, MAUT and MARCOS methods, which are current and popular in MCDM methods, and analyzes low-cost and traditional airline enterprises operating in Europe together.

3. METHODOLOGY

In the study, 6 airline operators operating in Europe were selected and subjected to financial performance measurement on the basis of 8 financial criteria. The relevant criteria were determined as a result of the literature review. MCDM methods were used to determine financial performance. The analysis was carried out with the CRITIC method in order to determine the importance levels of 8 financial criteria. By integrating the results obtained from the CRITIC method with the MAUT and MARCOS methods, the financial performance ranking of 6 airline companies was obtained.

The airlines identified as alternatives are in Table 1 and the criteria for measuring financial performance are set out in Table 2.

Table 1. Airline Used in the Study

Airlines	IATA Code
Turkish Airlines	**TK**
Pegasus Airlines	**PC**
Lufthansa	**LH**
Air France	**AF**
Ryanair	**FR**
EasyJet	**EC**

Table 2. Financial Criteria Used in the Study

Codes	Direction of Criterion	Criteria	Formulas	Studies Using Criteria
FR1	Benefit	Current ratio	Current assets / Short term debt	Gallizo & Salvador, 2003; Perçin & Aldalou, 2018; Abdel-Basset et al. 2020
FR2	Benefit	Cash ratio	Cash / Short term debt	Perçin & Aldalou, 2018; Kızıl & Aslan, 2019; Yaşar & Över, 2022
FR3	Cost	Financial leverage ratio	Total debt / Total assets	Moghimi & Anvari, 2014; Gümüş & Bolel, 2017; Dayı & Esmer, 2017
FR4	Cost	Equity Multiplier	Equity / Total debt	Turan Kurtaran, 2016; Karkacıer & Yazgan, 2017; Yılmaz et al. 2017

FR5	Benefit	Asset turnover rate	Sales / Total assets	Dalak et al. 2018; Macit & Göçer, 2020; Arsu, 2021
FR6	Benefit	Equity turnover rate	Sales / equity	Akkaya, 2004; Ding & Liang, 2005; Avcı & Çınaroğlu, 2018
FR7	Benefit	Return on equity ratio	Net profit / equity	Doğan 2015; Özbek & Ghouchi, 2021; Ömürbek & Kınay, 2013; Cocis et al. 2021
FR8	Benefit	Return on assets ratio	Net profit / Total assets	Öncü et al., 2013; Doğan & Mecek 2015; Dong et al., 2018; Kablan & Altuk, 2021

The financial data of the airlines examined within the scope of the study between 2019-2021 were accessed from the annual reports and annual reports on the websites of the airline operators. Due to the fact that the data of the relevant airlines for 2022 have not yet been published, the study is restricted to 2021. Since the CRITIC, MAUT and MARCOS methods used in the study consist of many stages and separate analyzes should be performed for each year, the analyzes of 2021, which is the current year in the study, are presented in detail through tables. The details of the analyzes that took place in 2019 and 2020 were shared in the Appendix section at the end of the study.

3.1. CRITIC Method

CRITIC (CRiteria importance through inter-criteria correlation) method is a method introduced to the literature by Diakoulaki et al. for the objective determination of criterion weights (Ulutaş & Karaköy, 2019: 225). In this method, the importance levels of the criteria in the decision process are determined by taking into account the standard deviation of the criteria and the correlation relationships between the criteria (Işık, 2019: 547).

The stages of this approach are as follows (Yaşar and Çınaroğlu, 2021:962):

Step 1: A decision matrix containing m decision alternatives and n evaluation criteria is created.

$$X = [x_{ij}]_{n*m} = \begin{bmatrix} X_{11} & X_{12} & ...X_{1m} \\ X_{21} & X_{22} & ...X_{2m} \\ \vdots & \vdots & \vdots \ \vdots \\ X_{n1} & X_{n2}\cdots & X_{nm} \end{bmatrix} \quad (1)$$

Step 2: In order to eliminate the abnormalities, the decision matrix is normalized based on the types of criteria that are benefit-qualified or cost-qualified criteria.

The normalization of the criteria of the benefits quality is as follows:

$$r_{ij} = \frac{x_{ij}-x_j^{min}}{x_j^{max}-x_j^{min}} \quad (2)$$

The normalization of cost-qualified criteria is as follows:

$$r_{ij}=\frac{x_j^{max}-x_{ij}}{x_j^{max}-x_j^{min}} \quad (3)$$

In the equations $\overline{x_j^{min}}$ represents the minimum value of the j.criterion, x_j^{max} indicates the maximum value of the j.criterion.

Step 3: Using the elements in the normalized decision matrix, the correlation coefficient values between the criteria pairs are calculated as shown below.

$$P_{jk} = \frac{\sum_{i=1}^{m}(r_{ij}-\overline{r_j})(r_{ik}-\overline{r_k})}{\sqrt{\sum_{i=1}^{m}(r_{ij}-r_j)^2 \sum_{i=1}^{m}(r_{ik}-r_k)^2}} \quad (4)$$

Step 4: The amount of information value (C_j) is calculated as shown in the equation below.

$$C_j = \sigma_j \sum_{k=1}^{n}\left(1 - P_{jk}\right) \quad (5)$$

$|\sigma_j|$ refers to the standard deviation value of criterion j. and is calculated as follows:

$$\sigma_j = \sqrt{\frac{\sum_{i=1}^{m}(r_{ij}-\overline{r_j})^2}{m}} \quad (6)$$

Step 5: In the last step, the weight values of each criterion are determined with the help of the following equation.

$$w_j = \frac{c_j}{\sum_{k=1}^{2} c_k} \quad (7)$$

3.2. MAUT Method

This method also referred to as utility theory, Multi-Attribute Utility Theory (MAUT), which was proposed by Fishburn (1967), Fishburn & Keeney (1974) and developed by Løken (2007), determines useful options based on concrete and abstract criteria (Løken & Botterud, 2007: 1586-1587).

Step 1: The criteria (an) that are relevant to the Decision Problem and the criteria/qualifications (x_m) that will be supportive in selecting the criteria should be determined.

Step 2: The assignment of the values (w_i) of the weights for which the priorities are determined and the correct evaluation of the criteria is carried out. The sum of all wi values must be equal to 1.

$$\sum_1^m w_i = 1 \quad (8)$$

Step 3: The value criteria of the criteria are assigned. Assignments are quantitative values for quantitative criteria. For qualitative criteria, bilateral comparisons are made by taking into account. In line with these, value assignments are made in the system of 5, 100 etc.

Step 4: The assigned values are put into the decision matrix and the normalization application continues. In the normalization application, first of all, the best and worst values are determined for all qualities the best value is assigned to 1 value and the worst value is 0 and the calculation of other values is started. The formula is as follows:

$$ui\ (xi) = \frac{X - xi^-}{xi^+ - xi^-} \quad (9)$$

The terms used in this formula are as follows:

$X\dot{I}^+$: Best Value for Qualification

$X\dot{I}^-$: Best Value for Qualification

X : Current Utility Value in Calculated Line

Step 5: After the normalization application, the application of determining the benefit values is started. Utility Function application:

$$U(X) = \sum_1^m ui\ (xi) * wi \quad (10)$$

$U(X)$: Alternative Utility Value

$ui\ (xi)$: Normalized Utility Values for Every Criterion and Every Alternative

wi: Weight Values.

3.3. MARCOS Method

MARCOS (Measurement Alternatives and Ranking According to Compromise Solution) Stevic et al. (2019) is a multi-criteria decision-making method introduced to the literature. This method involves measuring alternatives and ranking them according to a compromise solution. The compromise solution is based on the determination of utility functions according to the distance between ideal and non-ideal (anti-ideal) solutions and their combinations (Gençtürk et al., 2021).

The steps of the method are carried out in the following stages (Sümerli Sarıgül et al., 2023);

Step 1: Creating the Decision Matrix:

The decision matrix is obtained by determining the evaluation criteria and alternatives.

Step 2: Creating the Extended Startup Matrix:

As seen in Equation (11), the ideal (AI) and non-ideal (AAI) solutions are added to the initial decision matrix to obtain an extended initial matrix.

$$C_1\ C_2 \quad \cdots \quad C_n$$

$$X^G = \begin{matrix} A_1 \\ A_2 \\ \vdots \\ A_m \\ AI \\ AAI \end{matrix} \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ x_{m1} & x_{m1} & \cdots & x_{mn} \\ x_{ai1} & x_{ai2} & \cdots & x_{ain} \\ x_{aa1} & x_{aa2} & \cdots & x_{aan} \end{bmatrix} \tag{11}$$

AI and AAI values; Equality (12) and Equality (13) are used to calculate the criteria according to the benefit-cost direction.

$$AI = \max_i X_{ij} \rightarrow j \in F \quad and \quad \min_i X_{ij} \rightarrow j \in M \tag{12}$$

$$AAI = \min_i X_{ij} \rightarrow j \in F \quad and \quad \max_i X_{ij} \rightarrow j \in M \tag{13}$$

Here F represents the benefit-side criteria, and M represents the cost-side criteria.

Step 3: Normalize the Extended Startup Matrix:

For the normalization process, Equality (14) is used for benefit-based criteria and Equality (15) is used for cost-oriented criteria.

$$n_{ij} = \frac{x_{ij}}{x_{ai}} \quad j \in F \tag{14}$$

$$n_{ij} = \frac{x_{ai}}{x_{ij}} \quad j \in M \tag{15}$$

Step 4: Creating the Weighted Matrix:

Equation (16) is used to create the weighted matrix (V). The weighted matrix is obtained by multiplying the elements of the normalized matrix by the criterion weights (w_j).

$$v_{ij} = n_{ij}.w_j \tag{16}$$

Step 5: Calculation of the degree of utility of the alternatives:

With the help of equality (17) and (18), the degree of utility is calculated according to ideal and non-ideal solutions, respectively. The S_i value in the equations refers to the sum of the weighted matrix elements and is calculated using Equation (19).

$$K_i^+ = \frac{S_i}{S_{ai}} \tag{17}$$

$$K_i^- = \frac{S_i}{S_{aai}} \tag{18}$$

$$S_i = \sum_{i=1}^{n} v_{ij} \tag{19}$$

Step 6: Calculation of Utility Functions of Alternatives:

The utility function refers to the consensus solution of the observed alternative according to the ideal and anti-ideal solution. The utility function of the alternatives is calculated by Equality (20).

$$f(K_i) = \frac{K_i^+ + K_i^-}{1 + \frac{1-f(K_i^+)}{f(K_i^+)} + \frac{1-f(K_i^-)}{f(K_i^-)}} \tag{20}$$

In the equation, $f(K_i^+)$ refers to the utility function according to the ideal solution and $f(K_i^-)$ refers to the utility function according to the non-ideal solution. It is calculated using Equality (21) and (22) respectively.

$$f(K_i^+) = \frac{K_i^-}{K_i^+ + K_i^-} \tag{21}$$

$$f(K_i^-) = \frac{K_i^+}{K_i^+ + K_i^-} \tag{22}$$

Step 7: Ranking the Alternatives:

Sort is done according to the utility functions calculated by equality (20). The alternative with the highest value is determined as the most preferred alternative.

4. RESULTS

In this part of the study, 2019, 2020 and 2021 financial data of 6 airline operators included in the analysis were analyzed using CRITIC, MAUT and MARCOS methods. While determining the importance of financial criteria with the CRITIC method, financial performance ranking was obtained with MAUT and MARCOS methods.

The decision matrix, which is used in all of the methods, is arranged according to Equation (1). The decision matrix for the years 2021-2019 is included in Table 3.

Table 3. Decision Matrix

2021	FR1	FR2	FR3	FR4	FR5	FR6	FR7	FR8
TK	0,729	0,395	0,742	0,347	0,403	1,563	0,140	0,036
PC	1,073	0,671	0,861	0,161	0,190	1,365	-0,191	-0,027
LH	1,303	0,229	0,785	0,274	0,483	2,248	-0,309	-0,066
AF	0,915	0,568	1,124	0,111	0,053	0,426	0,863	0,107
FR	0,980	0,751	0,623	0,605	0,133	0,352	0,218	0,082
EC	1,556	1,321	0,730	0,370	0,149	0,552	0,325	0,088
2020	**FR1**	**FR2**	**FR3**	**FR4**	**FR5**	**FR6**	**FR7**	**FR8**
TK	0,647	0,281	0,789	0,267	0,264	1,251	-0,155	-0,033
PC	0,824	0,554	0,815	0,227	0,165	0,892	-0,365	-0,068
LH	0,743	0,098	0,764	0,309	0,421	1,782	-0,102	-0,024
AF	0,840	0,545	1,177	0,150	0,047	0,268	1,330	0,235
FR	0,816	0,466	0,667	0,500	0,576	1,729	0,132	0,044
EC	0,670	0,597	0,771	0,297	0,363	1,585	0,568	0,130
2019	**FR1**	**FR2**	**FR3**	**FR4**	**FR5**	**FR6**	**FR7**	**FR8**
TK	0,800	0,348	0,722	0,384	0,535	1,927	0,115	0,032
PC	1,278	0,879	0,746	0,340	0,524	2,064	0,250	0,063
LH	0,410	0,108	0,722	0,385	0,559	2,009	0,073	0,020
AF	0,675	0,294	0,925	0,081	0,088	1,182	0,127	0,010
FR	0,929	0,409	0,606	0,649	0,581	1,476	0,164	0,065
EC	0,794	0,482	0,634	0,576	0,782	2,139	0,117	0,043

4.1. Findings on the CRITIC Method

The decision matrix, the first step of the CRITIC method, is shown in Table 3. The normalization process is applied to remove the abnormality between the measurement units and to ensure that the values can be valued between 0 and 1. In the normalization process, Equality (2) was used for benefit-qualified criteria and Equality (3) was used for cost-qualified criteria. The normalization process is shown in Table 4. As an example, the year 2021 is included and the steps for the other years are included in the appendices of the study.

Table 4. Normalization Process

2021	FR1	FR2	FR3	FR4	FR5	FR6	FR7	FR8
TK	0,000	0,153	0,762	0,522	0,680	0,310	0,383	0,590
PC	0,415	0,405	0,525	0,897	0,143	0,259	0,101	0,230
LH	0,695	0,000	0,677	0,670	0,883	0,485	0,000	0,000
AF	0,225	0,310	0,000	1,000	1,000	1,000	1,000	1,000
FR	0,304	0,478	1,000	0,000	0,000	0,000	0,450	0,856
EC	1,000	1,000	0,787	0,475	0,041	0,051	0,541	0,889

According to Equation (4), the correlation coefficient between the criteria was calculated and given in Table 5.

Table 5. Correlation Matrix

2021	FR1	FR2	FR3	FR4	FR5	FR6	FR7	FR8
FR1	1,000	0,571	0,211	-0,046	-0,337	-0,316	-0,227	-0,138
FR2	0,571	1,000	0,215	-0,269	-0,725	-0,493	0,323	0,574
FR3	0,211	0,215	1,000	-0,870	-0,642	-0,921	-0,536	-0,149
FR4	-0,046	-0,269	-0,870	1,000	0,578	0,760	0,122	-0,253
FR5	-0,337	-0,725	-0,642	0,578	1,000	0,875	0,206	-0,179
FR6	-0,316	-0,493	-0,921	0,760	0,875	1,000	0,470	0,051

FR7	-0,227	0,323	-0,536	0,122	0,206	0,470	1,000	0,904
FR8	-0,138	0,574	-0,149	-0,253	-0,179	0,051	0,904	1,000

Equity (5) was used for the purpose of calculating the value of the amount of information. The amount of information obtained is shown in Table 6.

Table 6. $1 - P_{jk}$ Matrix

2021	FR1	FR2	FR3	FR4	FR5	FR6	FR7	FR8
FR1	0,000	0,429	0,789	1,046	1,337	1,316	1,227	1,138
FR2	0,429	0,000	0,785	1,269	1,725	1,493	0,677	0,426
FR3	0,789	0,785	0,000	1,870	1,642	1,921	1,536	1,149
FR4	1,046	1,269	1,870	0,000	0,422	0,240	0,878	1,253
FR5	1,337	1,725	1,642	0,422	0,000	0,125	0,794	1,179
FR6	1,316	1,493	1,921	0,240	0,125	0,000	0,530	0,949
FR7	1,227	0,677	1,536	0,878	0,794	0,530	0,000	0,096
FR8	1,138	0,426	1,149	1,253	1,179	0,949	0,096	0,000

The finding of weights related to the criteria is provided by Equality (7). The criterion weights for 2019, 2020 and 2021 are shown in Table 7.

Table 7. Calculation of Importance Levels of Criteria

2021	FR1	FR2	FR3	FR4	FR5	FR6	FR7	FR8
σ_j	0,357	0,345	0,343	0,356	0,449	0,364	0,355	0,401
C_j	2,600	2,347	3,326	2,486	3,240	2,393	2,039	2,485
w_j	0,124	0,112	0,159	0,119	0,155	0,114	0,097	0,119
2020	**FR1**	**FR2**	**FR3**	**FR4**	**FR5**	**FR6**	**FR7**	**FR8**
σ_j	0,431	0,391	0,347	0,335	0,359	0,338	0,368	0,382
C_j	2,552	2,288	3,707	2,437	1,984	1,559	1,590	1,643
w_j	0,144	0,129	0,209	0,137	0,112	0,088	0,090	0,093
2019	**FR1**	**FR2**	**FR3**	**FR4**	**FR5**	**FR6**	**FR7**	**FR8**
σ_j	0,331	0,335	0,352	0,351	0,419	0,391	0,344	0,409
C_j	1,588	1,606	2,935	2,726	3,188	2,945	1,637	2,412
w_j	0,083	0,084	0,154	0,143	0,167	0,155	0,086	0,127

When Table 7 is examined, the most important criterion for 2021 is FR3 with a value of 0.159, FR3 with a value of 0.209 for 2020, and FR5 with a value of 0.167 for 2019 is determined as the most important criterion. The ranking of the relevant criteria is given in Figure 1.

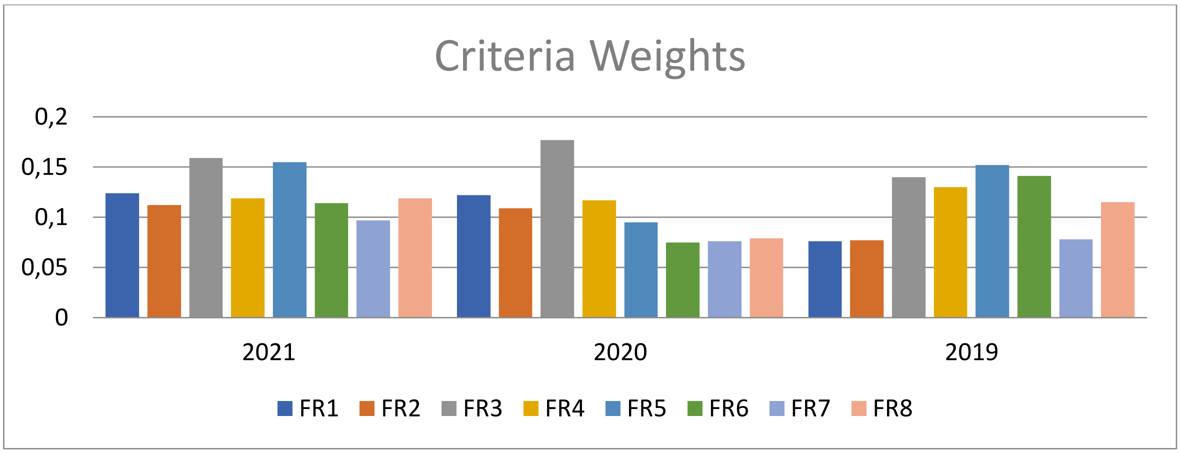

Figure 1. Criterion Weights by Year

The criterion weights obtained here will be used in both the MAUT method and the CODAS method.

4.2. Findings of the MAUT Method

The decision matrix, the initial stage of the MAUT method, is shown in Table 3. The sum of the criterion weights determined by the CRITIC method must be equal to 1. Equality (8) was used to check that the weights were equal to 1.

For the normalization of values, the best values are given 1 and the worst values are zero. For the normalization of the other values, Equation (9) is used and the normalized decision matrix is given in Table 8.

Table 8. Normalization Process

2021	FR1	FR2	FR3	FR4	FR5	FR6	FR7	FR8
TK	0,000	0,153	0,238	0,478	0,680	0,310	0,383	0,590
PC	0,415	0,405	0,475	0,103	0,143	0,259	0,101	0,230
LH	0,695	0,000	0,323	0,330	0,883	0,485	0,000	0,000
AF	0,225	0,310	1,000	0,000	1,000	1,000	1,000	1,000
FR	0,304	0,478	0,000	1,000	0,000	0,000	0,450	0,856
EC	1,000	1,000	0,213	0,525	0,041	0,051	0,541	0,889

Utility values are determined with the help of normalized values. The utility value is calculated by Equation (10) and given in Table 9.

Table 9. Utility Matrix

2021	FR1	FR2	FR3	FR4	FR5	FR6	FR7	FR8
TK	0,000	0,017	0,038	0,057	0,105	0,035	0,037	0,070
PC	0,052	0,045	0,076	0,012	0,022	0,030	0,010	0,027
LH	0,086	0,000	0,051	0,039	0,137	0,055	0,000	0,000
AF	0,028	0,035	0,159	0,000	0,155	0,114	0,097	0,119
FR	0,038	0,054	0,000	0,119	0,000	0,000	0,044	0,102
EC	0,124	0,112	0,034	0,062	0,006	0,006	0,052	0,106

Through the obtained utility values, the ranking of the alternatives with Equality (10) is obtained and is included in Table 10.

Table 10. Determining the Ranking

Airline	2021	2020	2019
	w_j	w_j	w_j
TK	0,360	0,209	0,280
PC	0,273	0,340	0,520
LH	0,369	0,314	0,182
AF	0,707	0,822	0,549
FR	0,356	0,571	0,423
EC	0,503	0,443	0,444

When Table 10 is examined, Air France has been the best-performing airline for the 3 years considered. The ranking of the financial performance of other airlines in the relevant years is given in Figure 2.

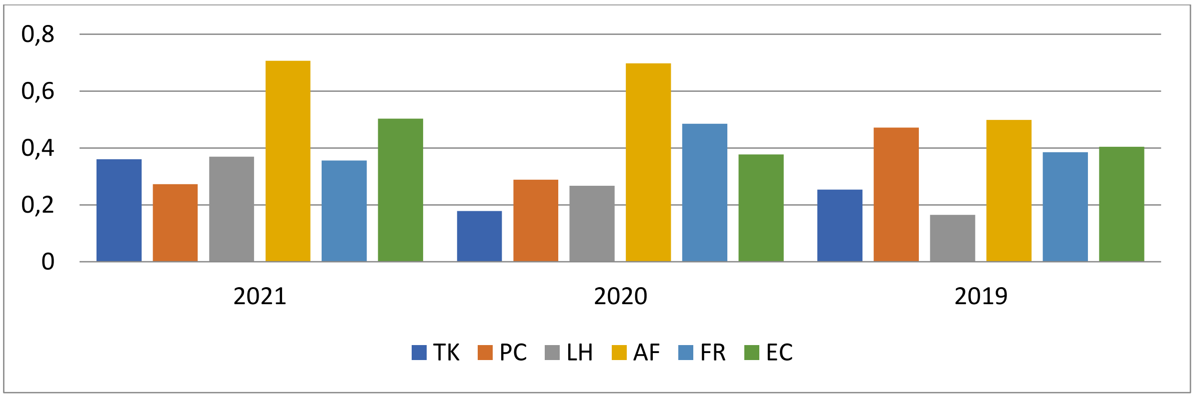

Figure 2. Financial Performance Ranking by Year with MAUT Method

4.3. Findings of the MARCOS Method

The decision matrix, which is the first step of the MARCOS method, is included in Table 3 as in other methods. Equations 12 and 13 were used respectively to create the expanded decision matrix and to calculate the AI and AII values.

Table 11. Expanded Decision Matrix

	FR1	FR2	FR3	FR4	FR5	FR6	FR7	FR8
TK	0,729	0,395	0,742	0,347	0,403	1,563	0,140	0,036
PC	1,073	0,671	0,861	0,161	0,190	1,365	-0,191	-0,027
LH	1,303	0,229	0,785	0,274	0,483	2,248	-0,309	-0,066
AF	0,915	0,568	1,124	0,111	0,530	4,261	0,863	0,107
FR	0,980	0,751	0,623	0,605	0,133	0,352	0,218	0,082
EC	1,556	1,321	0,730	0,370	0,149	0,552	0,325	0,088
AI	1,556	1,321	0,623	0,111	0,530	4,261	0,863	0,107
AII	0,729	0,229	1,124	0,605	0,133	0,352	-0,309	-0,066

After the expanded decision matrix is brought to the Equality 11 format, the normalization process is carried out. In the normalization process, Equality 14 is used for benefit-side criteria and Equality 15 is used for cost-side criteria. The normalized decision matrix is shown in Table 12.

Table 12. Normalized Decision Matrix

	BENEFIT	*BENEFIT*	*COST*	*COST*	*BENEFIT*	*BENEFIT*	*BENEFIT*	*BENEFIT*
	FR1	**FR2**	**FR3**	**FR4**	**FR5**	**FR6**	**FR7**	**FR8**
TK	0,469	0,299	0,839	0,319	0,760	0,367	0,162	0,337
PC	0,689	0,508	0,724	0,686	0,358	0,320	-0,221	-0,247
LH	0,838	0,173	0,794	0,404	0,912	0,528	-0,358	-0,619
AF	0,588	0,430	0,554	1,000	1,000	1,000	1,000	1,000
FR	0,630	0,569	1,000	0,183	0,250	0,083	0,253	0,767
EC	1,000	1,000	0,853	0,299	0,281	0,130	0,377	0,820
AI	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
AII	0,469	0,173	0,554	0,183	0,250	0,083	-0,358	-0,619
w_j	0,124	0,112	0,159	0,119	0,155	0,114	0,097	0,119

The normalized decision matrix is multiplied by the criterion weights obtained through the CRITIC method to create a weighted decision matrix. Equation 16 is used for this process. The weighted matrix is located in Table 13.

Table 13. Weighted Matrix

	FR1	FR2	FR3	FR4	FR5	FR6	FR7	FR8
TK	0,058	0,034	0,133	0,038	0,118	0,042	0,016	0,040
PC	0,086	0,057	0,115	0,082	0,055	0,037	-0,022	-0,029
LH	0,104	0,019	0,126	0,048	0,141	0,060	-0,035	-0,074
AF	0,073	0,048	0,088	0,119	0,155	0,114	0,097	0,119
FR	0,078	0,064	0,159	0,022	0,039	0,009	0,025	0,091
EC	0,124	0,112	0,136	0,036	0,044	0,015	0,037	0,097
AI	0,124	0,112	0,159	0,119	0,155	0,114	0,097	0,119
AII	0,058	0,019	0,088	0,022	0,039	0,009	-0,035	-0,074

Equations 17, 18, 19, 21 and 22 were used, respectively, for the calculation of utility degrees and utility functions for the alternatives. With these obtained values, the value of the utility functions of the alternatives was determined thanks to Equation 20 and thus the ranking was obtained.

Table 14. Calculation of Utility Values

	S_i	K_i^-	K_i^+	$f(K_i^-)$	$f(K_i^+)$	$f(K)$
TK	0,527	4,630	0,528	0,102	0,898	13,404
PC	0,418	3,673	0,419	0,102	0,898	12,447
LH	0,458	4,024	0,459	0,102	0,898	12,798
AF	0,583	5,118	0,583	0,102	0,898	13,892
FR	0,499	4,381	0,499	0,102	0,898	13,155
EC	0,617	5,419	0,618	0,102	0,898	14,193

When Table 14 is examined, it is determined that EasyJet ranks first with a value of 14,193 for 2021. The benefit values calculated for the years considered within the scope of the study are included in Table 15.

Table 15. Degrees of Benefit by Year

	2021	**2020**	**2019**
Airline	$f(K)$	$f(K)$	$f(K)$
TK	13,404	5,763	5,259
PC	12,447	5,887	5,908
LH	12,798	5,900	5,015
AF	13,892	6,551	4,873
FR	13,155	6,520	5,538
EC	14,193	6,589	5,623

When Table 15 is examined, EasyJet ranks first with a value of 6,589 for 2020. In 2019, Pegasus Airlines was selected with the highest financial performance of 5,908. The ranking of financial performance by year is shown in Figure 3.

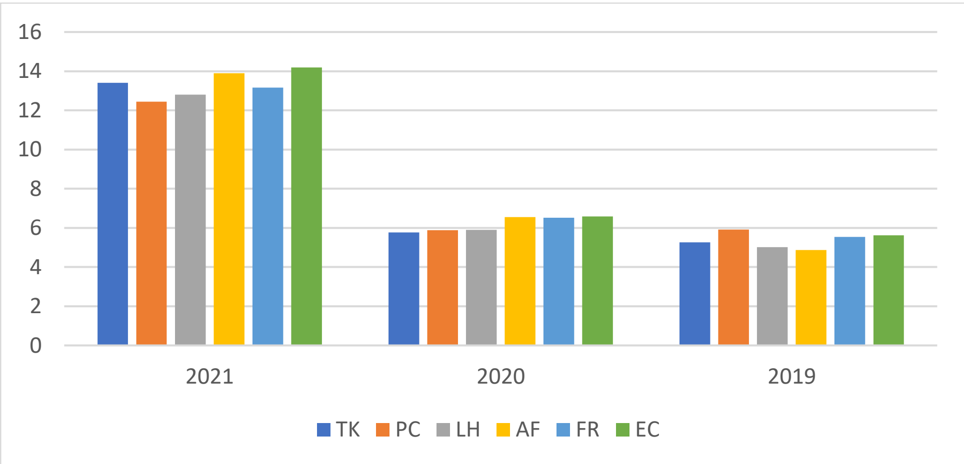

Figure 3. Financial Performance Ranking by Year with MARCOS Method

5. CONCLUSION

The transportation sector plays an important role in the development of an economy by connecting different sectors of the economy (Yaşar, 2022). In the aviation sector, which is an important branch of the transportation sector, it has prepared the ground for the increasingly competitive environment in the globalizing world with the acceleration of activities (Sümerli Sarıgül & Coşkun, 2022). In an increasingly competitive environment, financial performance measurement has also become a focal point for airline operators. Thanks to the financial performance indicators, company executives and stakeholders can be informed about the company's financial position and have an idea about the direction of the steps towards the future.

Within the scope of the study, it is aimed to measure the financial performance of 6 airline companies operating in Europe between 2019-2021. While determining the importance levels of the financial criteria with the CRITIC method, which is one of the MCDM methods, the financial performance ranking of the relevant airlines was obtained by integrating the results of the CRITIC method into the MAUT and MARCOS methods. The financial criteria included in the analysis are; current ratio, cash ratio, financial leverage ratio, equity multiplier, asset turnover rate, equity turnover rate, return on equity and return on assets ratio.

When the findings obtained from the CRITIC method are examined; The most important criterion affecting financial performance for 2021 was the financial leverage ratio. The criteria following the relevant ranking continue in the form of asset turnover rate, current rate, and equity multiplier. The criterion with the least significant value for 2021 was determined as the return on equity ratio. When the year 2020 is examined, it is determined that the most important criterion is the financial leverage ratio. The criteria following the relevant ranking are the current rate, and equity multiplier. It was determined that the least important criterion in 2020 was the equity turnover rate. While the most important value for 2021 and 2020 was determined as the financial leverage ratio, it was determined that the most important criterion in 2019 was the asset turnover rate. It was determined that the least important criterion was the current ratio.

The benchmark weights obtained thanks to the CRITIC method were integrated into the MAUT and MARCOS methods and the success ranking of the financial performances of 6 airline companies was obtained. According to the findings obtained from the MAUT method; The airline with the highest financial performance success in the periods considered was determined as Air France. In the MARCOS method, EasyJet was the airline with the highest level of financial performance for 2021. It was identified as the EasyJet with the best performance in 2020 and Pegasus Airlines in 2019.

If the criteria, alternative, method or data set included in the analysis change, it will be inevitable to obtain different results. In future studies, the importance of different criteria can be re-evaluated by using objective or subjective weighting methods. With the inclusion of different MCDM techniques in the study, more comments about the performance of airline companies and ranking studies involving the comparison of companies can be discussed. In addition, studies in this field can be supported by making evaluations with different methods.

The period in which the study is discussed is a period in which the global COVID-19 pandemic is experienced and economic crises are seen. One of the sectors most financially affected by the pandemic has been the aviation sector. With the analyzes to be made in future studies, the results of this study can be compared and the past effects of the pandemic can be examined in detail.

This study provides some policy recommendations for improving the financial performance of airline operators. In order to increase the activities of the aviation sector and increase passenger demand, policymakers should give importance to tourism activities. With the support of tourism activities, there will be an increase in the demands of tourists coming and going to the countries. Meeting these demands will be possible by air transportation. In line with the increasing demand for airline transportation, it is thought that although there are improvements in the financial performance of airline enterprises, it will also contribute to the country's economy.

AUTHORS' DECLARATION
This paper complies with Research and Publication Ethics, has no conflict of interest to declare, and has received no financial support.

AUTHORS' CONTRIBUTIONS

Conceptualization, writing-original draft, editing – SSS and EY, data collection, methodology, formal analysis – MÜ, Final Approval and Accountability – SSS, EY and MÜ.

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APPENDIX

Appendix 1. Findings on the CRITIC Method (2020)

Appendix 1.1. Normalization Process

	FR1	FR2	FR3	FR4	FR5	FR6	FR7	FR8
TK	0,000	0,366	0,760	0,666	0,240	0,201	0,124	0,115
PC	0,915	0,914	0,710	0,779	0,000	0,000	0,000	0,000
LH	0,496	0,000	0,810	0,545	0,623	0,498	0,155	0,143
AF	1,000	0,896	0,000	1,000	0,752	1,000	1,000	1,000
FR	0,873	0,737	1,000	0,000	1,000	0,468	0,293	0,368
EC	0,117	1,000	0,796	0,580	0,481	0,388	0,550	0,652

Appendix 1.2. Correlation Matrix

	FR1	FR2	FR3	FR4	FR5	FR6	FR7	FR8
FR1	1,000	0,326	-0,391	0,038	0,304	0,347	0,245	0,215
FR2	0,326	1,000	-0,293	0,159	-0,055	0,055	0,450	0,504
FR3	-0,391	-0,293	1,000	-0,797	-0,054	-0,687	-0,769	-0,690
FR4	0,038	0,159	-0,797	1,000	-0,519	0,195	0,363	0,277
FR5	0,304	-0,055	-0,054	-0,519	1,000	0,737	0,516	0,547
FR6	0,347	0,055	-0,687	0,195	0,737	1,000	0,883	0,852
FR7	0,245	0,450	-0,769	0,363	0,516	0,883	1,000	0,992
FR8	0,215	0,504	-0,690	0,277	0,547	0,852	0,992	1,000

Appendix 1.3. $1 - P_{jk}$Matrix

	FR1	FR2	FR3	FR4	FR5	FR6	FR7	FR8
FR1	0,000	0,674	1,391	0,962	0,696	0,653	0,755	0,785
FR2	0,674	0,000	1,293	0,841	1,055	0,945	0,550	0,496
FR3	1,391	1,293	0,000	1,797	1,054	1,687	1,769	1,690
FR4	0,962	0,841	1,797	0,000	1,519	0,805	0,637	0,723
FR5	0,696	1,055	1,054	1,519	0,000	0,263	0,484	0,453
FR6	0,653	0,945	1,687	0,805	0,263	0,000	0,117	0,148
FR7	0,755	0,550	1,769	0,637	0,484	0,117	0,000	0,008
FR8	0,785	0,496	1,690	0,723	0,453	0,148	0,008	0,000

Appendix 1.4. Calculation of Importance Levels of Criteria

	FR1	FR2	FR3	FR4	FR5	FR6	FR7	FR8
$\boldsymbol{\sigma_j}$	0,431	0,391	0,347	0,335	0,359	0,338	0,368	0,382
$\boldsymbol{C_j}$	2,552	2,288	3,707	2,437	1,984	1,559	1,590	1,643
$\boldsymbol{w_j}$	0,144	0,129	0,209	0,137	0,112	0,088	0,090	0,093

Appendix 2. Findings on the CRITIC Method (2019)

Appendix 2.1. Normalization Process

	FR1	FR2	FR3	FR4	FR5	FR6	FR7	FR8
TK	0,449	0,312	0,636	0,466	0,032	0,044	0,234	0,406
PC	1,000	1,000	0,561	0,544	0,000	0,057	1,000	0,979
LH	0,000	0,000	0,638	0,464	0,097	0,051	0,000	0,198
AF	0,306	0,241	0,000	1,000	1,000	1,000	0,306	0,000
FR	0,598	0,391	1,000	0,000	0,159	0,000	0,513	1,000
EC	0,443	0,485	0,914	0,128	0,716	0,064	0,247	0,609

Appendix 2.2. Correlation Matrix

	FR1	FR2	FR3	FR4	FR5	FR6	FR7	FR8
FR1	1,000	0,959	0,177	-0,167	-0,291	-0,242	0,956	0,802
FR2	0,959	1,000	0,129	-0,104	-0,214	-0,228	0,931	0,730
FR3	0,177	0,129	1,000	-0,989	-0,484	-0,884	0,019	0,690
FR4	-0,167	-0,104	-0,989	1,000	0,384	0,810	-0,011	-0,687
FR5	-0,291	-0,214	-0,484	0,384	1,000	0,788	-0,273	-0,513
FR6	-0,242	-0,228	-0,884	0,810	0,788	1,000	-0,115	-0,656
FR7	0,956	0,931	0,019	-0,011	-0,273	-0,115	1,000	0,732
FR8	0,802	0,730	0,690	-0,687	-0,513	-0,656	0,732	1,000

Appendix 2.3. $1 - P_{jk}$Matrix

	FR1	FR2	FR3	FR4	FR5	FR6	FR7	FR8
FR1	0,000	0,041	0,823	1,167	1,291	1,242	0,044	0,198
FR2	0,041	0,000	0,871	1,104	1,214	1,228	0,069	0,270
FR3	0,823	0,871	0,000	1,989	1,484	1,884	0,981	0,310
FR4	1,167	1,104	1,989	0,000	0,616	0,190	1,011	1,687
FR5	1,291	1,214	1,484	0,616	0,000	0,212	1,273	1,513
FR6	1,242	1,228	1,884	0,190	0,212	0,000	1,115	1,656
FR7	0,044	0,069	0,981	1,011	1,273	1,115	0,000	0,268
FR8	0,198	0,270	0,310	1,687	1,513	1,656	0,268	0,000

Appendix 2.4. Calculation of Importance Levels of Criteria

	FR1	FR2	FR3	FR4	FR5	FR6	FR7	FR8
σ_j	0,331	0,335	0,352	0,351	0,419	0,391	0,344	0,409
C_j	1,588	1,606	2,935	2,726	3,188	2,945	1,637	2,412
w_j	0,083	0,084	0,154	0,143	0,167	0,155	0,086	0,127

Appendix 3. Findings on the MAUT Method (2020)

Appendix 3.1. Normalization Process

	FR1	FR2	FR3	FR4	FR5	FR6	FR7	FR8
TK	0,000	0,366	0,240	0,334	0,240	0,201	0,124	0,115
PC	0,915	0,914	0,290	0,221	0,000	0,000	0,000	0,000
LH	0,496	0,000	0,190	0,455	0,623	0,498	0,155	0,143
AF	1,000	0,896	1,000	0,000	0,752	1,000	1,000	1,000
FR	0,873	0,737	0,000	1,000	1,000	0,468	0,293	0,368
EC	0,117	1,000	0,204	0,420	0,481	0,388	0,550	0,652

Appendix 3.2. Utility Matrix

	FR1	FR2	FR3	FR4	FR5	FR6	FR7	FR8
TK	0,000	0,047	0,050	0,046	0,027	0,018	0,011	0,011
PC	0,131	0,118	0,061	0,030	0,000	0,000	0,000	0,000
LH	0,071	0,000	0,040	0,062	0,070	0,044	0,014	0,013
AF	0,144	0,115	0,209	0,000	0,084	0,088	0,090	0,093
FR	0,125	0,095	0,000	0,137	0,112	0,041	0,026	0,034
EC	0,017	0,129	0,043	0,058	0,054	0,034	0,049	0,060

Appendix 3.3. Determining the Ranking

	Total
TK	0,209
PC	0,340
LH	0,314
AF	0,822
FR	0,571
EC	0,443

Appendix 4. Findings on the MAUT Method (2019)

Appendix 4.1. Normalization Process

	FR1	FR2	FR3	FR4	FR5	FR6	FR7	FR8
TK	0,449	0,312	0,364	0,534	0,032	0,044	0,234	0,406
PC	1,000	1,000	0,439	0,456	0,000	0,057	1,000	0,979
LH	0,000	0,000	0,362	0,536	0,097	0,051	0,000	0,198
AF	0,306	0,241	1,000	0,000	1,000	1,000	0,306	0,000
FR	0,598	0,391	0,000	1,000	0,159	0,000	0,513	1,000
EC	0,443	0,485	0,086	0,872	0,716	0,064	0,247	0,609

Appendix 4.2. Utility Matrix

	FR1	FR2	FR3	FR4	FR5	FR6	FR7	FR8
TK	0,037	0,026	0,056	0,077	0,005	0,007	0,020	0,051
PC	0,083	0,084	0,068	0,065	0,000	0,009	0,086	0,124
LH	0,000	0,000	0,056	0,077	0,016	0,008	0,000	0,025
AF	0,025	0,020	0,154	0,000	0,167	0,155	0,026	0,000
FR	0,050	0,033	0,000	0,143	0,027	0,000	0,044	0,127
EC	0,037	0,041	0,013	0,125	0,120	0,010	0,021	0,077

Appendix 4.3. Determining the Ranking

	Total
TK	0,280
PC	0,520
LH	0,182
AF	0,549
FR	0,423
EC	0,444

Appendix 5. Findings on the MARCOS Method (2020)

Appendix 5.1. Expanded Decision Matrix

	FR1	FR2	FR3	FR4	FR5	FR6	FR7	FR8
TK	0,647	0,281	0,789	0,267	0,264	1,251	-0,155	-0,033
PC	0,824	0,554	0,815	0,227	0,165	0,892	-0,365	-0,068
LH	0,743	0,098	0,764	0,309	0,421	1,782	-0,102	-0,024
AF	0,840	0,545	1,177	0,150	0,047	0,268	1,330	0,235
FR	0,816	0,466	0,667	0,500	0,576	1,729	0,132	0,044
EC	0,670	0,597	0,771	0,297	0,363	1,585	0,568	0,130
AI	0,840	0,597	0,667	0,150	0,576	1,782	1,330	0,235
AII	0,647	0,098	1,177	0,500	0,047	0,268	-0,365	-0,068

Appendix 5.2. Normalized Decision Matrix

	FR1	FR2	FR3	FR4	FR5	FR6	FR7	FR8
TK	0,771	0,470	0,845	0,563	0,458	0,702	-0,117	-0,139
PC	0,980	0,928	0,818	0,661	0,287	0,500	-0,274	-0,287
LH	0,884	0,165	0,873	0,486	0,731	1,000	-0,077	-0,103
AF	1,000	0,914	0,567	1,000	0,082	0,150	1,000	1,000
FR	0,971	0,780	1,000	0,301	1,000	0,970	0,099	0,187
EC	0,797	1,000	0,865	0,506	0,630	0,889	0,427	0,553
AI	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
AII	0,771	0,165	0,567	0,301	0,082	0,150	-0,274	-0,287
w_j	0,144	0,129	0,209	0,137	0,112	0,088	0,090	0,093

Appendix 5.3. Weighted Matrix

	FR1	FR2	FR3	FR4	FR5	FR6	FR7	FR8
TK	0,111	0,061	0,176	0,077	0,051	0,062	-0,010	-0,013
PC	0,141	0,120	0,171	0,091	0,032	0,044	-0,025	-0,027
LH	0,127	0,021	0,182	0,067	0,082	0,088	-0,007	-0,009
AF	0,144	0,118	0,118	0,137	0,009	0,013	0,090	0,093
FR	0,140	0,101	0,209	0,041	0,112	0,085	0,009	0,017
EC	0,115	0,129	0,181	0,069	0,070	0,078	0,038	0,051
$\boldsymbol{AI}$	0,144	0,129	0,209	0,137	0,112	0,088	0,090	0,093
$\boldsymbol{AII}$	0,111	0,021	0,118	0,041	0,009	0,013	-0,025	-0,027

Appendix 5.4. Calculation of Utility Values

	$\boldsymbol{S_i}$	$\boldsymbol{K_i^-}$	$\boldsymbol{K_i^+}$	$\boldsymbol{f(K_i^-)}$	$\boldsymbol{f(K_i^+)}$	$\boldsymbol{f(K)}$
TK	0,514	1,957	0,514	0,208	0,792	5,763
PC	0,547	2,081	0,547	0,208	0,792	5,887
LH	0,550	2,094	0,550	0,208	0,792	5,900
AF	0,721	2,745	0,721	0,208	0,792	6,551
FR	0,713	2,714	0,713	0,208	0,792	6,520
EC	0,731	2,783	0,731	0,208	0,792	6,589

Appendix 6. Findings on the MARCOS Method (2019)

Appendix 6.1. Expanded Decision Matrix

	FR1	FR2	FR3	FR4	FR5	FR6	FR7	FR8
TK	0,800	0,348	0,722	0,384	0,535	1,927	0,115	0,032
PC	1,278	0,879	0,746	0,340	0,524	2,064	0,250	0,063
LH	0,410	0,108	0,722	0,385	0,559	2,009	0,073	0,020
AF	0,675	0,294	0,925	0,081	0,088	1,182	0,127	0,010
FR	0,929	0,409	0,606	0,649	0,581	1,476	0,164	0,065
EC	0,794	0,482	0,634	0,576	0,782	2,139	0,117	0,043
$\boldsymbol{AI}$	1,278	0,879	0,606	0,081	0,782	2,139	0,250	0,065
$\boldsymbol{AII}$	0,410	0,108	0,925	0,649	0,088	1,182	0,073	0,010

Appendix 6.2. Normalized Decision Matrix

	FR1	FR2	FR3	FR4	FR5	FR6	FR7	FR8
TK	0,626	0,396	0,840	0,210	0,684	0,901	0,460	0,494
PC	1,000	1,000	0,813	0,238	0,669	0,965	1,000	0,982
LH	0,321	0,123	0,840	0,210	0,714	0,939	0,294	0,317
AF	0,528	0,334	0,656	1,000	0,113	0,553	0,510	0,148
FR	0,727	0,465	1,000	0,125	0,743	0,690	0,656	1,000
EC	0,622	0,548	0,956	0,140	1,000	1,000	0,468	0,663
$\boldsymbol{AI}$	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
$\boldsymbol{AII}$	0,321	0,123	0,656	0,125	0,113	0,553	0,294	0,148
$\boldsymbol{w_j}$	0,083	0,084	0,154	0,143	0,167	0,155	0,086	0,127

Appendix 6.3. Weighted Matrix

	FR1	FR2	FR3	FR4	FR5	FR6	FR7	FR8
TK	0,052	0,033	0,129	0,030	0,115	0,139	0,040	0,063
PC	0,083	0,084	0,125	0,034	0,112	0,149	0,086	0,124
LH	0,027	0,010	0,130	0,030	0,120	0,145	0,025	0,040
AF	0,044	0,028	0,101	0,143	0,019	0,086	0,044	0,019
FR	0,061	0,039	0,154	0,018	0,124	0,107	0,056	0,127
EC	0,052	0,046	0,147	0,020	0,167	0,155	0,040	0,084
AI	0,083	0,084	0,154	0,143	0,167	0,155	0,086	0,127
AII	0,027	0,010	0,101	0,018	0,019	0,086	0,025	0,019

Appendix 6.4. Calculation of Utility Values

	S_i	K_i^-	K_i^+	$f(K_i^-)$	$f(K_i^+)$	$f(K)$
TK	0,601	1,975	0,601	0,233	0,767	5,259
PC	0,799	2,624	0,799	0,233	0,767	5,908
LH	0,527	1,731	0,527	0,233	0,767	5,015
AF	0,484	1,588	0,484	0,233	0,767	4,873
FR	0,686	2,254	0,686	0,233	0,767	5,538
EC	0,712	2,338	0,712	0,233	0,767	5,623