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## RESEARCH ARTICLE

## Financial Performance Evaluation of Airline Companies with Fuzzy AHP and Grey Relational Analysis Methods

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### Abstract

Air transport is an essential part of the transportation sector to provide speed, reliability and economic advantage. It is possible to say that; companies operating in the aviation sector have a financially fragile structure. There are many airline companies in the aviation sector in the world and Turkey. In this study five airline companies from EU member states and Turkey, including Turkish Airlines (THY), British Airways, Air France KLM, Lufthansa and Ryanair's financial performance in the 2012-2018 period were evaluated. To determine the importance of the financial criteria, which were determined according to the literature, eight different expert opinions were taken and the weights of the criteria were determined according to expert's opinions with the Fuzzy Analytical Hierarchy Process (FAHP) method. The financial performance rankings of the companies were realized with the Grey Relational Analysis (GRA) method. When looking at the analysis results of 2018, the company with the best financial performance was determined as THY. It is followed by Air France KLM, British Airways, Ryanair and Lufthansa, respectively. In the study, the Spearman correlation method was applied to the financial performance rankings determined by the GRA. The rankings were interpreted statistically, and Kendall's Tau correlation test was applied to examine the relationship between the number of flight destinations and the financial performance rankings of airline companies.

### Keywords

Fuzzy Analytical Hierarchy Process, Grey Relational Analysis, Financial Performance, Airline Companies

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## Introduction

The transportation sector is important as a need in human life. The transportation sector is divided into four main groups. Transportation is carried out within the scope of moving living and non-living creatures from one point to another with airline, railway, highway, and seaway options. In addition to being fast and reliable, transportation should provide an economic advantage when choosing among the transportation sectors. Air transportation is the fastest and most reliable among the four transportation sectors compared to other industries (Göktepe, 2007).

Air transport consists of two different sections. Firstly, the air transport system which covers transporting passengers by air, except for moving an asset. Secondly, unlike general aviation, air transport involves activities using small aircraft. Agricultural spraying, sportive shows, rescue activities are included in the general aviation concept (Gerede, 2002).

Financial performance evaluation is a significant issue for all companies and organizations as well as for airline companies. The financial performance evaluation process for airline companies enables the determination of positive or negative aspects of an enterprise compared to competing companies. Thanks to the evaluation, the enterprises determine their position in the sector, thus contributing to the process of making optimal decisions in the management process of the enterprise.

In the literature, financial performance evaluation has been done in different sectors with different methods. Financial performance evaluation studies with multi-criteria decision-making methods are frequently encountered in the literature. Heshmati et al. (2014) analyzed the companies operating in the petrochemical industry using the FAHP method. After the analysis, Arak, Fanavaran and Abadan petrochemical companies were found to be the best companies in terms of financial performance. In their studies carried out by Tayyar et al. (2014) applied the FAHP and GRA. Looking at the analysis results, they concluded that the rate of profitability was more prominent among the weights of the criteria that Kaya et al. (2017) carried out analysis with ORESTE, TOPSIS and ELECTRE methods. After the analysis of brokerage houses, the company with the best financial performance was determined. Siew et al. (2018), dealt with the businesses operating in the coffee business in Malaysia. They found a difference of 0.097 between the best business and the financially lowest business. Öztürk and Onurlubaş (2019) examined three firms operating in Samsun using Analytical Hierarchy Process and TOPSIS methods in their studies. When looking at the results of the mentioned methods, they determined that the comfort of the inner comfort of the aircraft is the most effective criterion for determining the performance. At the same time, firm A had the best financial performance among these three companies.

In this study, a financial performance evaluation of airline companies belonging to various countries was made. When studies on financial performance evaluation

about the aviation sector in literature were analyzed, it was seen that some of them are applied to companies of a single country. Akkaya (2004) evaluated the airline companies financial performance with the 13 criteria. Using the TOPSIS method for financial performance ranking, Akkaya (2004) concluded that more than one airline company could obtain more efficient results. Okumuş and Asil (2007), created two different groups and tried to determine the differences between the socio-demographic characteristics of these groups. They made this analysis using the discriminant method. Within the research framework, by applying 511 questionnaires, they aimed to determine the characteristics of domestic and foreign passengers' airway preferences. Gürel (2012) evaluated the financial performance of three airline companies operating in Turkey by using the FAHP method. As a result of the analysis made on the data of THY, Onurair and Pegasus, it was determined that THY has the best financial performance. Akgün and Soy Temür (2016) studied a financial performance assessment of the airline companies between 2010 and 2015. While the Pegasus airline had the best financial performance between 2011-2014, they concluded that THY was financially better in the remaining periods (Ellibeş 2020).

Barros et al. (2015) evaluated the information of the airline companies about their financial actions, and they concluded that the adverse effects and financial conditions decreased due to the fuel prices of aircraft operating in Asia. Avcı and Çınaroğlu (2018) studied the financial performance of five airline companies operating in Europe. They used the AHP and TOPSIS methods for their financial performance rankings between the 2012-2016 periods. The company with the best financial performance was Ryanair.

When we look at financial performance evaluation studies criteria; It was observed that current ratio, leverage ratio, profitability ratio, activity ratio, liquidity ratio, growth rate, asset return ratio, equity ratio, reserve requirement ratio, net profit margin, profitability per share, dividend rates were used ((Wang (2008), Uygurtürk). & Korkmaz (2012), Ömürbek & Kınay (2013), Poorhossein et al. (2013), Heshmati et al. (2014), Akkus et al. (2015), Siew et al. (2018)).

In this study, while evaluating the financial performance of airline companies, and the literature, twelve criteria were determined under three main categories. The main criteria are liquidity ratios, financial ratios, profitability ratios, sub-criteria current ratio, acid-test ratio, cash ratio, leverage ratio, financing ratio, debt / equity, tangible assets / equity, equity / total foreign resources, financial profitability, gross profit margin, net profit margin and asset profitability. Weights of all criteria were determined by taking the opinions of eight experts. Expert opinions were converted into fuzzy numbers by using linguistic variables in the FAHP method. After determining the weight transactions, financial performance rankings of five airlines were made using the GRA method. Airline companies are affected by many situations in financial

performance evaluations. In the study, the relationship between the number of flight points in these situations and the ranking of financial performance was investigated. Statistically, similarities were determined by using the Spearman correlation on the airline companies determined during these periods. Finally, the relationship between the number of flight destinations and financial performance is examined using Kendall’s Tau correlation test.

The difference of this study from other studies in the literature can be summarized as follows: Financial performance analysis has not been done in previous studies on the companies evaluated. In addition, the integrated Fuzzy AHP and GRA methods used in this study were not used in previous financial performance studies.

### Methods

In this part of the study, the methods used for financial performance evaluation are explained. Weights of performance criteria were; obtained from expert opinions based on the linguistic variables. They were obtained by transforming linguistic variables into fuzzy numbers and then the values defuzzified with the FAHP method. After determining the criteria weights, financial performance rankings were obtained with GRA.

#### Fuzzy Analytical Hierarchy Process

The hierarchical structures expressed as fuzzy clusters were revealed because the decisions taken today are not based on numerical data or decisions that are taken in line with the uncertainties. When the literature is examined, many findings related to this method are found. Laarhoven and Pedryctz (1983) compared the data obtained with fuzzy triangular numbers with fuzzy rates. With this method, more than one decision maker’s predictions are included in mutually formed matrices. In contrast to this advantage of the method, the application of too many mathematical operations in modeling and the fact that these operations can be modeled only with fuzzy triangular numbers are considered the disadvantage of the method. Chang (1996) was improved the fuzzy triangular numbers for comparison when using the analytical hierarchy process method (Kaptanoğlu et al. 2006). The linguistic variables used in the Fuzzy AHP Method are shown in Table 1.

Table 1  
*Linguistic Variables and Triangular Fuzzy Numbers*

Linguistic Variables	Fuzzy Scale	Counter Scale
Equally important	(1,1,1)	(1,1,1)
More equally important	(1,3,5)	(1/5,1/3,1)
Much more equally important	(3,5,7)	(1/7,1/5,1/3)
Too much more equally important	(5,7,9)	(1/9,1/7,1/5)
Absolutely important	(7,9,9)	(1/9,1/9,1/7)

The algorithm of the method given by Chang to the literature is shown below:

$$S_i = \sum_{j=1}^m M_{gi}^j \times \left[ \sum_{i=1}^n \sum_{j=1}^m M_{gi}^j \right]^{-1} \tag{1}$$

To find the expression in the equation, “ $\sum_{j=1}^m M_{gi}^j$ ”, “m” must be added to the fuzzy numbers: “m”. Matrix addition can be shown as follows (Kahraman et al., 2004);

$$\sum_{j=1}^m M_{gi}^j = \left( \sum_{j=1}^m l_j, \sum_{j=1}^m m_j, \sum_{j=1}^m u_j \right) \tag{2}$$

To find the other factor in the equation, the triangle values must be added to the fuzzy values;

$$\sum_{i=1}^n \sum_{j=1}^m M_{gi}^j = \left( \sum_{j=1}^n l_j, \sum_{j=1}^n m_j, \sum_{j=1}^n u_j \right) \tag{3}$$

After obtaining the two parts in the equation, the inverse of the vector in the equation must be calculated as follows;

$$\sum_{i=1}^n \sum_{j=1}^m M_{gi}^j = \left( \frac{1}{\sum_{j=1}^n u_j}, \frac{1}{\sum_{j=1}^n m_j}, \frac{1}{\sum_{j=1}^n l_j} \right) \tag{4}$$

In the second step after completing the operations, the probability degrees for  $M_1 = (l_1, m_1, u_1)M_2(l_2, m_2, u_2)$  are calculated as follows;

$$V(M_2 \geq M_1) = \sup_{y \geq x} \left[ \min(\mu_{M_1}(x), \mu_{M_2}(y)) \right] \tag{5}$$

Equation  $M_1 = (l_1, m_1, u_1)M_2(l_2, m_2, u_2)$  triangular fuzzy numbers (Göksu et al., 2008);

$$V(M_2 \geq M_1) = \text{hgt}(M_1 \cap M_2) = \mu_{M_2}(d) \begin{cases} 1 & , m_2 \geq m_1 \\ 0 & , l_1 \geq u_2 \\ \frac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)} & , \text{other situations} \end{cases} \tag{6}$$

In the third stage, the probability degree of a triangular fuzzy number is estimated to be higher than the number of triangles “k”;

$$V(M \geq M_1, M_2, \dots, M_k) = V[(M \geq M_1), (M \geq M_2), \dots, (M \geq M_k)] = \min V(M \geq M_i), i = 1, 2, 3, \dots, k \tag{7}$$

k = 1, 2, 3, …, n ; k ≠ j ise  $d(A_j) = \min V(s_j \geq s_k)$ , it may be possible to define the weight vector as follows;

$$W' = (d(A_1), d(A_2), d(A_3) \dots, d'(A_n))^T \tag{8}$$

It can be defined as “ $A_i$ ”  $i(1,2,3,\dots,n)$  in the equation.

Finally, the normalization process of the most recent vector is performed;

$$W = (d(A_1), d(A_2), d(A_3), \dots, d(A_n))^T \tag{9}$$

**Grey Relational Analysis (GRA) Method**

The GRA method is a multi-criteria decision-making method based on the grey system theory. In the GRA method, the classification and decision-making process occurs based on the grey relational degrees (Wen, 2004). This method is used to classify the sample variables in the case that the samples are small or the distribution status of the sample is unknown (Feng et al., 2000). The GRA method can be applied to quantitative datasets as well as datasets with linguistic criteria. The advantages of the method can be shown as working with a small data set and easy mathematical operations (Dogan, 2013).

The steps of GRA are as follows;

- Setting data and examining decision matrices

Alternative options of “ $m$ ” in the decision-making matrix of “ $m \times n$ ” are determined as the symbol of the criteria in the decision-making matrix of “ $n$ ”;

$$\begin{bmatrix} X_1(1) & X_1(2) & X_1(n) \\ X_2(1) & X_2(2) & X_2(n) \\ X_m(1) & X_m(2) & X_m(n) \end{bmatrix} \tag{10}$$

- Creating reference series and comparison matrix

Creating a reference series may vary depending on the application types to be performed in the study. In the study,  $X_0=(1,1,1,\dots,1)$  was determined. The main reason for its determination in this way is to obtain the series that will be closest to the reference series (Özdemir et al., 2009).

- Creating the normalization process normalization matrix

If the criteria are different from each other, it is difficult to compare between criteria. For this reason, it is necessary to apply the normalization process to the data. Normalization can be done as follows (Elitaş et al., 2012);

$$X_i(k) = [xi(k) - \min xi(k)] / [\max. xi(k) - \min xi(k)] \tag{11}$$

$$X_i(k) = [\max. xi(k) - xi(k)] / [\max. xi(k) - \min xi(k)] \tag{12}$$

$$X_i(k) = 1 - |xi(k) - ui| / \max |xi(k) - ui| \tag{13}$$

- Creating an absolute value table

In this step, when creating the absolute value, the differences in the coefficients of the specified criteria should be calculated. The difference between the coefficients can be defined as the difference between the number of lines and the reference value (Bektaş et al., 2013).

$$\Delta X_i(k) = |Y_0(1) - X_1(1)|, |Y_0(2) - X_1(2)|, |Y_0(3) - X_1(3)|, \dots, |Y_0(n) - X_1(n)| \quad (14)$$

- Creating a grey relational coefficient matrix

The values that make up the difference data are calculated. Here, the operation is made between the most change in the data series and the data showing the least change. is  $\delta$  separator coefficient and usually used as 0.5.

$$K(j) = (\Delta min + \delta \Delta max) / (\Delta i(j) + \delta \Delta max) \quad (15)$$

- Creation of grey relational degrees

$$\varphi_i = \frac{1}{n} \sum_{m=1}^n K(m) \quad (16)$$

In the equation here, the degree of the grey relation of the alternative “i” is shown. Also, if the criteria have different weights, the grey relational degree is calculated as follows (Şişman et al. 2013);

$$\varphi_i = \frac{1}{n} \sum_{m=1}^n K(m) w(m) \quad (17)$$

“W (m)” in the equation established to calculate the criteria with different weights. It shows the degree of importance belonging to the criterion.

### Financial Performance Evaluation

In this part of the study, the financial performance evaluation of five airline companies was carried out using FAHP and GRA methods.

The steps to be implemented are as follows: The data of the airline companies were obtained from the companies’ year-end income table after the criteria were determined. Using the FAHP method, the weights of the criteria were determined according to expert opinions. The financial performances of five airlines, including THY, Air France KLM, British Airways, Ryanair and Lufthansa, were calculated and ranked using the GRA method.

#### *Step 1: Determination of Criteria*

While determining the criteria used in the research, the most important rates were determined in terms of the financial performance of the enterprises and the criteria were selected considering the previous studies in the literature. The criterion consists of 12 criteria under 3 main groups. The criteria are shown with the help of Figure 1. The criteria can be briefly explained as follows

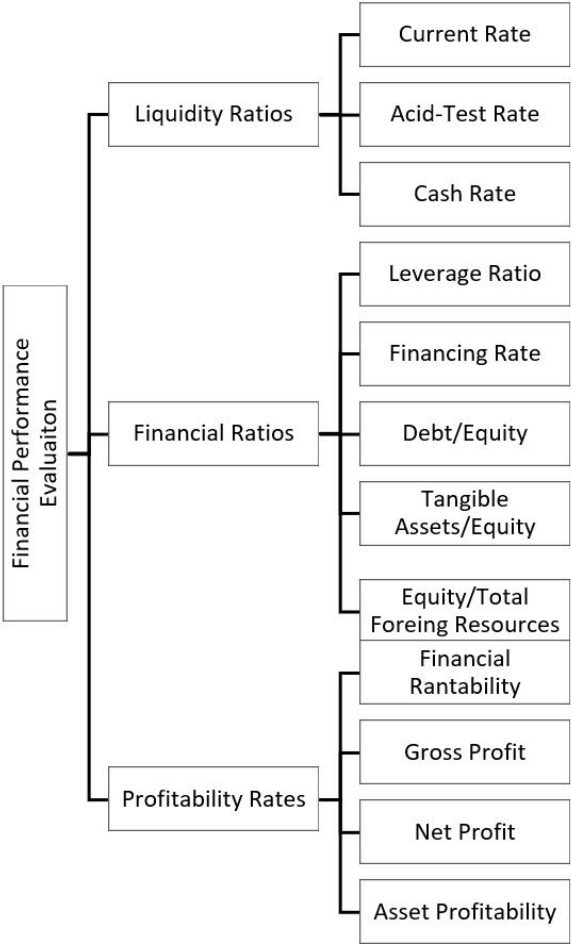


Figure 1. Financial Performance Evaluation Criteria

**Sub Criteria of Main Criteria 1: Liquidity Ratios**

**1.1. Current Rate (CR):** Working capital should be in proportion to companies with short-term debts. The current rate is expected to be above 2.

The current ratio shows the status of the entity’s cash values and, its ability to cover the debt. In other words, the high cash value of the business means that it can meet its debts in the short term.



**1.2. Acid-Test Rate (ATR):** It is the value formed by dividing the liquid values of the business into short-term debts. The acid test rate shows the strength of the company's cash and convertible resources to pay off its short-term debt.

**1.3. Cash Rate (CRA):** The presence of the firm's existing cash and securities (liquid assets) shows how much short-term debt can be covered if the firm's cash inflows are cut. The cash rate is expected to be above 1.

### ***Sub Criteria of Main Criteria 2: Financial Ratios***

**2.1. Leverage Ratio (LR):** It is the rate that shows what percentage of firm assets are covered by foreign resources. The leverage ratio is expected to be 50% lower. The firm above this value indicates that it is risky.

**2.2. Financing Rate (FR):** The ratio of equity to the sum of short-term foreign resources and long-term foreign resources. This rate is known as the financial independence degree of the company.

**2.3. Debt/Equity Ratio (DE):** This rate is the opposite of the financing rate. The Debt / Equity ratio is expected to be below 1.

**2.4. Tangible Assets/Equity Ratio (TA):** It is the ratio that shows how much of the tangible assets of the company are covered by equity. This rate is expected to be over 0.7.

**2.5. Equity/Total Foreign Resources Ratio (ETF):** It is the rate that indicates how much of the assets belonging to the firm meets with equity. This ratio is the opposite of the leverage ratio. The said ratio being below 0.3 indicates that the firm has high debt.

### ***Sub Criteria of Main Criteria 3: Profitability Rates***

**3.1. Financial Rantability (FRA):** It shows the relationship between firms' equity and net profit. The high rate in question indicates that firm profitability has a good level.

**3.2. Gross Profit (GP):** It is the percentage share of the total sales revenue of a company after the expenses related to the product and service are deducted. This rate also plays an important role in the production phase. It is an important rate that gives information about the company's risk and return.

**3.3. Net Profit (NP):** It measures the company's after-tax sales profits.

**3.4. Asset Profitability (AP):** This rate indicates the total investments of a company. If the rate of return on assets is high, the firm is expected to generate high income from its investments.

*Step 2: Determining the Importance Levels of Criteria*

FAHP was used to determine the importance of the criteria by the opinions of 8 experts. Firstly, the main criteria weights were determined and then the importance levels of the sub-criteria were determined.

Table 2 shows the fuzzy binary comparison matrix of the main criteria. The binary comparison matrix was determined, by using Chang’s (1996) method and the steps of determining the weights of the main criteria are shown below. Determination of the weights of the main criteria by applying Chang’s method is shown with the help of Table 3. Following the operations using Chang’s method, the probability values of the main criteria were determined. With the determination of probability values, the normalization process was performed on probability values. After the normalization process, the weight levels of the main criteria are shown with the help of Table 4. These transactions have been applied for all sub-criteria. Significance levels of the sub-criteria are shown with the help of Table 5.

Table 2  
*Fuzzy Binary Comparison Matrix of Main Criteria*

	<b>Liquidity Ratios</b>	<b>Financial Ratios</b>	<b>Profitability Rates</b>
Liquidity Ratios	(1,1,1)	(6,7,8)	(2,3,4)
Financial Ratios	(1/8,1/7,1/6)	(1,1,1)	(1/6,1/5,1/4)
Profitability Rates	(1/4,1/3,1/2)	(4,5,6)	(1,1,1)

Table 3  
*Weight Determination according to Chang (1996)*

	<b>Liquidity Ratios</b>	<b>Financial Ratios</b>	<b>Profitability</b>	<b>Sum of Triangular Rates Numbers</b>
Liquidity Ratios	(1,1,1)	(6,7,8)	(2,3,4)	(9,11,13)
Financial Ratios	(1/8,1/7,1/6)	(1,1,1)	(1/6,1/5,1/4)	(1,29,1.34,1.41)
Profitability Rates	(1/4,1/3,1/2)	(4,5,6)	(1,1,1)	(5.25,6.33,7.5)
				<b>(15,54, 18.67, 21.91)</b>
Liquidity Ratios	(9,11,13) X (1/21.91,1/18.67,1/15.54)			(139.86, 205.37, 284.83)
Financial Ratios	(1,29,1.34,1.41) X(1/21.91,1/18.67,1/15.54)			(20.04, 25.02, 30.89)
Profitability Rates	(5.25,6.33,7.5) X (1/21.91,1/18.67,1/15.54)			(81,585, 118.18, 164,32)

Table 4  
*Weights of Main Criteria*

Liquidity Ratios	0.7087
Financial Ratios	0.1367
Profitability Rates	0.1545

After analyzing the main criteria, it was observed; that the liquidity ratios had the most significant weight among the three main criteria to be interpreted according to expert opinions. Secondly, profitability rates are determined, and finally, financial rates come.

After the operations of the main criteria, the weighting of the sub-criteria of the main criteria proceeds in the same direction as the calculation of the main criteria. The comparison matrix created according to the answers of the expert opinions of the sub-criteria of the main criteria is as shown below.

Table 5  
*Weights of Sub Criteria*

Sub Criteria	Weights
Current Rate	0.16
Acid-Test Rate	0.35
Cash Rate	0.42
Leverage Ratio	0.2
Financing Rate	0.12
Debt/Equity	0.24
Tangible Assets/Equity	0.24
Equity/Total Foreign Resources	0.21
Financial Rantability	0.16
Gross Profit	0.33
Net Profit	0.47
Asset Profitability	0.04

### *Step3: Obtaining Financial Performance Ranking with GRA*

The criteria weights obtained with the FAHP method ranked on the airline companies by applying the GRA method.

In practice, the analysis was made for each criterion with the data obtained from the airlines' income statement for the period 2012-2018.<sup>1</sup> Here, the steps of the analysis carried out with the 2018 data in detail will be shown. The decision matrix was created as the first step of the GRA method for 2018. The decision matrix of the criteria is shown with the help of Table 6:

Table 6  
*GRA Decision Matrix*

	CR	ATR	CRA	LR	FR	DE	TA	ETF	FRA	GP	NP	AP
THY	0.87	0.83	0.42	0.72	0.4	2.48	2.34	0.4	0.13	0.19	0.06	0.03
Lufthansa	0.24	0.23	0.18	0.46	0.61	1.63	0.85	0.61	0.27	0.19	0.09	0.05
British	0.68	0.65	0.39	0.63	0.56	1.77	1.09	0.56	0.33	0.21	0.19	0.08
Air France	0.74	0.69	0.46	0.9	0.09	7.3	3.8	0.09	0.12	0.09	0.07	0.06
Ryanair	0.5	0.46	0.32	0.62	0.56	1.76	1.81	0.56	0.42	0.29	0.24	0.11

After the decision matrix is created, the reference series should be created as a second step under the maximum and minimum levels according to the criteria levels determined in the GRA form. The creation of the reference series is shown in Table

<sup>1</sup> Turkish Airlines Annual Report 2012-2018.  
Air France KLM Annual Report 2012-2018.  
Lufthansa Annual Report 2012-2018.  
British Airways Annual Report 2012-2018.  
Ryanair Annual Report 2012-2018.

7. After determining the reference series created on the criteria whose maximum and minimum levels are determined, the normalization process should be performed on the criteria. The normalized matrix is shown below in Table 8. In the normalization process in the findings obtained from the criteria, an absolute value table was created on the criteria data in the next step. The absolute value table is given below with the help of Table 9.

Table 7  
*Reference Series*

	CR	ATR	CRA	LR	FR	DE	TA	ETF	FRA	GP	NP	AP
REFERENCE	0.87	0.83	0.46	0.9	0.61	7.3	3.8	0.61	0.42	0.29	0.24	0.11
THY	0.87	0.83	0.42	0.72	0.4	2.48	2.34	0.4	0.13	0.19	0.06	0.03
Lufthansa	0.24	0.23	0.18	0.46	0.61	1.63	0.85	0.61	0.27	0.19	0.09	0.05
British	0.68	0.65	0.39	0.63	0.56	1.77	1.09	0.56	0.33	0.21	0.19	0.08
Air France	0.74	0.69	0.46	0.9	0.09	7.3	3.8	0.09	0.12	0.09	0.07	0.06
Ryanair	0.5	0.46	0.32	0.62	0.56	1.76	1.81	0.56	0.42	0.29	0.24	0.11

Table 8  
*Normalized Matrix*

	CO	ATO	NO	KO	FO	BÖ	MDV	ÖT	MR	BKM	NKM	AK
REFERENCE	1	1	1	1	1	1	1	1	1	1	1	1
THY	1	1	0.8	0.5	0.5	1	0.50	0.5	0.03	0.5	0	0
Lufthansa	0.2	0	0	0	1	0.4	0	1	0.5	0.5	0.16	0.2
British	0.5	0.7	0.7	0.3	0.9	0.5	0.08	0.9	0.7	0.6	0.72	0.6
Air France	0.6	0.76	1	1	0	0.3	1	0	0	0	0.05	0.3
Ryanair	0.9	0.38	0.5	0.3	0.8	0.9	0.34	0.9	1	1	1	1

Table 9  
*Absolute Values*

	CO	ATO	NO	KO	FO	BÖ	MDV	ÖT	MR	BKM	NKM	AK
THY	0.14	0	0.14	0.49	0.40	0	0.49	0.40	0.97	0.5	1	1
Lufthansa	0.73	1	1	1	0	0.55	1	0	0.5	0.5	0.83	0.75
British	0.46	0.3	0.25	0.66	0.04	0.48	0.91	0.09	0.3	0.4	0.28	0.35
Air France	0.38	0.23	0	0	1	0.31	0	1	1	1	0.94	0.65
Ryanair	0.63	0.66	0.5	0.63	0.09	0.02	0.67	0.09	0	0	0	0

In following the absolute value table, the GRA matrix will be created. One of the issues to be considered while creating the grey relational matrix is to obtain the most significant change value in the array and the smallest change value in the array and use it by finding the necessary calculations on these values (Kökçam et al., 2018). The GRA matrix is given in Table 10.

Table 10  
*GRA Matrix*

	CO	ATO	NO	KO	FO	BÖ	MDV	ÖT	MR	BKM	NKM	AK
THY	1	1	0.7	0.5	0.1	1	0.50	0.5	0.9	0.5	0.33	0.3
Lufthansa	0.4	0.33	0.3	0.3	1	0.6	0.33	1	0.5	0.5	0.3	0.4
British	0.6	0.65	0.7	0.8	0.3	0.5	0.39	0.8	0.6	0.56	0.6	0.5
Air France	0.6	0.68	1	1	0.3	0.3	1	0.3	0.3	0.3	0.38	0.4
Ryanair	0.5	0.4	0.5	0.4	0.8	0.9	0.4	0.8	1	1	1	1

In the step after the grey relational analysis matrix, calculating the grey relational degrees and performance ranks on the data of the airline companies were created. The calculated values are shown in Table 11.

Table 11  
*Grey Relational Degrees*

	CO	ATO	NO	KO	FO	BÖ	MDV	ÖT	MR	BKM	NKM	AK	Sıra
THY	1	1	0.7	0.5	0.5	1	0.52	0.5	0.3	0.5	0.33	0.3	3
Lufthansa	0.6	0.3	0.3	0.3	1	0.6	0.33	1	0.5	0.5	0.37	0.4	5
British	0.6	0.5	0.7	0.4	0.7	0.5	0.34	0.7	0.2	0.5	0.62	0.4	2
Air France	0.6	0.8	1	1	0.3	0.2	1	0.3	0.3	0.33	0.36	0.4	4
Ryanair	0.5	0.4	0.5	0.4	0.8	0.9	0.45	0.8	1	1	1	1	1

According to expert opinions, the most important main criterion among the three main criteria is Liquidity Ratios, Financial Ratios and Profitability Ratios. Therefore, it is concluded that the sub-criteria weights of liquidity ratios are more effective when compared to the other sub-criteria. Within this framework, there were differences in the order created by the help of the previous Table and the multiplication of the weights.

In following the determination of the grey relational grades, the last step of the GRA method is passed, and the new order obtained using the determined weights is shown with the help of Table 12.

Table 12  
*GRA Results*

Wi	CO	ATO	NO	KO	FO	BÖ	MDV	ÖT	MR	BKM	NKM	AK	
	0.13	0.26	0.32	0.03	0.02	0.03	0.03	0.03	0.02	0.05	0.07	0.01	
THY	1	1	0.7	0.5	0.5	1	0.50	0.5	0.3	0.5	0.33	0.3	1
Lufthansa	0.4	0.33	0.3	0.3	1	0.4	0.33	1	0.5	0.5	0.37	0.4	5
British	0.6	0.62	0.6	0.4	0.7	0.5	0.35	0.8	0.6	0.55	0.64	0.5	3
Air France	0.2	0.68	1	1	0.3	0.2	1	0.3	0.3	0.33	0.34	0.4	2
Ryanair	0.1	0.44	0.5	0.4	0.3	0.9	0.42	0.8	1	1	1	1	4

When looking at the ranking in the 2018 period, THY has been determined as the best financial performance. Air France, British Airways, Ryanair and Lufthansa are respectively. The analyzes have been carried out for all other periods. Financial performance rankings determined by GRA method between 2012-2018 are shown with the help of Table 13:

Table 13  
*Financial Performance Ranking Between 2012-2018 Periods*

	2012	2013	2014	2015	2016	2017	2018
THY	4	4	1	2	1	1	1
AIR FRANCE	3	1	4	3	3	3	2
LUFTHANSA	5	5	5	5	5	5	5
BRITISH	1	2	3	4	2	2	3
RYANAIR	2	3	2	1	4	4	4

The best financial performance company in 2012 was determined as British Airways. Financial performance evaluation was followed by Ryanair, Air France KLM, THY and Lufthansa, respectively. In 2013, the company with the best financial performance was determined as Air France KLM, while British Airways, Ryanair, THY and Lufthansa were ranked respectively. The financial performance ranking for 2014 was determined as THY, Ryanair, British Airways, Air France KLM and Lufthansa. In 2015, the company with the best financial performance was determined as Ryanair, followed by THY, Air France KLM, British Airways, and Lufthansa. According to the analysis results, the financial performance ranking for the 2016-2017 period was formed in the same order. At the same time, the best financial performance belongs to THY, British Airways, Air France KLM, Ryanair and Lufthansa, respectively. The company with the best financial performance was determined as THY in 2018, followed by Air France KLM, British Airways, Ryanair, and Lufthansa.

**Step 4: Statistical Analysis**

The Spearman correlation method was used to analyze the differences between the financial performance ranking values obtained by the GRA method by years (Uygurtürk et al., 2012).

Spearman correlation is the nonparametric type of the coefficient of Pearson correlation. In this method, the data of the variables are sorted first and then the result is obtained by using the Pearson equation. The Spearman correlation is a different feature from the Pearson correlation; while the Spearman correlation has a monotonic relationship, Pearson correlation has a linear relationship.

Spearman correlation method is presented with the help of equation 19:

$$\rho = 1 - \frac{6 \sum d_i^2}{N(N^2 - 1)} \tag{19}$$

*P*: Spearman correlation coefficient

$d_2^1$  = The square of the difference between the order of the two variables

*N* = Expresses the number of main mass units.

The results of the Spearman correlation test applied to the financial ranking determined by the GRA are presented below with the help of Table 14:

Table 14  
Spearman Correlation Test Results

	2012	2013	2014	2015	2016	2017	2018
2012	1,000	,700	,300	,300	,300	,300	,100
2013	,700	1,000	,000	,200	,300	,300	,400
2014	,300	,000	1,000	,800	,700	,700	,600
2015	,300	,200	,800	1,000	,300	,300	,400
2016	,300	,300	,700	,300	1,000	1,000**	,900*
2017	,300	,300	,700	,300	1,000**	1,000	,900*
2018	,100	,400	,600	,400	,900*	,900*	1,000

\* Correlation is significant at 0.05 significance level (2-way).

\*\* Correlation is significant at the 0.01 significance level (2-way).

When the Spearman correlation analysis results are analyzed, it was seen that the financial performance ranking of the airline companies has a positive level of 1% between 2016-2017 and a positive relationship of 5% in the 2018 financial performance ranking.

For the Spearman correlation results of 2017, a positive correlation of 1% was found with the 2016 financial ranking assessment and a positive relationship of 5% with 2018 ranking values.

According to the 2018 analysis results, it is concluded that there is a positive correlation between 2016-2017 financial performance ranking evaluations.

#### **Step 5: Examination of Flight Point Number and Financial Performance Ranking**

After testing the statistical relationship between the financial rankings that have changed over the years with the Spearman correlation test, the relationship between the number of airline companies' flight destinations and the ranking of financial performance was examined.

Airline companies operating in the aviation industry should increase the number of flight destinations to increase the market share in question, increase profitability and increase the customer portfolio. Airline companies should make a strategic decision to determine the new flight destination, considering their market share.

Increases in flight points are expected to contribute to airlines. With the increase in the number of flight points in airlines, more customers will gain while costs will increase. In the study, the similarity of the number of airline companies' flight points with the determined financial performance ranking was investigated.

While the financial performance rankings of the existing airlines are evaluated within the periods discussed in the study, the same ranking results have been observed in the last three periods. It was determined that THY was better than other airlines in terms of financial performance in the period in question. This was followed by Air France KLM, British Airways, Ryanair and Lufthansa, respectively.

Flight point data of the airlines used in the research are shown below with the help of Table 15.

Kendall’s Tau correlation test is used to determine the relationship between the flight point and financial performance. Kendall’s Tau is a nonparametric test such as the Spearman correlation test, which is more effective in small samples. Kendall’s Tau test is applied to data from all airlines for 2018. Here, while listing the financial performance ranking determined by the GRA method, the number of flight destinations of 2018 for all these airline companies is the number of flight points to be processed.

Table 15  
Number of Airlines’ Flight Points<sup>2</sup>

Airline Companies	Number of Countries Flying	Number of Flight Points
THY	122	304
Air France	93	175
Lufthansa	78	209
British Airways	70	170
Ryanair	40	223

By making correlation analysis, null and alternative hypotheses are determined before the test and analysis process begins.

The null and alternative hypothesis to be tested in this analysis is as follows:

$H_0$ : There is no relationship between financial performance and flight number numbers.

$H_1$ : There is a relationship between financial performance and flight number numbers.

Kendall’s Tau correlation test results for financial performance rankings and flight point numbers are presented below with the help of Table 15.

Table 15  
Kendall’s Tau Correlation Test

	Financial Performance	Flight Point
Financial Performance	1,000	,200
Sig. (2-way)		,624
Flight Point	,200	1,000
Sig. (2-way)	,624	

When Kendall’s Tau correlation test results are analyzed, we accept the  $H_0$  hypothesis that the “p-value” (Sig.) is more than 5%. There is no significant relationship between the two variables for selection. In the correlation tests, the coefficient of the

2 Turkish Airlines Annual Report 2018  
Air France KLM Annual Report 2018  
Lufthansa Annual Report 2018.  
British Airways Annual Report 2018.  
Ryanair Annual Report 2018.



coefficient is determined according to the relationship between the two variables. Kendall's Tau correlation coefficient between analyzes was due to a positive (+) -related relationship between the two variables. It can be said that there should be a positive relationship and a correct relationship between these two variables. Even if the expansion of the customer portfolio is ensured thanks to new flight destinations, new flight destinations require huge financial obligations for airlines.

### **Conclusion**

In this study, during the period 2012-2018, the financial performance of airline companies operating in four countries and Turkey has been analyzed. The airline companies subject to the analysis are THY, Lufthansa, British Airways, Air France KLM and Ryanair companies.

The financial performance analysis made in the research consists of three stages. At the first stage, financial performance criteria were determined. Data on these criteria, including the period 2012-2018, were obtained from the income statements and then expert opinions were taken to determine the weight of the criteria. In the second stage, it is aimed to determine the weight of the criteria evaluated by expert opinions using the FAHP method. Considering expert opinions, it is concluded that liquidity ratios are superior. In the third and last stage, the financial performance ranking was determined using the GRA method. The change of the financial performance ranking by years was statistically tested and interpreted. In addition, the existence of the relationship between the performance sequences obtained and the number of flight points of the enterprises were statistically analyzed.

British Airways airline company had the best financial performance in 2012. Ryanair, Air France KLM, THY and Lufthansa followed respectively. In the 2013 period, it was determined that the data observed in 2012 changed. Air France KLM, which was third in 2012, was determined to have the best financial performance in 2013. It is concluded that the 2013 financial performance ranking is British Airways, Ryanair, THY and Lufthansa. In 2014; THY had the best financial performance. It is followed by Ryanair, British Airways, Air France KLM and Lufthansa, respectively. Ryanair, which has favored low-cost flight policy since its establishment and, was in second place in the previous period, showed the best financial performance in 2015 and THY, Air France, British Airways and Lufthansa followed respectively. When looking at the results, it is seen that all of the airline companies were fixed in the same row in the 2016-2017 period. When the ranking in the current period is analyzed, THY had the best financial performance, and it is followed by British Airways, Air France KLM, Ryanair and Lufthansa, respectively. When the 2018 financial performance ranking is analyzed, the performance ranking is as THY, Air France KLM, British Airways, Ryanair, and Lufthansa.

When the number of flight destinations belonging to airline companies is examined, it is seen that THY operation had the most flight points in 2018. THY was followed by Air France, Lufthansa, British Airways and Ryanair. Ranking in flight point numbers and financial performance ranking is not similar. Kendall's Tau correlation test was performed to statistically evaluate the relationship between the number of flight points and their financial performance. After the analysis, it was concluded that there was no statistically significant relationship between the number of flight points and financial performance ranking. The number of flight destinations and businesses' financial performance differ according to all years and all airline companies. The most obvious of these differences is observed as Lufthansa airline company. While Lufthansa is ranked third in the airline flight point rankings, it is ranked fifth in the financial performance evaluation rankings covering the 2012-2018 period. When the ticket prices in these periods are analyzed, it is seen that Lufthansa Airlines has the lowest income. Despite the large number of Lufthansa Airlines flight destinations, it has got a low financial performance. This situation could be based on customer dissatisfaction, high ticket prices, etc.

In future studies, financial performance evaluation can be done by using different multi-criteria decision-making methods and by increasing the number of enterprises and analysis periods. In addition, the financial performance of companies operating in other sectors can be measured by the methodology applied in this study.

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**Finansal Destek:** Yazarlar bu çalışma için finansal destek almadığını beyan etmiştir.

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