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FINANCIAL EFFICIENCY ANALYSIS THE MALMQUIST TFP METHOD: AN APPLICATION ON STAR ALLIANCE MEMBER AIRLINES

Malmquist TFP Yöntemiyle Finansal Etkinlik Analizi: Star Alliance Üyesi Havayolu İşletmelerinde Bir Uygulama

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Abstract

The purpose of this study is to analyze the financial efficiency of 15 airlines that are members of the Star Alliance which is considered the largest international strategic airline network for the period 2016-2019 using the Malmquist Total Factor Efficiency method. In addition, other purposes include the comparison of the change in technical efficiency (TE), technological change (TD) and total factor productivity (TFP) values of airlines that are members of the Star Alliance As a result of the analysis, it was found that the average technological change and total factor productivity values of the airlines in question increased in the period 2016-2017, and the average technical efficiency values decreased. On the other hand, in the period 2017-2018, the opposite situation was observed. In the period 2018-2019, technical efficiency, technological change and total factor productivity values decreased. It was found that the technical efficiency values of the Air Canada and Turkish Airlines increased during the entire period, while the average technical efficiency, technological change and total factor

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productivity values of the Air New Zealand, Asiana Airlines, Avianca, Lufthansa and Thai Airways decreased.

Keywords: Airline strategic alliances, efficiency, productivity, malmquist total factor productivity, financial performance.

JEL Kodları: L93; M19.

Öz

Bu çalışmanın amacı, Dünyanın ilk global havacılık birliği olan Star Alliance'ın üyesi olan 15 havayolu işletmesinin 2016-2019 dönemine ait finansal etkinlik ve verimlilik analizinin Malmquist Toplam Faktör Verimliliği yöntemi ile incelenmesidir. Bunun yanı sıra Star Alliance grubuna üye olan havayolu işletmelerinin teknik etkinlikteki değişim (TE), Teknolojik değişim (TD) ve toplam faktör verimlilik (TFV) değerlerinin karşılaştırılmasıdır. Analiz sonucunda söz konusu havayolu işletmelerinin 2016-2017 döneminde ortalama TD ve TFV değerlerinin arttığı, ortalama TE değerlerinin ise azaldığı tespit edilmiştir. 2017-2018 döneminde ise tam tersi bir durumun yaşandığı görülmüştür. 2018-2019 döneminde ilgili havayolu işletmelerinin ortalama TED, TD ve TFV değerlerinde azalışların olduğu tespit edilmiştir. Air Canada ve Turkish Airlines işletmelerinin tüm dönem boyunca teknik etkinlik ve verimlilik değerlerinin arttığı tespit edilirken Air New Zealand, Asiana Airlines, Avianca, Lufthansa ve Thai Airways işletmelerinin ortalama TED, TD ve TFV değerlerinin azaldığı tespit edilmiştir.

Anahtar Kelimeler: Havayolu stratejik işbirlikleri, etkinlik, verimlilik, malmquist toplam faktör verimliliği. finansal perfomans.

JEL Codes: L93; M19.

1. Introduction

The air transport industry is a global industry in terms of the importance and scope of the activities carried out, where advanced technologies are used, high costs exist, and competition is intense. From this perspective, airlines working in this industry with has a dynamic structure have to develop various policies and strategies to gain a sustainable competitive advantage, grow, improve quality, control costs, and keep pace with technological developments. One of the most important strategies airline strategic alliances (Kleyman and Seristö, 2001: 303).

There are various reasons why airlines become members of strategic alliances. These reasons include increasing service quality, reducing costs, expanding the flight network, reaching markets, obtaining market leadership and increasing competitiveness (Oum, et al., 2000: 41).

Airlines can carry out a large number of commercial activities thanks to strategic alliances. These activities are codesharing, frequent flyer programs, joint ventures, and pool agreements. Airlines reduce their costs, expand their flight destinations, overcome restrictive laws and regulations, increase customer satisfaction through these activities (Goetz and Shapiro, 2012: 737).

Today, there are three global strategic airline alliances in the industry: Star Alliance, SkyTeam and Oneworld. Current information on strategic airline alliances is shown in Table 1.

Table 1: General Situation of Major Airline Alliances (2020)

	Star Alliance	**SkyTeam**	**OneWorld**
Number of Members	26	19	14
Year of Foundation	1997	2000	1999
Annual Passenger Number (Million)	762	676	548
FleetSize	5033	3054	3553
Number of Flight Per Day	19100	15445	13100
Number of Employees	443703	392155	493650
Number of Countries Flied	195	170	161

Reference: www.staralliance.com, www. oneworld.com, www.skyteam.com

There are many benefits that strategic alliances provide to passengers as well as to airlines. These benefits are; access to a better flight network, seamless travel, benefiting from the facilities provided by other member airlines to their passengers at the airport, discounts on ticket prices and frequent flyer programs (Binatlı, 2019: 217).

Figure 1: Market Shares of Strategic Airline Alliances

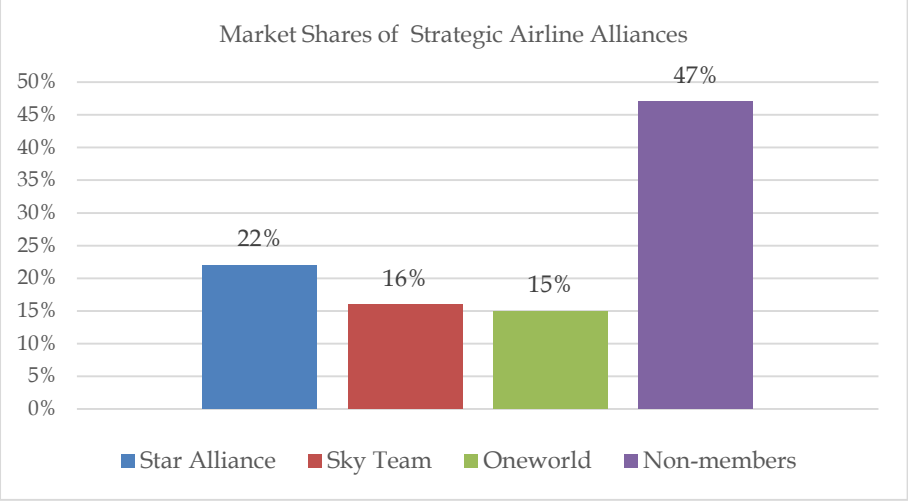

Figure 1 shows the market shares of airlines which are members of Star Alliance, SkyTeam and Oneworld, and airlines that are not members of any airline cooperation. Accordingly, the total market share of member airlines stands at 53%. Star Alliance, with a market share of 22%, is the largest strategic alliance.

This study aims to analyze the financial efficiency and productivity analysis of 15 airlines belonging to the Star Alliance for the period 2016-2019 using the MTFP (Malmquist Total Factor Productivity) method. In addition, the other aim is to compare the technical efficiency changes and technological changes in question.

Later in the study, the literature is mentioned, and detailed information is given about the MTFP method. In the next section, the decision-making units included in the analysis and the input and output variables are explained. Then the application process is described. Finally, the last section, the findings are evaluated.

2. Literature Review

In the literature, there are various studies on which the operational and financial performance of airports and airlines (Barros and Peypoch, 2009; Öncü et al., 2013; Tsui et al., 2014; Abbott, 2015; Asker, 2017; Sakthidharan and Sivaraman, 2018; Derici and Uygur, 2019; Kuljanin et al., 2019; Huynh, 2020; Fragoudaki and Giokas, 2020;

Fernandez et al., 2021; Zarraga et al., 2021; Güner and Cebeci, 2021; Pereira and Mello, 2021).

Various studies examining the performances of carriers using financial indicators. As an example, Asker and Aydın (2021) compared the financial and operational efficiencies of airlines operating in different parts of the world and implemented different business models for the 2013-2018 period. He suggested that traditional airlines were more efficient from an operational point of view, and low-cost airlines were more efficient from a financial point of view. Öncü et al. (2013) analyzed the financial efficiency of 7 airlines operating in Turkey for the year 2010 using data envelopment analysis. The input variables were short-term liabilities/total assets, current ratio, shareholders' equity/assets, and the cost of goods sold. The output variables included asset profitability and net profit margin. The results showed that 3 out of 7 airlines were efficient. Huang (2021) analysed the financial performance of 22 Asia-Pacific carriers for the 2016–2019 period the Malmquist productivity index and the conditional value -at risk measure. The results revealed that only three traditional carriers could sustain their improved financial efficiency for the 2016-2019 period.

Pires and Fernandes (2012) examined the financial performance of 42 carriers in 2001 and 2002 with data envelopment analysis and Malmquist total factor productivity index in their study examining the effect of the terrorist attack in the USA on September 11, 2001, on the financial performance of airlines. As a result of the research, it was determined that airlines performed better financially in 2002 than in 2001. In another study, Wang et al. (2017) examined the financial performance of 49 airlines operating in various regions of the world for the period 2008-2013 through data envelopment analysis. As a result of the research, it was determined that airlines performed worse in the 2008-2009 period compared to other periods. Barros and Couto (2013) used the Luenberger productivity tool to examine productivity fluctuations of European carriers, putting together financial and operational variables from 2000 to 2011. For comparative aims, the Malmquist index was estimated. According to the study results, most European carriers, apart from Finnair, Austrian Airlines, Virgin Atlantic, Easy Jet and Ryanair's productivity did not grow between

2001 and 2011. Therefore, except for the external environment's effect, the managerial reasons for technical efficiency could be due to differences in the strategies employed by the different carriers the networks served.

In addition to the financial performance of airlines, there are studies focusing only on operational performance in the literature. For example, Öz and Köksal (2016) compared the efficiency of Star Alliance members for the years 2013 and 2014 using data envelopment analysis. The inputs in the study are the number of aircraft, the number of employees, the number of airports served, and the number of countries served. The outputs are the annual number of passengers, the number of daily flights, revenue passenger kilometer and revenue from sales. According to the results, there are differences in the efficiency of airlines and some airlines waste resources. Yu et al. (2017) evaluated the efficiency of 30 airlines between the years 2009 and 2012. The inputs are personnel expenses, number of leased aircrafts, fuel expenses and available seat kilometers, while the output is revenue passenger kilometers. According to the results of the study, total operational efficiency tends to decrease on an annual basis.

Pereira and Mello (2021) evaluated the operational efficiency of Brazilian airlines with DEA considering the Covid-19 pandemic. According to the result of the study, airlines owning different types of aircraft in their fleet have better efficiency during crises such as the pandemic. Kiracı and Asker (2019) examined the efficiency of 45 airlines operating in different parts of the world between the years 2010 and 2016 with data envelopment analysis. In addition, they established the factors determining the efficiency through the Tobit regression method. According to the findings of the study, fourteen airlines were efficient in all periods, while ten airlines were efficient in some years. According to the Tobit analysis result, it has been revealed that an increase in the load factor, the total number of passengers carried and total income variables leads to an efficiency increase. Derici and Uygur (2019) measured the efficiency of Turkish Airlines and Pegasus using the DEA method between the years 2012 and 2015. According to the results of the analysis, Pegasus Airlines was more efficient than Turkish Airlines.

3. Malmquist Total Factor Productivity Index

The Malmquist Index is a two-way index which measures productivity growth between two units in one period or one unit in two different periods. Stan Malmquist, Swedish economist, introduced the Malmquist Index as the standard of living in 1953, and Christensen and Diewert applied it to production theory in 1982. In 1989, the Malmquist Index was calculated by data envelopment analysis, and the Index was broken down into two factors: technology and efficiency in 1994 (Mostoli et. al., 2019: 12).

The mathematical expression of the distance function of the Malmquist Total factor productivity change index during the comparison of the t period, which is accepted as a reference, with the t+1 period is given below (Fare et.al., 1994:70):

$$m(y_{t+1}, x_{t+1}, y_t, x_t) = \left[\frac{d^t(x_{t+1}, y_{t+1})}{d^t(x_t, y_t)} \times \frac{d^{t+1}(x_{t+1}, y_{t+1})}{d^{t+1}(x_t, y_t)} \right]^{1/2} \quad (1)$$

The value x_t expressed in the formula represents the input vector of the t period, x_{t+1} value represents the input vector of the t+1 period, y_t value indicates output vector of t period, y_{t+1} value shows the output vector of the t+1 period. The equation expressed above can also be expressed as follows.

$$m(y_{t+1}, x_{t+1}, y_t, x_t) = \frac{d^{t+1}(x_{t+1}, y_{t+1})}{d^t(x_t, y_t)} \left[\frac{d^t(x_{t+1}, y_{t+1})}{d^{t+1}(x_{t+1}, y_{t+1})} \times \frac{d^t(x_t, y_t)}{d^{t+1}(x_t, y_t)} \right]^{1/2} \quad (2)$$

The index can be divided into technical efficiency change and technological change components and shown as follows (Fare et.al., 1994:71):

$$\text{TED} = \frac{d^{t+1}(x_{t+1}, y_{t+1})}{d^t(x_t, y_t)} \quad (3)$$

$$\text{TD} = \left[\frac{d^t(x_{t+1}, y_{t+1})}{d^{t+1}(x_{t+1}, y_{t+1})} \times \frac{d^t(x_t, y_t)}{d^{t+1}(x_t, y_t)} \right]^{1/2} \quad (4)$$

The change in technical efficiency is found by multiplying the change in scale efficiency by the change in pure technical efficiency.

While the change value in scale efficiency measures whether the decision-making unit operates at an appropriate scale, the change value in pure technical efficiency measures the managerial efficiency of the decision-making units (Ar et. al., 2014:150).

A value of less than 1 in Malmquist total factor productivity change means that the efficiency and productivity value decrease. A value of more than one means that the efficiency and productivity value increase (Coelli, 1996:28).

4. Emprical Findings

In this study, the efficiency and productivity analysis of 15 Star Alliance member airlines is examined using the MTFP method between the years 2016 and 2019. However, the technical efficiency change values and technological change values of the airlines in question were compared. The financial data of the airlines were obtained from the Thomson Reuters Data Stream database. Efficiency analysis of airlines was carried out through DEAP 2.1 software program.

The financial data included in the study was selected among the financial indicators that best reflect the financial position of airlines. For example, total capital, which best reflects the financial strength of airlines, was considered as an input variable in the study. This variable shows the total amount of capital that the partners of the airlines have put forward for the company. The other input variable, total debt, reflects the total amount of foreign resources used by airlines to finance their activities. Another input variable, total operating expense, consists of various expenses incurred by airlines to continue their operations. These include fuel and personnel expenses.

The net profit included in the study as an output variable shows the amount of net profit that airlines receive at the end of each period. The other output variable, total income, refers to the total amount of revenue generated by airlines as a result of ticket sales. Another output variable, total operating income, is the income obtained as a result of subtracting flight costs from the total amount of income received by airlines as a result of flight operations.

The financial variables were selected by taking into account similar studies in the literature (Asker, 2021b; Aydın and Kaya Aydın, 2021; Kiracı and Asker, 2021; Asker and Aydın 2021; Battal, 2020; Bakır et al., 2020; Kiracı, 2019; Dayı and Esmer, 2019; Kottas and Madas 2018; Wang et al., 2017; Min and Joo, 2016; Teker et al., 2016; Öncü et al., 2013; Ömürbek and Kınay, 2013; Mahesh and Prasad, 2012).

In order to make the analysis results more reliable, all the data related to the financial variables used in the study were calculated in dollars. The input and output variables included in the analysis are shown in Table 2.

Table 2: Variables Used in the Analysis of Efficiency and Productivity

Input Variables	**Explanation**
Total Capital	The total amount of capital owned by airlines
Total Debt	The total amount of debt
Total Operating Expenses	The total amount of operating expenses spent by airline companies
Output Variables	Explanation
Net Profit	The amount of net profit
Total Income	The total amount of Income generated by airlines
Total Operating Income	The total amount of operating income generated by airlines

The success of productivity and efficiency analysis depends on the harmonisation of input and output variables. Therefore, the inputs and output are included in the analysis, the correlation table should be examined, and the variables displaying high correlation should be removed from the analysis. In this direction, correlation analysis was applied to the financial variables used in the study. The descriptive statistics and correlation analysis are given in Table 3-4.

Table 3: Descriptive Statistics of Input-Output Variables

	Total Capital	Total Dept	Total Operating Expense	Net Profit	Total Income	Total Operating Income
Mean	9358	1173	1153	6050	1239	8908
Median	5024	7773	6341	2538	5929	4165
Maximum	2973	4108	4014	3009	4325	4976
Minimum	3075	4500	1080	-9330	1129	-150
Std. Dev.	7854	1028	1108	7968	1203	1117
Skewness	0.7693	1.1572	1.4874	1.319	1.4692	2.0277
Kurtosis	2.3613	3.3475	4.1127	4.2609	4.0116	6.8381
Jarque-Bera	6.9391	13.694	25.2195	21.396	24.146	77.9479
Probability	0.0311	0.0010	0.0000	0.0002	0.0001	0.0000
Sum	5.62E	7.04E	6.92E	3630	7.44E	53449
Sum Sq. Dev.	3.64E	6.24E	7.25E+1	3.75E+1	8.54E+1	7.36E+1
Observations	60	60	60	60	60	60

Table 4: Correlation Analysis of Input-Output Variables

	Total Capital	Total Dept	Total Operating Expense	Net Profit	Total Income	Total Operating Income
Total Capital	1	0.7962	0.7070	0.6375	0.7140	0.6550
Total Dept	0.7962	1	0.8057	0.7662	0.8090	0.7434
Total Operating Expense	0.7070	0.8057	1	0.8090	0.7984	0.7236
Net Profit	0.6375	0.7662	0.8090	1	0.8014	0.7871
Total Income	0.7140	0.8090	0.7984	0.8014	1	0.7533
Total Operating Income	0.6550	0.7434	0.7236	0.7871	0.7533	1

First, technical efficiency change (TEC) and technological change (TC) were compared, and then the total factor productivity (TFP) of member airlines were compared by the MTFP method. While values greater than 1 show that efficiency increases, values less than 1 indicate that efficiency decreases. The TEC, TC, and TFP values of member airlines are shown in Tables 5-6.

Table 5: Average TEC, TC and TFP Values of Member of Star Alliance Group (2016-2019)

Airlines	TEC	TC	TFP
AEGEAN AIRLINES	1.000	0.949	0.949
AIR CANADA	1.006	1.001	1.007
AIR CHINA	0.969	1.005	0.974
AIR NEW ZEALAND	0.978	0.982	0.960
ALL NIPPON AIRWAYS	1.014	0.976	0.990
ASIANA AIRLINES	0.970	0.984	0.955
AVIANCA	0.990	0.998	0.988
COPA AIRLINES	1.000	1.000	1.000
EVA AIRWAYS	1.006	0.995	1.001
LUFTHANSA	0.982	0.968	0.951
SAS	1.012	0.953	0.964
SINGAPORE AIRLINES	0.984	1.005	0.988
THAI AIRWAYS	0.978	0.994	0.972
TURKISH AIRLINES	1.023	1.009	1.032
UNITED CONTINENTAL	1.000	0.965	0.965
Average	0.994	0.985	0.979

According to Table 5, the average technical efficiency change value of the airlines that are members of the Star Alliance group decreased by about 0.6%, the average technological change value decreased by about 1.5%, and the average total factor productivity value decreased by about 2% in the period 2016-2019. Technical efficiency change is influenced by the general activities of the enterprise, while technological change is influenced by non-operational factors. In this respect, the airline companies in question were adversely affected by both internal and external factors in the relevant period. As a result of this situation, the average total factor productivity value of most of the airlines decreased.

Air Canada and Turkish Airlines increased their average technical efficiency change, technological change and total factor productivity values during the period in question. From this point of view, it can be said that these airlines were positively affected by internal and external factors during the relevant period.

Table 6: TEC, TC and TFP Values of Member of Star Alliance Group

	TEC			TC			TFP		
Airlines	2016-2017	2017-2018	2018-2019	2016-2017	2017-2018	2018-2019	2016-2017	2017-2018	2018-2019
AEGEAN AIRLINES	1.00	1.00	1.00	1.35	0.93	0.67	1.35	0.93	0.67
AIRCANADA	1.01	0.97	1.02	1.32	0.70	1.06	1.34	0.69	1.09
AIR CHINA	0.91	1.04	0.95	1.02	0.93	1.05	0.94	0.97	1.00
AIR NEW ZEALAND	0.97	1.03	0.93	0.98	0.94	1.02	0.95	0.96	0.95
ALL NIPPON AIRWAYS	0.98	1.06	1.00	1.02	0.94	0.95	1.00	1.09	0.95
ASIANA AIRLINES	1.03	0.99	0.89	0.97	0.98	0.99	1.00	0.97	0.89
AVIANCA	0.99	1.02	0.94	1.00	0.96	1.02	1.00	0.99	0.96
COPA AIRLINES	1.00	1.00	1.00	1.19	0.65	1.27	1.19	0.65	1.27
EVA AIRWAYS	1.01	1.02	0.98	0.99	0.97	1.01	1.00	0.99	0.99
LUFTHANSA	0.96	1.01	0.97	1.12	0.94	0.85	1.08	0.95	0.83
SAS	1.05	1.01	1.01	1.02	0.9	0.85	1.03	1.00	0.87
SINGAPORE AIRLINES	0.94	1.07	0.93	1.03	0.95	1.02	0.98	1.02	0.95
THAI AIRWAYS	1.01	0.97	0.95	0.99	0.97	1.01	1.00	0.95	0.96
TURKISH AIRLINES	1.10	1.08	0.89	1.02	0.9	1.06	1.12	1.02	0.95
UNITED CONTINENTAL	0.98	1.01	1.00	0.86	0.95	1.08	0.85	0.96	1.08
Average	0.96	1.22	0.96	1.05	0.91	0.99	1.05	0.93	0.95

Table 6 shows technical efficiency change, technological change and total factor productivity values of the airlines that are members of the Star Alliance group. Accordingly, average technical efficiency change value decreased by about 0.4% in the period 2016-2017, while it increased by about 5% in the period 2017-2018 and 2018-2019.

Airlines average technology change value increased by 2% in 2016-2017 and decreased by 8.5% in 2017-2018 and 6.5% in 2018-2019. Examining the average total factor productivity value of the airlines, it

decreased by around 3.5% in 2016-2017, by around 0.9% in 2017-2018 and by around 4.5% in 2018-2019. It is thought that the decrease in the average TFP value is due to the change in technical efficiency in the 2016-2017 period, and the decrease in the 2017-2018 and 2018-2019 periods is due to technological change. From this point of view, it can be said that both administrative and environmental influences caused the inefficiency during this period.

The technical efficiency change values of Aegean Airlines and Copa Airlines remained constant, while the value of Sas Airlines was constantly increasing. On the other hand was found that the total factor productivity values of Air Newzealand Airlines were constantly decreasing, while other airlines' values fluctuated.

5. Conclusion

The TEC, TC, and TFP values of airlines were calculated using the MTFP method. As a result average TEC values of the airlines in question decreased by 0.6%, the average TC values decreased by 1.5%, and the average TFP values decreased by 2.1%. Due to the decrease in the TEC and TC values, the TFP values also decreased. Considering that non-operating factors and managerial decisions influence TC and TEC values, the airlines in question are negatively affected by both managerial and non-operating factors. Accordingly, it can be said that the financial performance of the relevant airlines as of the said period is not good. Furthermore has been observed that these results obtained are compatible with the results of Asker's (a) (2021) study and are not compatible with the results of Öz and Köksal's (2016) and Min and Joo (2016)'s studies. It is believed that the main reason for this situation is owing to the fact that the relevant studies cover different periods and variables. As of the aforementioned period, only Air Canada and Turkish Airlines could increase their average TEC, TC and TFP values, while other airlines had fluctuations in their efficiency and productivity values.

When the efficiency and productivity change values of the member airlines were examined on a period-by-period basis, it was found that the average TEC value decreased by 0.4%, and the average TC and TFP values increased by approximately 5% in the 2016-2017 period. In the

2017-2018 period, the average TEC value increased by 2%, and average TC and TFP values decreased by 8.5% and 6.5%, respectively. In the 2018-2019 period, the average TEC, TC and TFP values decreased by 3.5%, 0.9%, and 4.5%, respectively. It can be said that the mentioned airlines were not efficient from a managerial point of view in the 2016-2017 period, they were negatively affected by external factors in the 2017-2018 period, and they were negatively affected by both internal and external factors in the 2018-2019 period. Although these results are taken into consideration in different periods and variables, they are compatible with the results of the studies of Kottas and Madas (2018) and Pires and Fernandes (2012).

This study, which analyzes the financial efficiency and productivity of member airlines, provides general information on the financial situation of airlines for investors, lenders, and airline managers.

There are some limitations of this study. The first limitation is that we obtained the data of only 15 out of 26 airlines that are members of the Star Alliance. Another limitation is that three input and three output variables were used.

In this study, only the financial performance of the airlines that are members of the Star Alliance was focused on. In future studies, other strategic alliances' financial, operational, and environmental performance might be examined through more variables.

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