The Determinants of Airline Operational Performance: An Empirical Study on Major World Airlines

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Havayolu İşletmelerinin Operasyonel Performansının Belirleyicileri: Dünyadaki Büyük Havayolu İşletmeleri Üzerinde Ampirik Bir Araştırma

Abstract

The air transport industry is a dynamic sector and operates in a dynamic environment. This situation leads to intense competition among airlines and, consequently, to a search for new methods to improve the operational performance. It is claimed that revealing the factors affecting the operational performance of airline companies might provide them with strategic advantages in such a competitive market. Therefore, this study attempts to fill a gap existant in the current literature by empirically examining the factors determining the operational performance of airline companies. The operational data for the period between 1990 and 2017 of 52 airlines, which control more than 90% of the global air passenger transport industry, were analyzed using panel data analysis. The results of the study show that the number of passengers carried, the load factor, the number of flights made by the airlines, the rate of use of the aircraft and the amount of cargo carried by the airlines significantly affect their operational performance.

Keywords	:	Operational Performance, Airlines, Panel Data Analysis.
JEL Classification Codes	:	C23, L25, L93.

Öz

Hava taşımacılığı endüstrisi dinamik bir endüstri olup bünyesinde gerçekleştirilen faaliyetler dinamik bir çevrede sürdürülmektedir. Bu durum havayolu işletmeleri arasında yoğun bir rekabete sebebiyet vermekte ve havayollarının operasyonel performansını geliştirmesine olanak sağlamakta ve onları yeni arayışlara yönlendirmektedir. Havayolu şirketlerinin operasyonel performansını etkileyen faktörlerin ortaya çıkarılmasının onlara stratejik avantajlar sağlayacağı iddia edilmektedir. Dolayısıyla bu araştırma, literatürde yer alan araştırmaların aksine havayolu işletmelerinin operasyonel performansını etkileyen faktörlere odaklanmaktadır. Bu çalışmanın amacı, havayolu şirketlerinin operasyonel performansını belirleyen faktörlerin ampirik olarak incelenmesidir. Küresel hava yolcu taşımacılığı endüstrisinin %90'ından fazlasını kontrol eden 52 havayolu işletmesinin 1990 ve 2017 yılları arasındaki operasyonel verileri panel veri analizi kullanılarak analiz edilmiştir. Araştırmanın sonuçları, taşınan yolcu sayısının, doluluk oranının, havayollarının yaptığı uçuş sayısının, uçağın kullanım oranının ve taşınan kargo miktarının operasyonel performansı anlamlı olarak etkilediğini göstermektedir.

Anahtar Sözcükler	:	Operasyonel Performans, Havayolları, Panel Veri Analizi.

1. Introduction

In order to monitor the operational, safety and financial dimensions of performance, the importance of performance measurements has long been known (Francis et al., 2005: 207). Performance measurement is critical for every enterprise involved in air transportation. With these measurements, companies are able to establish an understanding of their internal systems which then informs its understanding of the competition. A comprehensive performance measurement is also an essential tool in achieving the goals of the enterprise. Another role played by performance measurement is that it relays information to the organization concerning inefficient processes (Saeedi et al., 2018) giving the organization an opportunity to find the means to improve the ineffective aspects into systems that can benefit the organization. With regards to management, there is also the fact that what cannot be measured cannot be managed (Emil et al., 2005: 9). This makes performance measurement in an enterprise a vital aspect of its sustainability.

The performance of the airlines in the air transport system has undoubtedly been influenced to a great extent by the liberalization movements that started in the United States (USA) in 1978 (Graham et al., 1983; Barbot et al., 2008; Joo & Fowler, 2012). Following the USA, regulations were made to liberalize the air transport market in Europe in 1988 (Doganis, 2006: 46). In the following years, it is evident that regulations have been made for the liberalization of the air transport market in many countries around the world. The volumetric increase that came with the winds of liberalization also led to an increase in the number of airlines, number of passengers and the amount of production, factors which have significantly affected the operational and financial performance as well as the safety performance of the airlines.

There are many studies in the literature on the measurement of financial (Behn & Riley, 1999) operational (Barros & Peyboch, 2009; Schefczyk, 1993) and safety (Rose, 1990; Liou et al., 2007) performances of airlines. Some of the studies evaluated the performance of the airlines both financially and operationally (Feng & Wang, 2000; Scheraga, 2004; Barbot et al., 2008). Other studies like that by Dinçer et al (2017), however, considered performance in its entirety. The vast majority of these studies evaluated performance on the basis of efficiency with the most widely applied methodologies being Data Envelopment Analysis (Chiou & Chen, 2006; Assaf & Josiassen, 2012; Min & Joo, 2016; Yu et al., 2017; Seufert et al., 2017), Network Data Envelopment Analysis (Zhu, 2011; Lozano & Gutierrez, 2014), Total Factor Productivity (Barbot et al., 2008; See & Rashid, 2016; Scotti & Volta, 2017) and TOPSIS (Feng & Wang, 2000; Perçin & Aldalou, 2018). Other methods that have been used to determine the performance of airlines include ANOVA (Gilbert & Wong, 2003), multi-criteria decision making (Hsu & Liou, 2013; Pineda, 2018), and the Structural Equation Model (Jenatabadi & Ismail, 2012; 2014).

When the studies listed above are taken into consideration in their entirety, it is clearly understood that researchers have conducted studies on the performance analysis of airline companies. In addition, it is possible to say that they evaluate the performance of the airline companies in various dimensions.

Nevertheless, no studies have been found in the literature on the determinants of airline operational performance. In this respect, this study is expected to contribute to the literature in several ways and fill the gap on this issue. First, there is a gap in the literature on the determinants of operational performance and one of the motivations of this research is to fill this gap. Secondly, when the number of airlines and the size of the dataset used in the study are taken into consideration, this study differs significantly in terms of the scope of other studies in aviation literature. Finally, the study examined a 28-year period (1990-2017) which allows the findings to be more consistent and reliable. Considering the difficulty in obtaining data in airlines and aviation, especially operational data, this study also seeks to make a contribution to literature in terms of the period analyzed.

This study used the Revenue Passenger-Kilometers (RPK) as the dependable variable in a bid to establish the factors that determine the operational performance of airlines. When the RPK data for the 52 airlines included in the study is examined, it can be seen that these airlines have more than a 90% share of the world air passenger transport market (see Appendix-1). This shows the significance of this study in terms of its scope. The rest of this study, which examines the factors affecting the operational performance of airlines, is planned as follows. The second section will outline and explain the variables used in the study and the research model, while the third section will include the dataset used and the methodology of the study. In the fourth section, the results of the preliminary tests and the empirical findings obtained from the analysis will be outlined. Finally, the fifth section will discuss and evaluate the findings of the study.

2. Research Model

This study was designed to examine the factors that determine the operational performance of airlines. The operational performance in this study is measured by RPK and, therefore, it was used as the dependent variable in the article. The independent variables used in the study are Passengers Carried (PC), Load Factor (LF), Aircraft Departures (AD), Aircraft Hours (AH), and Available Tonne-Kilometres (ATK). In the continuation of the study, information about the definition of the model and the variables will be included.

The model and the model equation which represent the analysis of the factors determining the operational performance of airlines is given below.

$$RPK_{it} = \beta_0 + \beta_1 PC_{it} + \beta_2 LF_{it} + \beta_3 AD_{it} + \beta_4 AH_{it} + \beta_5 ATK_{it} + \varepsilon_{it} \tag{1}$$

The explanations for the variables used in the model are as follows:

Revenue Passenger-Kilometer (RPK) is one of the parameters included in the tools used in determining operational performance (Francis et al., 2005). The Revenue Passenger Kilometers (RPK), which represents the dependent variable in the model, is the numerical value obtained by multiplying the number of passengers carried at a particular price and the distance traveled by those passengers. The result of the multiplication gives the distance traveled by all paying passengers in kilometers (Gerede, 2015: 32). In the model given

above, RPK is expressed as the numerical value obtained by multiplying the distance traveled by airline *i* in *t* time.

Airlines are enterprises that provide transportation services and they perform this service by transporting passengers and cargo between two points at a desired time. In this context, the number of passengers carried is considered to have an important role in determining the operational performance of the airline. The number of passengers transported in the model above refers to the numerical number of passengers actually transported by airline *i* in *t* time.

Load factor (LF) is a rate that increases with the number of passengers. As the LF on each flight increases, the fixed costs are distributed over more passengers thereby reducing the cost per passenger on the flight (Zhang et al., 2014: 8). At the same time, the high LF achieved by airplanes with relatively larger capacities is also very effective in reducing costs (Graham et al., 1983: 123). The LF is therefore thought to have a significant impact on operational performance. The LF in the model is the ratio obtained by dividing the total number of passengers transported by airline *i* in *t* time by the total number of seats available to the airline.

In order to transport passengers from one place to another, airlines need to take off from the starting airport, cover the necessary distance and then land at their destination airport. The number of departures in the model (Aircraft Departures-AD) is actually the number of flights since a flight basically consists of take-off cruise landing stages. In this model, the number of flights is represented by the total number of departures performed by airline *i* in *t* time.

One of the factors affecting the financial side of operational performance is the amount of time the airplane stays in the air. Airlines wishing to obtain efficiency and effectiveness would the planes need to be in the air for as long as possible. This is because airlines are in the business of flight services and only earn money as long as they perform this service. Consequently, it is expected that operational performance will be affected positively the longer the aircraft stays in airborne otherwise the efficiency of the airline is expected to decrease (Belobaba, 2009). The total flight time in this model is the sum of all flights in terms of time performed by airline *i* in *t* time.

ATK is the value obtained by multiplying the total amount of cargo capacity (passenger, freight and postage) offered for sale by the flight distance (Gerede, 2015: 32). In the model used in this study, ATK is expressed as a numerical value obtained by multiplying the total load capacity offered by airline *i* in *t* time by the distance covered.

3. Data and Methodology

The data of the study was obtained from the ICAO Data Plus database. Panel data was used as the method of analysis in the study.

The process of determining economic or financial links using a panel data model created from time-dimensioned cross-sectional data, or panel data models is known as panel data analysis (Tatoglu, 2016: 5). The panel data equation shows the change in the cross-sectional units i (i= 1, …, N), in time t (t = 1, …, N) as well as the dependent variable Y and independent variable or the variables X, as shown below.

$$Y_{it} = \alpha_{it} + \beta_{it}X_{it} + \varepsilon_{it}$$

Where ε_{it} represents the error terms.

Before conducting a panel data analysis, it is necessary to perform some pre-tests. In this context, it was necessary to determine the correlation coefficient between the explanatory variables (it should be less than 0.80 otherwise a multicollinearity problem arises) and whether the series is stationary or not. The following sections of the study give the results of the stationary tests, model identification tests, heteroscedasticity and autocorrelation tests as well as the findings from the model.

4. Empirical Findings

Firstly, we present the descriptive statistics for the study which examined the factors that determined the operational performance of airlines. In the table below, descriptive statistics of RPK used as dependent variable and other variables used in the study are given.

Descriptive statistics of dependent and independent variables of the study can be seen in the table above (see Table 1). Accordingly, the average RPK values of the airlines is 25 million. In addition, the average number of passengers carried by airlines is 6.7 million. For the airlines included in the analysis, the maximum number of passengers is 59 million and the minimum is 1500. This shows that the airlines included in the analysis have different sizes. Therefore, it is seen that the study covers a wide range of airlines. This extent of coverage is also seen in the other variables. The maximum and minimum values of the load factor, aircraft departures, aircraft hours and tone-km available variables indicate that data from several airlines of different sizes were included in the analysis. As mentioned in the previous sections of the study, analyzing the data of many airline companies of different sizes, allows generalization of the analysis findings.

Table: 1
Descriptive Statistics

	RPK	PC	LF	AD	AH	ATK
Mean	25547844	6782214	0.706	56811	208865.3	5561172
Median	10964677	3300919	0.714	27311	103555.5	2268714
Maximum	2.90E+08	59356313	0.887	525263	1357782	64215960
Minimum	511	1502	0.268	108	269	96
Std. Deviation	34356869	8595996	0.086	75219.49	252907.6	7383415
Skewness	2.414853	2.327805	-0.773	2.774864	1.969148	2.316712
Kurtosis	11.24549	9.458433	4.255	12.60718	6.785872	11.1916
Observation	1456	1456	1456	1456	1456	1456

The existence of a high correlation (0.80 and above) among the independent variables included in the regression model causes multicollinearity problems. However, when the

correlation between the independent variables used in the model is examined, it shows that this is quite low (see Table 2). This shows that all independent variables in the model can be used statistically.

Table: 2
Correlation Matrix for Independent Variables

	DPC	LF	DAD	DAH	DATK
DPC	1				
LF	0.2273	1			
DAD	0.7373	0.0570	1		
DAH	0.7236	0.1272	0.7293	1	
DATK	0.7849	0.1508	0.5853	0.7305	1

All variables included in the analysis other than LF were found to become stationary after the first differential. As a result, the LF variable was included in the analysis with all the other variables after the first differential (see Table 3).

Table: 3
Panel Unit Root Test Results

Variable	Model	Levin, Lin & Chu -t		Im, Pesaran and Shin -W		ADF - Fisher Chi^2	
		Stat.	Prob.	Stat.	Prob.	Stat.	Prob.
RPK	Constant	5.31716	1.0000	9.43223	1.0000	42.0362	1.0000
	Constant and Trend	3.48077	0.9998	4.10442	1.0000	71.0813	1.0000
ΔRPK	Constant	-6.56615	0.0000	-11.9843	0.0000	351.455	0.0000
	Constant and Trend	-4.91039	0.0000	-9.84475	0.0000	288.388	0.0000
ASK	Constant	3.62095	0.9999	6.89795	1.0000	62.3656	0.9996
	Constant and Trend	4.32072	1.0000	3.71467	0.9999	83.9095	0.9261
ΔASK	Constant	-9.47244	0.0000	-12.3737	0.0000	365.949	0.0000
	Constant and Trend	-8.77838	0.0000	-10.1033	0.0000	295.901	0.0000
PC	Constant	5.98404	1.0000	9.68309	1.0000	38.8829	1.0000
	Constant and Trend	3.09538	0.9990	3.09235	0.9990	80.7138	0.9561
ΔPC	Constant	-9.48349	0.0000	-13.7554	0.0000	397.098	0.0000
	Constant and Trend	-7.63184	0.0000	-11.8277	0.0000	335.158	0.0000
LF	Constant	-2.00051	0.0227	1.25447	0.8952	74.4741	0.9872
	Constant and Trend	-0.43643	0.3313	-3.84605	0.0001	167.668	0.0001
AK	Constant	1.61524	0.9469	5.66762	1.0000	66.976	0.9982
	Constant and Trend	3.53218	0.9998	3.88839	0.9999	72.7042	0.9915
ΔAK	Constant	-11.5178	0.0000	-13.1286	0.0000	384.068	0.0000
	Constant and Trend	-10.1168	0.0000	-10.6152	0.0000	305.339	0.0000
AD	Constant	0.97537	0.8353	2.86634	0.9979	91.3765	0.8069
	Constant and Trend	0.39589	0.6539	0.62545	0.7342	104.678	0.4629
ΔAD	Constant	-14.2558	0.0000	-15.8518	0.0000	451.132	0.0000
	Constant and Trend	-12.0434	0.0000	-12.9175	0.0000	358.147	0.0000
AH	Constant	2.12059	0.9830	5.69543	1.0000	64.9801	0.9990
	Constant and Trend	1.50892	0.9343	3.35301	0.9996	75.0028	0.9857
ΔAH	Constant	-12.2962	0.0000	-14.7335	0.0000	425.818	0.0000
	Constant and Trend	-11.0286	0.0000	-12.2738	0.0000	347.195	0.0000
ATK	Constant	1.80077	0.9641	4.28213	1.0000	93.9752	0.7493
	Constant and Trend	2.18521	0.9856	3.20349	0.9993	84.732	0.9165
ΔATK	Constant	-10.9614	0.0000	-13.7865	0.0000	399.325	0.0000
	Constant and Trend	-9.74102	0.0000	-11.8149	0.0000	335.339	0.0000

Note: The maximum delay length was taken as 1 and the optimum delay length was determined according to the Schwarz Info Criteria (SIC) criteria. All hypothesis tests were based on the significance level of 0.05 (5%).

After performing the correlation and stability tests for the series, the next step was to decide on the most appropriate model between the Classical Model, Fixed Effects Model, and Random Effects Models. To this end, an F-test was conducted to test the validity of the Classical Model against the Fixed Effects Model, the Breusch-Pagan LM test to compare the conformity of the Classical Model to the Random Effects Model, and the Hausman test to decide between the Fixed Effects Model and the Random Effects Model. The results of F

test and LM test show that the classical model should not be applied (H_0 Reject). As a result, the findings of the analysis show that the Random Effects Model should be used in this study (see Table 4).

Table: 4
Model Identification Test Results

F Test		LM Test		Hausman Test	
Stat.	Prob.	Stat.	Prob.	Stat.	Prob.
1.7254	0.0001	15.808	0.0001	0.39	0.5305

The Levene, Brown and Forsythe test statistics show the rejection of hypothesis H_0, which proposed that "the variance of the units are equal" (see Table 5). The variance was thus found not to be fixed.

Table: 5
Heteroscedasticity Test Results

	Stat	Prob.	Degree of freedom (df)	Test Hypothesis	Decision
W0	11.233	0.0000	df(51, 1352)		
W50	9.9746	0.0000	df(51, 1352)	No heteroscedasticity	H_0 Reject
W10	10.557	0.0000	df(51, 1352)		

Note: All hypothesis tests were based on the significance level of 0.05 (5%).

Bhargava, Franzini and Narendranathan's DW autocorrelation test, Baltagi and Wu's LBI test and LM test were used to test the presence of autocorrelation in the model. The extant literature does not identify any critical value for DW and LBI tests, but a statistical value of less than 2 indicates autocorrelation. The statistical value for DW and LBI autocorrelation tests is very close to the critical value of 2 (see Table 6). Besides this, the LM probability value is greater than 0.05 which indicates the acceptance of hypothesis H_0 which proposes that "there is no autocorrelation". The model, therefore, concluded that there was no autocorrelation in the model.

Table: 6
Autocorrelation Test Results

Test	Stat	Prob.	Decision
Durbin Watson (DW)	1.9670		---
Baltagi-Wu (LBI)	2.0788		---
LM-stat	0.1900	0.6628	H_0 Accepted

Note: All hypothesis tests were based on the significance level of 0.05 (5%).

According to the results of the random effects model, the operational performance of airlines is significantly affected by the variables for the number of passengers (PC), load factor (LF), number of flights (AD), the rate of use of the aircraft (AH) and the amount of transported cargo (ATK) (see Table 7). The results further point out that the number of passengers and the total amount of cargo carried by the airlines has a positive effect on the operational performance at 1% significance level. The load factor has a positive effect on operational performance at the level of 5% and the rate of use of the aircraft at the level of 10%. On the other hand, the total number of flights made by the airlines was found to have a negative impact on the operational performance at the level of 1%. RPK, which is used as a dependent variable in the study, is a production parameter obtained by multiplying the flight length (range) and the number of passengers transported to the destinations operated

by airlines. Therefore, RPK is the most important indicator of the production of airline
companies. For RPK to be high, airplanes need to stay in the air longer, airlines should
arrange flights to destinations at greater distances and airlines are required to perform flights
with high load factor. The findings of the study show that there is a close relationship
between the number of passengers carried (PC), the load factor (LF) and the rate of use of
the aircraft (AH), in accordance with our expectations.

Table: 7
GLS Method Estimation Results

Variable	Coefficient Estimate	Robust Standard Error	z	Prob.	[%95 Confidence Interval]	
PC	2.958001	0.2262973	13.07	0.0000	2.514467	3.401536
LF	885421.1	419316.1	2.11	0.0350	63576.65	1707266
AD	-107.1449	13.04986	-8.21	0.0000	-132.7222	-81.56764
AH	10.23762	5.726304	1.79	0.0740	-0.9857322	21.46097
ATK	1.924533	0.2506089	7.68	0.0000	1.433349	2.415718
C	-643958.4	270285.6	-2.38	0.0170	-1173708	-114208.4
Number of Observations: 1404			Wald $\chi^2(5) = 1144.84$		$R^2 = 0.9248$	
Number of Groups: 52			Prob > $\chi^2 = 0.0000$			

5. Conclusion

The empirical findings of the study show that the number of passengers, load factor,
the number of flights made by airlines, the rate of use of airplanes and the amount of cargo
significantly affect the operational performance of the airlines. From this, the number of
passengers, load factor, aircraft usage rate and the amount of cargo carried were found to
positively affect the operational performance of airlines while the number of flights was
found to negatively impact operational performance. The findings of the study are consistent
with the structure of air transportation. The results show that the increase in the number of
flights does not increase the operational performance, and that an increased number of flights
on inefficient routes only lowers the operational performance.

When the results obtained in the study are evaluated in general, it is seen that there is
a close relationship between employee and aircraft efficiency and operational performance.
Accordingly, in order to increase the operational performance of airline companies, airlines
should use their assets, especially the aircraft, efficiently. Therefore, airline companies
should focus on operational indicators such as the number of flights, flight duration and load
factor, rather than increasing the number of new destinations. In addition, the fact that
airlines may stop flights on lines where there is a relatively inefficient demand, which
adversely affects the airline operations and the load factor, may contribute positively to
operational performance.

We believe that the findings of the study provide valuable information to airlines on
what they need to do to improve their operational performance and thus are vital to both the
airlines and airline stakeholders. Airlines can benefit from an increased operational
performance by operating on routes which may lead to increased passenger numbers and
hence load factor. In addition to this, we believe that navigation planning will likely improve
the performance of the airline by increasing the usage rate of their aircraft or the duration
taken by the aircraft in the air. Finally, it can also be concluded that the number of flights on

routes with lower load factor does not contribute to effective management returns as well as the operational performance.

References

Assaf, A.G. & A. Josiassen (2012), "European vs. U.S. airlines: Performance comparison in a dynamic market", *Tourism Management*, 33(2), 317-326.

Barbot, C. & Á. Costa & E. Sochirca (2008), "Airlines performance in the new market context: A comparative productivity and efficiency analysis", *Journal of Air Transport Management*, 14(5), 270-274.

Barros, C.P. & N. Peypoch (2009), "An evaluation of European airlines' operational performance", *International Journal of Production Economics*, 122(2), 525-533.

Behn, B.K. & R.A. Riley Jr. (1999), "Using nonfinancial information to predict financial performance: The case of the US airline industry", *Journal of Accounting, Auditing & Finance*, 14(1), 29-56.

Belobaba, P. (2009), "Airline operating costs and measures of productivity", in: *The Global Airline Industry*, P. Belobaba & A. Odoni & C. Barnhart (eds.), 136-139.

Chiou, Y.C. & Y.H. Chen (2006), "Route-based performance evaluation of Taiwanese domestic airlines using data envelopment analysis", *Transportation Research Part E: Logistics and Transportation Review*, 42(2), 116-127.

Dinçer, H. & Ü. Hacıoğlu & S. Yüksel (2017), "Balanced scorecard based performance measurement of European airlines using a hybrid multicriteria decision making approach under the fuzzy environment", *Journal of Air Transport Management*, 63, 17-33.

Doganis, R. (2005), *Airline business in the 21st century*, Routledge.

Emil, M.F. & H.H. Yılmaz & C.V. Rijkeghem (2005), *Kamu Borcu Nasıl Oluştu? Bu Noktaya Nasıl Gelindi?*, İstanbul: Tesev Yayınları Türkiye-Avrupa Birliği İlişkileri Serisi.

Feng, C.M. & R.T. Wang (2000), "Performance evaluation for airlines including the consideration of financial ratios", *Journal of Air Transport Management*, 6(3), 133-142.

Francis, G. & I. Humphreys & J. Fry (2005), "The nature and prevalence of the use of performance measurement techniques by airlines", *Journal of Air Transport Management*, 11(4), 207-217.

Gerede, E. (2015), "Havayolu İşletmeciliğine İlişkin Temel Kavramlar", in: *Havayolu Taşımacılığı ve Ekonomik Düzenlemeler Teori ve Türkiye Uygulaması*, 1-46.

Gilbert, D. & R.K. Wong (2003), "Passenger expectations and airline services: a Hong Kong based study", *Tourism Management*, 24(5), 519-532.

Graham, D.R. & D.P. Kaplan & D.S. Sibley (1983), "Efficiency and competition in the airline industry", *The Bell Journal of Economics*, 14(1), 118-138.

Hsu, C.C. & J.J. Liou (2013), "An outsourcing provider decision model for the airline industry", *Journal of Air Transport Management*, 28, 40-46.

Jenatabadi, H.S. & N.A. Ismail (2012), "A new perspective on modeling of airline performance", in: *3rd International Conference on Business and Economic Research*, March.

Jenatabadi, H.S. & N.A. Ismail (2014), "Application of structural equation modelling for estimating airline performance", *Journal of Air Transport Management*, 40, 25-33.

Joo, S.J. & K.L. Fowler (2014), "Exploring comparative efficiency and determinants of efficiency for major world airlines", *Benchmarking: An International Journal*, 21(4), 675-687.

Liou, J.J. & G.H. Tzeng & H.C. Chang (2007), "Airline safety measurement using a hybrid model", *Journal of Air Transport Management*, 13(4), 243-249.

Lozano, S. & E. Gutiérrez (2014), "A slacks-based network DEA efficiency analysis of European airlines", *Transportation Planning and Technology*, 37(7), 623-637.

Min, H. & S.J. Joo (2016), "A comparative performance analysis of airline strategic alliances using data envelopment analysis", *Journal of Air Transport Management*, 52, 99-110.

Perçin, S. & E. Aldalou (2018), "Financial Performance Evaluation of Turkish Airline Companies Using Integrated Fuzzy AHP Fuzzy TOPSIS Model", *Uluslararası İktisadi ve İdari İncelemeler Dergisi*, (18. EYİ Özel Sayısı), 583-598.

Pineda, P.J.G. & J.J. Liou & C.C. Hsu & Y.C. Chuang (2018), "An integrated MCDM model for improving airline operational and financial performance", *Journal of Air Transport Management*, 68, 103-117.

Rose, N.L. (1990), "Profitability and product quality: Economic determinants of airline safety performance", *Journal of Political Economy*, *98*(5, Part 1), 944-964.

Saeedi, H. & B. Behdani & B. Wiegmans & R. Zuidwijk (2018), *Performance Measurement in Freight Transport Systems: A Literature Review*.

Schefczyk, M. (1993), "Operational performance of airlines: an extension of traditional measurement paradigms", *Strategic Management Journal*, 14(4), 301-317.

Scheraga, C.A. (2004), "Operational efficiency versus financial mobility in the global airline industry: A data envelopment and Tobit analysis", *Transportation Research Part A: Policy and Practice*, 38(5), 383-404.

Scotti, D. & N. Volta (2017), "Profitability change in the global airline industry", *Transportation Research Part E: Logistics and Transportation Review*, 102, 1-12.

See, K.F. & A.A. Rashid (2016), "Total factor productivity analysis of Malaysia Airlines: Lessons from the past and directions for the future", *Research in Transportation Economics*, 56, 42-49.

Seufert, J.H. & A. Arjomandi & K.H. Dakpo (2017), "Evaluating airline operational performance: A Luenberger-Hicks-Moorsteen productivity indicator", *Transportation Research Part E: Logistics and Transportation Review*, 104, 52-68.

Tatoğlu, F.Y. (2016), *Panel Veri Ekonometrisi*, Beta Yayınevi.

Yu, M.M. & L.H. Chen & H. Chiang (2017), "The effects of alliances and size on airlines' dynamic operational performance", *Transportation Research Part A: Policy and Practice*, 106, 197-214.

Zhang, Q. & H. Yang & Q. Wang & A. Zhang (2014), "Market power and its determinants in the Chinese airline industry", *Transportation Research Part A: Policy and Practice*, 64, 1-13.

Zhu, J. (2011), "Airlines Performance via Two-Stage Network DEA Approach", *Journal of CENTRUM Cathedra: The Business and Economics Research Journal*, 4(2), 260-269.

Appendix: 1
List of Airlines Used in the Research and Their RPK Values in 2017

ID	AIRLINE	RPK 2017 (000)	ID	AIRLINE	RPK 2017 (000)
1	AEROFLOT RUSSIAN AIRLINES	91.810.353	27	HAWAIIAN AIRLINES	26.227.836
2	AEROLINEAS ARGENTINAS	21.051.160	28	HORIZON AIR	3.770.649
3	AEROMEXICO	32.681.907	29	IBERIA	48.391.436
4	AIR CANADA	126.321.246	30	ICELANDAIR	12.790.957
5	AIR FRANCE	143.973.477	31	IRAN AIR	3.720.739
6	AIR INDIA	44.729.323	32	JAPAN AIRLINES	62.867.000
7	AIR MADAGASCAR	751.721	33	KLM	103.486.777
8	AIR MAURITIUS	7.280.888	34	KOREAN AIR	77.843.389
9	ALASKA	56.802.662	35	KUWAIT AIRWAYS	11.655.640
10	ALL NIPPON AIRWAYS	84.767.643	36	LACSA	2.599.416
11	AMERICAN	323.909.964	37	LAN CHILE	24.367.802
12	ASIANA	42.343.478	38	LOT	12.660.235
13	AURIGNY	150.331	39	LUFTHANSA	152.355.447
14	AVIANCA	24.837.378	40	MALAYSIAN AIRLINES	32.983.352
15	BANGLADESH BIMAN	6.759.113	41	MONARCH AIRLINES	6.712.953
16	BMI REGIONAL	511.559	42	PIA (Pakistan International)	13.990.967
17	BRITISH AIRWAYS	144.737.811	43	QANTAS	76.790.794
18	CATHAY PACIFIC	111.761.318	44	SAS	37.623.592
19	CZECH AIRLINES	3.412.592	45	SRILANKAN AIRLINES	14.168.546
20	DELTA	314.976.039	46	TAP AIR PORTUGAL	34.711.238
21	DRAGONAIR	14.901.515	47	TAROM	2.758.713
22	EGYPT AIR	18.476.121	48	THAI AIRWAYS	68.112.810
23	EL AL	22.526.981	49	THY (Turkish Airlines)	136.522.850
24	EMIRATES	288.885.910	50	TUNIS AIR	5.601.818
25	FINNAIR	31.047.004	51	VIRGIN ATLANTIC	34.390.426
26	GARUDA	39.228.689	52	UNITED	310.463.650