EFFICIENCY EVALUATION OF TURKISH AIRPORTS WITH DEA AND MALMQUIST-TFP INDEX APPROACH

Dr.Öğr. Üyesi Savaş Selahattin ATEŞ
Eskişehir Anadolu University
ssates@anadolu.edu.tr
https://orcid.org/0000-0003-2462-0039

Dr. Öğr.Üyesi Seçil ULUFER
İstanbul Aydın Üniversitesi-ABMYO
secilulufer@aydin.edu.tr
https://orcid.org/0000-0002-5522-324X

Şevket ALTINBAŞ
Eskişehir Anadolu University
sevketaltinbas@anadolu.edu.tr
https://orcid.org/0000-0002-5981-4223

ABSTRACT
The need to reach one place from a place that is part of human life is provided by different modes of transportation according to the possibilities and needs that are available. Airline transport is also unique and has an important place in our lives with superior features compared to other modes of transportation. There are many elements within the air transport system in ensuring air transport. Airports are the mainstay of these elements. Today, assessing the performance of airport operators operating as a business is important to ensure efficiency. Through performance evaluation, useful information can be generated for managers to take decisions that will be of benefit to the business. In this study, taking into account all these 27 airports operated by the DHM in Turkey was subjected to performance evaluation under certain criteria. In this context, the productivity change between 2012-2016 of the selected airports with Malmquist-TFP productivity index which is a

Geliş Tarihi: 15.05.2017, Kabul Tarihi: 15.06.2018, DOI NO: 10.17932/IAU.IAUD.m.13091352.2018.3/39.83-94
Araştırma Makalesi - Bu makale Turnitin programıyla kontrol edilmiştir.

frequently used Data Envelopment Analysis technique in literature is examined. According to the results of the analysis, the total factor productivity increased by 3.6% on average in the related period.

Keywords: *Efficiency, Airport, Data Envelopment Analysis, Malmquist-TFP Index*

TÜRKİYE'DEKİ HAVALİMANLARININ 2012-2016 YILLARI ARASINDAKİ ETKİNLİKLERİNİN VERİ ZARFLAMA ANALİZİ VE MALMQUİST-TFV ENDEKSİ METODUYLA İNCELENMESİ

ÖZ

İnsan yaşamının bir parçası olan bir yerden bir yere ulaşma ihtiyacı elde bulunan imkân ve ihtiyaçlara göre farklı ulaşım modlarıyla sağlanmaktadır. Havayolu taşımacılığı da kendine has ve diğer ulaşım modlarına göre üstün birtakım özellikleriyle hayatımızda önemli bir yere sahiptir. Havayolu taşımacılığının sağlanmasında hava taşımacılığı sistemi içerisinde birçok unsur yer almaktadır. Havalimanları bu unsurların başlıcalarındandır. Günümüzde bir işletme olarak faaliyet gösteren havalimanı işletmelerinin performansının değerlendirilmesi verimliliğin sağlanması açısından önemlidir. Performans değerlendirmesi sayesinde yöneticilerin işletme yararına olacak kararları almasında faydalı bilgiler üretilebilmektedir. Bu çalışmada tüm bunlar göz önüne alınarak, Türkiye'de DHMİ tarafından işletilen 27 havalimanı belirli kıstaslar altında performans değerlendirmesine tabi tutulmuştur. Bu kapsamda literatürde sıkça kullanılan Veri Zarflama Analizi tekniği olan Malmquist-TFV verimlilik endeksiyle seçilen havalimanlarının 2012-2016 yılları arasındaki verimlilik değişikliği incelenmiştir. Analiz sonuçlarına göre ilgili dönemde toplam faktör verimliliğinin ortalama olarak %3,6'lık bir artış gösterdiği tespit edilmiştir.

Anahtar Kelimeler: *Etkinlik, Havalimanı, Veri Zarflama Analizi, Malmquist-TFV Endeksi*

INTRODUCTION

Transportation has been one of the most important elements of our life in terms of facilitating the daily life of people from the past. It has taken its place as equipped with the latest technologies today, renewing itself in the course of continuous development and change from the past to the present day.

Many modes of transportation make our life easier; the most advantageous in terms of speed and time benefit from these, is undoubtedly air transportation. If it is necessary to handle air transportation in a system; air transport system is formed.

In its simplest form, air transport is the shift of air from an air vehicle to provide space and time for people, cargo, and mail (Gerede, 2002). The air transport system is also a system formed by bringing together elements that contribute to this displacement movement. One of the most important of these elements is the airports. A land created in land or water for the purpose of landing, departure and ground movements of air vehicles with the buildings, facilities and equipment in the airport (ICAO Annex 14, 2009). According to 2016 data, there are 41,820 small and international airports worldwide (The World Factbook, 2016)

Airports are complex administrative and operational systems. Especially the rapid increase of passenger and cargo traffic leads to more intensive use of the airports, which makes it more effective and efficient to use the airport resources. As a matter of fact, it is necessary to know the issues such as the level of reaching the targets determined in the operation of the airport and what activities should be done in order to reach these targets. For these reasons, airport operators need to measure and evaluate their performance. When we think of the airport as a system, some inputs are processed, and various outputs are obtained. In this input-output context it is possible to measure the performance of the airport. There are various methods to measure airport performance. One of these and the most commonly used is the data envelopment analysis. Data envelopment analysis is a linear programming-based performance analysis method that measures the effectiveness of various developed formulas when there are multiple inputs. In this study, efficiency analysis was conducted by analyzing data envelopment analysis of Turkish airports and the change of activity between Malmquist-TFP index and 2012-2016 period was examined.

DATA ENVELOPMENT ANALYSİS

Data Envelopment Analysis can be defined as a linear programming-based method used to evaluate the relative activities of decision points responsible for outputting or outputting using similar inputs. The main feature that distinguishes Data Envelopment Analysis from other methods for similar purposes is that it can be evaluated in cases where there are many inputs and outputs. As a result of the analysis, information on the efficiency of each decision point, how to improve the efficiency of the ineffective decision points on the input / output ratios, and the decision points that can be used as a reference are obtained (http://www.deu.edu.tr, tarihsiz)

Data Envelopment Analysis was first introduced by Farrell in 1957 with the suggestion of the Boundary Production Function in response to the Average Performance measure, and it became this day with the work of Charnes, Cooper, Banker and Rhodes.

The methods used in Data Envelopment Analysis can be solved with input or output focus. Input focus is defined as an analysis of changes in input quantities by holding output quantities constantly and output focus is defined as an analysis of changes in output quantities by keeping input quantities constant.

The VZA method was used for the first time in the CCR model of Charnes, Coopeer and Rhodes in 1978, and it is a technique that has been analyzed by fixed return on the scale (CRS). In the later period, the model (BCC) which was analyzed by variable return by scale (VRS) and used by Banker, Charnes and Cooper in 1984 was developed.

By means of the concept of total factor productivity, it is tried to obtain an output / input ratio by considering all inputs and outputs. Although the transition process from partial efficiency measures to total factor productivity allows accurate analysis of the efficiency of a data set with multiple input-output structures, challenges such as choosing the right inputs and outputs and determining their weight in the analysis can be explained by the estimation of the relationship between the technique and input and output (Charnes, Cooper, & Rhodes, 1978) which does not require various functional forms such as regression analysis.

MALMQUIST PRODUCTIVITY INDEX

The total productivity index (MPI) in the time period of change was calculated by Färe et al. Parallel to this, Caves et al explained the following formula by calculating the total efficiency of the airport between two different periods.

$$M(x^t, y^t, x^{t+1}, y^{t+1})=\left[\frac{D^t(x^{t+1},y^{t+1})}{D^t(X^t,b^t)} X \frac{D^{t+1}(X^{t+1},y^{t+1})}{D^{t+1}(X^t,y^t)}\right]^{1},$$

Where y is the output vector and x is generated using the input vector. The output indicates the process function and the variant describes the efficiency change in period t and period t + 1 under the limit technology reference for period t. As always, M gives the geometric mean of the working period and shows the progress or regress of the period related to DMU's boundary value technologies. If M> 1, productivity is improving. If M = 1, efficiency does not change. If M <1, efficiency decreases.

MPI is examined in two parts (Balıkçı, 2016);
Technical Productivity Index (TECI): Indicates the change in the relative activity of an airport with respect to t and t + 1.
Technological Change Index (TCI): The boundary between the periods in the time slot describes technological changes.
MPI is explained as follows

Malmquist productivity index = TECI (proportional change) * TCI (limit value) The Technical Productivity Index (TECI) describes the performance of the decision-making unit in improving its effectiveness, while the Technological Change Index (TCI) is used to describe airport efficiency between two periods and relates generally to airport operating technologies.

LITERATURE

Below are some of the dea work summarized (Peker, 2009)

Tablo 1. DEA Studies Applied At The Airport

AUTHOR NAME	METHOD	SAMPLE	INPUTS	OUTPUTS
Düzakın, E Güçray, A., 2001	DEA-BCC-CCR- Cross-Activity Model	39 Turkey Airports	-Runway number -Number of employees -Number of portable passengers	- Business revenue -Number of passengers - Cargo value
Lin, L.C. Hong, C.H, 2006	VZA-BCC-CCR- Cross-Activity Model	20 Great Airports	-Number of employees -Number of box office - Runway number	- Number of passengers - Cargo value
Malighetti, P. Gianmaria, M. Paleari, S. Renaato, R., 2008	VZA-Tobit Model	57 European Airport	- Airport size - Runway number - Number of parking spaces -Number of box office - Terminal area	- Number of passengers - Cargo value

PURPOSE OF TH RESEARCH

The aim of this study is to examine the efficiency changes of the airports in our country using Data Envelopment Analysis Method (VZA) and Malmquist-TFP index and to interpret the obtained analysis results as meaningful and useful.

THE IMPORTANCE OF RESEARCH

Airports, which have significant contributions to the economic and social development of countries, are important investments that require large capital infrastructures. Effective and efficient operation of the airports allows the investments to be returned more quickly, thus contributing more to the economy. The concept of activity is important from the past because of the scarcity of resources. Since the airport investments carried out by the state in our country are also observed in the public interest, importance is not given to the fact that the airports are working effectively. By conducting an efficiency analysis of airports with this study and analyzing the change of analysis results according to years, useful information in the sector is presented.

SCOPE OF THE STUDY

The scope of the research constitutes 27 Turkish international airports actively operated by DHMİ between 2012-2016.

RESEARCH METHOD

The research data was obtained from the annual reports of 2012, 2013, 2014, 2015 and 2016 which are regularly published by DHMİ every year. In the study, output based CCR model and Malmquist-TFP index based on fixed return assumption by scale were applied.

CHOİCE OF DECISION POINTS

The first step in Data Envelopment Analysis involves the selection of decision points where comparative effectiveness measurements are to be made. The homogeneity of the observation set is very important in terms of the significance of the results.

In this study, 27 airports were selected is operated by DHMİ in Turkey.

Table 2. Selected Airports

1.	İstanbul Atatürk	10. Gaziantep	19. Kayseri
2.	Ankara Esenboğa	11. Balıkesir Koca Seyit	20. Konya
3.	İzmir Adnan Menderes	12. Bursa Yenişehir	21. Malatya
4.	Antalya	13. Denizli Çardak	22. Nevşehir Kapadokya
5.	Muğla Dalaman	14. Diyarbakır	23. Samsun Çarşamba
6.	Muğla Milas-Bodrum	15. Elazığ	24. Sivas Nuri Demirağ
7.	Adana	16. Hatay	25. Şanlıurfa Gap
8.	Trabzon	17. Isparta Süleyman Demirel	26. Tekirdağ Çorlu
9.	Erzurum	18. Kars Harakani	27. Van Ferit Melen

SELECTION OF INPUT AND OUTPUT FACTORS

The selected inputs and outputs should be meaningful for correct conclusion. The aim here is to select the clusters of inputs and outputs that best express the set of observations. To this end, a set of inputs and outputs that will provide the optimum result for the analysis of the efficiences of the airports have been identified. Similar work previously done in the literature has been taken into account in the aviation sector when clusters have been set for this.

Table 3. Input and Output Factors Used in the Study

Inputs	**Explanation**
1. Pist Sayısı	Total number of runways at the airport (number)
2. Terminal Alanı	Total terminal area (m2)
outputs	**Explanation**
1. Passenger Traffic	Number of annual passengers who have flown from the airport (person)
2. Load Transmission	Total cargo, luggage and mail (tons)
3. Aircraft Traffic	Total number of flights in the year (airplane)

MODEL SELECTION

In the study, the Malmquist-TFP index and the output-oriented CCR model were used to measure the effectiveness of airports. The analysis results were obtained using the DEAP 2.1 computer package program developed by Tim Coelli (1996).

ANALYSIS RESULTS

At this stage, the activity changes of the 27 airports over the five-year period covering 2012-2016 years were examined using the Malmquist-TFP Index method. Findings obtained as a result of analysis; changes in the total factor productivity of the airports (Table 4) and the changes that occurred on the basis of years (Table 5).

When the results of the analysis made according to the airports are analyzed, it is observed that 23 of the 27 airports operated by DHMİ have TFPCH greater than 1 between 2012-2016. This indicates a general improvement in the majority of the airports (85.18%) in the period concerned. TFP average value in the related period was 1,036. This means that there is an average increase of 3.6% in TFP. Looking at the reasons for this increase, it can be opened with a 2% increase in technical activity and a 1.6% increase in technological change.

Table 4. Analysis Results According to Airports

	Efficiency Values				
Airports	**effch**	**techch**	**pech**	**sech**	**tfpch**
İstanbul Atatürk	1.026	0.975	1.000	1.026	1.000
Ankara Esenboğa	0.992	1.051	1.000	0.992	1.043
İzmir Adnan Menderes	1.004	1.027	1.000	1.004	1.031
Antalya	1.000	1.002	1.000	1.000	1.002
Muğla Dalaman	0.971	1.033	1.000	0.971	1.003
Muğla Milas-Bodrum	0.963	1.052	1.000	0.963	1.012
Adana	1.003	1.045	1.000	1.003	1.048
Trabzon	1.005	1.058	1.000	1.005	1.063
Erzurum	0.996	1.060	1.000	0.996	1.056
Gaziantep	1.011	1.044	1.000	1.011	1.055
Balıkesir Koca Seyit	1.000	0.916	1.000	1.000	0.916
Bursa Yenişehir	1.000	0.900	1.000	1.000	0.900
Denizli Çardak	1.008	1.073	1.000	1.008	1.081
Diyarbakır	1.000	1.046	1.000	1.000	1.046
Elazığ	1.006	1.048	1.000	1.006	1.054
Hatay	1.014	1.025	1.000	1.014	1.040
Isparta Süleyman Demirel	1.004	0.850	1.000	1.004	0.854
Kars Harakani	1.000	1.104	1.000	1.000	1.104
Kayseri	1.004	1.038	1.000	1.004	1.042
Konya	1.011	1.046	1.000	1.011	1.058
Malatya	1.007	1.058	1.000	1.007	1.066
Nevşehir Kapadokya	1.000	1.046	1.000	1.000	1.046
Samsun Çarşamba	0.974	1.042	1.000	0.974	1.015
Sivas Nuri Demirağ	1.000	1.029	1.000	1.000	1.029
Şanlıurfa Gap	1.018	1.049	1.000	1.018	1.067
Tekirdağ Çorlu	1.545	0.919	1.000	1.545	1.420
Van Ferit Melen	0.975	1.055	1.000	0.975	1.029
Average	1.016	1.020	1.000	1.016	1.036
>1	14	22	0	14	23
=1	7	0	27	7	1
<1	6	5	0	6	3

When the TFPCH value of each airport was examined in the related period, we see that the biggest increase occurred at 42% at Tekirdag Çorlu Airport. Tekirdağ Corlu Airport is followed by Kars Harakani (10,4%) and Denizli Cardak Airport (8,1%) respectively. Istanbul Atatürk Airport did not undergo any change with 1,000 TFPCH points during the related period. When we look at the TFPCH components, although the technical efficiency value increased by 2.6%, the technological change was stable by 2.5%. When we look at the airports where the TFPCH value declines, we see that the highest decrease is in the Isparta Süleyman Demirel Airport with TFPCH value of 14.6%. We can say that 15% decrease in technological change is the reason for this. Two other airports with TFPCH value are Bursa Yenişehir (10%) and Balıkesir Koca Seyit (8,4%). The decrease in the TFPCH value of these two airports is also due to the decline in technological change.

When the airports are evaluated according to their technological changes between 2012 and 2016, it is observed that a great majority of 22 of the 27 airports, ie 81%, are developing. The airports that showed a decrease in this area were Istanbul Atatürk (2.5%), Balikesir Koca Seyit (8.4%), Tekirdağ Corlu (8.1%), Bursa Yenişehir (10%) and Isparta Süleyman Demirel Airport (15% d.

Considering the change in the technical activities of the airports, it is observed that there are no increases in the 14 airports, 6 airports and 7 EFFCH values. Tekirdağ Çorlu (54.5%) airport showed the greatest improvement in this area, and the biggest drop was in Samsun Wednesday (2.6%) airport.

Table 5. Analysis Results According to Years

	Efficiency Values				
Year	**Effch**	**techch**	**pech**	**sech**	**tfpch**
2013	0.975	1.048	1.000	0.975	1.022
2014	1.051	0.986	1.000	1.051	1.036
2015	0.914	1.199	1.000	0.914	1.097
2016	1.136	0.874	1.000	1.136	0.993
Average	1.016	1.020	1.000	1.016	1.036

Looking at annual activity changes in the related period, it is seen that the total factor productivity change value increased in 2013, 2014 and 2015 compared to the previous year. In 2016, a decrease of 0.7% compared to the previous year was observed.

Looking at the changes in the EFFCH value in the relevant period, it is seen that in 2013 and 2015 there is a decrease compared to the previous year. In particular, a significant decline of 8.6% occurred in 2015. Again in 2014 and 2016, an increase in the value is observed. A significant increase of 13.6% was achieved in 2016. Looking at the changes in TECH, we see an increase in 2013 and 2015; A decrease is seen in 2014 and 2016.

CONCLUSION AND RECOMMENDATION

It is observed that the airport analyzed as a result of the study made in general increases in total factor productivity changes. While the total factor productivity of 23 airports increased, the ratio remained the same for the analyzed period and the value of the remaining 3 airports decreased. The increase in total factor productivity is mainly due to the increase in technological change. A total of 22 airports increased the value of technological change, while the value of 5 fell. This shows that airports are able to keep pace with technological change in the sector. The decrease in total factor productivity is seen to be a decrease in technological change values. There are 7 airports with technical efficiency values. The reason for this is that we can say that these airports do not work effectively as scale.

When the annual changes in the analysis results are examined, it is observed that the total factor productivity is generally higher than the previous year. However, it is seen that the only fall here is in 2016. The cause of this may be the decline in the value of technological change. However, when DHMİ passenger statistics are examined, it can be shown that the drop in the number of passengers, especially in the holiday regions, due to the special situation that our country has in 2016 is one of the reasons for this decrease.

As a result, traditional airport governments, especially in developed countries, have left their place to commercial business administrations. In our country in recent years, especially in the build-operate-transfer model, some parts of the airport such as the terminal are left to private businesses. DHMİ-managed airports should also study how to operate more effectively according to the characteristics of the zone in which they are located. This study is an example of measuring and evaluating the effectiveness of airports. Different studies can be done in the future, such as economic efficiency measurement using different input output variables. Again, private-government comparative studies can be carried out if

the number of private airport enterprises increases in our country. The results of the work done may be different. It can be said that the models used in the studies and the input-output sets do not differ.

REFERENCES

Balıkçı, C. (2016). Türkiye'deki Havaalanlarının 2009 – 2014 Yılları Arasındaki Etkinliğinin Veri Zarflama Analizi Ve Malmquist Endeks Metoduyla İncelenmesi. Konya.

Banker, R., Charnes, A., & Cooper, W. (1984). Some models for estimating technical and scale inefficiencies in data envelopment analysis. Management science.

Barros, C. P., & Dieke, P. U. (2008). Measuring the economic efficiency of airports: A Simar–Wilson methodology analysis. Transportation Research Part E: Logistics and Transportation Review, 44 (6), 1039-1051.

Charnes, A., Cooper, W., & Rhodes, E. (1978). Measuring the efficiency of decision making units. European Journal of Operational Research, .

Gerede, E. (2002). Havayolu taşımacılığında küreselleşme ve havayolu işbirlikleri-Thy Ao'da bir uygulama. Yayınlanmamış Doktora Tezi. Eskişehir: Anadolu Üniversitesi Sosyal Bilimler Enstitüsü.

ICAO Annex 14. (2009). ICAO.

Kıyıldı, R. K., & Karaşahin, M. (2006). Türkiye'deki Hava Alanlarının Veri Zarflama Analizi İle Altyapı Performansının Değerlendirilmesi. SDÜ Fen Bilimleri Enstitüsü Dergisi, 10 (3).

Peker, İ. (2009). Veri Zarflama Analizi İle Türkiye Havalimanlarında Bir Etkinlik Ölçümü Uygulaması. Ç.Ü. Sosyal Bilimler Enstitüsü Dergisi, Cilt 18, Sayı 2. (tarihsiz). http://www.deu.edu.tr: https://www.google.com.tr/url?sa=t&rct=j&q= &esrc=s&source=web&cd=4&cad=rja&uact=8&ved=0ahUKEwjS1IX_y6XYAhWE6RQKHX7NCjEQFghHMAM&url=http%3A%2F%2Fwww.deu.edu.tr%2Fuserweb%2Fk.yaralioglu%2Fdosyalar%2FVeri%2520%2520 Zarflama%2520Analizi.doc&usg=AOvVaw2pUA-wZv6 adresinden alındı

The World Factbook. (2016).

Yazgan, A. E. (2012). Veri Zarflama Analizi İle Etkinlik Ölçümleri ve Havacılık Sektöründe Bir Uygulama. Tokat.