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The Evaluating the Efficiency Performance of Turkish Airports (2010 – 2014)

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Abstract

Air transport has a very important position in today's social and commercial life. Therefore, effective management of the airports is very important for efficient use of resources and the provision for the investments. General Directorate of State Airports Authority (DHMI) in Turkey operate a large majority of the airports. It introduced a Build – Operate – Transfer (BOT) model and enables active private participation in airport management. This paper utilizes a data envelopment analysis (DEA) to compare the relative efficiency of the airports in Turkey for the years between 2010-2014. The analysis is performed in two stages. Firstly, efficiency scores for each airport are calculated. The number of employees, total expenses, the number of check in counters and the number of aprons were taken into account as inputs; the number of passengers, total revenues, aircraft traffic and baggage traffic were considered as outputs for DEA analysis. Secondly, statistical results and a censored Tobit regression model are employed to identify which factors significantly explain variations in the airport efficiency. Finally, efficiency scores and regression analysis are examined and evaluated.

Keywords: Data Envelopment Analysis; Tobit Regression; Airport; Efficiency.

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1. Introduction

In Turkey, management of Turkish airports and control of Turkish airspace are performed by General Directorate of State Airports Authority (DHMI). It started as a flying school in the year of 1912. The spectacular development of civil aviation made it necessary to separate the functions of air transport and the operation of aerodromes, which were entrusted to Turkish Airlines and the Directorate General of the State Airports Enterprise respectively. After having operated as the Airport Management Company, it reached its final destination as the State Airports Enterprise. It was born legally on 8 November, 1984 [1]. As part of air navigation by DHMI, traffic of airplanes and passengers, which are offered service has increased significantly in recent years. Especially, there has been significant progress at international flight airplane and passenger traffic of the international airports. Therefore, improving operation efficiency has become an important development strategy for Turkey.

The lack of detailed study about the Turkish airports in the literature increases the importance of this study. There is no detailed information all airports in Turkey but this study focuses on major 25 airports of Turkey. The authors in [2] used Malmquist productivity index to assess the operational performance of 21 Turkey airports during the period of 2009 through 2014. The authors in [3] studied the effect procargo on technical and scale efficiency using Data Envelopment Analysis (DEA) for 35 Spanish airports over the 2009 to 2011 period. The authors in [4] used the multi-criteria decision making method Analytic Hierarchy Process (AHP) to incorporate the weightings of input and output variables into Data Envelopment Analysis (DEA) and Assurance Region DEA (DEA-AR) models, with 24 major international airports in their empirical analysis. The authors in [5] evaluated the operational efficiency of 21 Asia–Pacific airports between 2002 and 2011. They were used a two-stage method: Data Envelopment Analysis (DEA) to assess airport efficiency, followed by the second-stage regression analysis to identify the key determinants of airport efficiency. The aim of this study is to measure and to explain the performance of Turkish airports. First, we used a non-parametric approach DEA method and calculated efficiency scores of overall Turkish airports over the period 2010-2014. Then, using efficiency measures derived from DEA method we investigated how the regression results provide a `net' performance and also identify what the relative importance of each variable is in affecting performance. Last, we evaluate the determinants of Turkish airports efficiency on four explanatory variables : the number of employees, total expenses, the number of check – in counters and the number of aprons by the Tobit regression model approach.

2. Materials and Methods

2.1. Tobit Regression Analysis

The tobit regression model, first proposed by Tobin in 1958, is intended for measures with censored data. On censored measures all cases falling above (or below) a specified threshold or cutoff value take on real, continuous values [6]. The tobit model is designed to estimate linear relationships between variables when there is either left- or right-censoring in the dependent variable. Censoring from above takes place when cases with a value at or above some threshold, all take on the value of that threshold, so that the true value might be equal to the threshold, but it might also be higher. In the case of censoring from below, values those that fall at or below some threshold are censored [7]. In the standard Tobit model, we have a dependent variable y that is left-censored at zero:

$$y_i^* = x_i'\beta + \varepsilon_i \quad (1)$$

$$y_i = \begin{cases} 0 & \text{if } y_i^* \leq 0 \\ y_i^* & \text{if } y_i^* > 0 \end{cases} \quad (2)$$

Here the subscript i = 1, . . . , N indicates the observation, y_i^* is an unobserved variable, x_i is a vector of explanatory variables, β is a vector of unknown parameters, and ϵ_i is a disturbance term. The censored regression model is a generalization of the standard Tobit model. The dependent variable can be either left-censored, right-censored, or both left-censored and right-censored, where the lower and/or upper limit of the dependent variable can be any number:

$$y_i^* = x_i'\beta + \varepsilon_i \quad (3)$$

$$y_i = \begin{cases} a & \text{if } y_i^* \leq a \\ y_i^* & \text{if } a < y_i^* < b \\ b & \text{if } y_i^* \geq b \end{cases} \quad (4)$$

Here a is the lower limit and b is the upper limit of the dependent variable. If a = $-\infty$ or b = ∞, the dependent variable is not left-censored or right-censored, respectively [8].

2.2. Data Envelopment Analysis

Data envelopment analysis (DEA) is a linear programming based approach for measuring relative efficiencies or performances of peer decision making units (DMUs) since the paper of [9], based on the seminal work of [10]. The performance or efficiency of a DMU is expressed in terms of a set of measures which are classified or coined as DEA inputs and outputs [11]. Suppose we have a set of n decision – making units (DMUs) in the model, and each DMU has m inputs and s outputs. The CCR model can be mathematically expressed as (5).

$$\text{Max } \frac{\sum_{r=1}^{s} u_{rk} Y_{rk}}{\sum_{i=1}^{m} v_{ik} X_{ik}}$$

Subject to:

$$\frac{\sum_{r=1}^{s} u_{rk} Y_{rj}}{\sum_{i=1}^{m} v_{ik} X_{ij}} \leq 1 \qquad \text{for all } j \quad (5)$$

$u_{rk} \geq 0$, $v_{ik} \geq 0$ for all r,k

Y_{rj} = the vector of output r produced by unit j,

X_{ij} = the vector of input i used by unit j,

u_{rk} = the weight given to output r by the base unit k

v_{ik} = the weight given to input i by the base unit k

$(r = 1, \dots, s)$, $(i = 1, \dots, m)$ [12,13,14].

The DEA relative efficiency measure (5) for a target decision making unit k can be determined by solving the above mentioned CCR model [9]. This approach is called the CCR (Charnes, Cooper and Rhodes) model. It calculates the efficiency ratio for the DMUs based on their inputs and outputs. CCR model is under constant returns to scale (CRS) technology [15].

This means that inputs and outputs are linked in a strictly proportional manner. While taking variable returns to scale (VRS) technology into consideration, the authors in [15] developed another basic DEA model is called BCC model.

It estimates the pure technical efficiency of a DMU at a given scale of operation. The only difference between the CCR and BCC models is the convexity condition of the BCC model, which means that the frontiers of the BCC model have piecewise linear and concave characteristics, which lead to variable returns to scale [16].

2.3. Dataset

Turkey has 53 operational airports nationwide managed by DHMI. Desired input – output variables has not been reached for the all airports such as newly formed. For this reason, we focuses on 25 major airports of Turkey in Table 1. Data were collected via the annual reports of the airports and DHMI website [17,18,1,19,20]. Annual data were collected for the period of 2010-2014 with a total of 200 observations.

Table 1: List of the selected airports

İstanbul Atatürk	Diyarbakır
Ankara Esenboga	Elazıg
İzmir Adnan Menderes	Hatay
Antalya	Kayseri
Mugla Dalaman	Konya
Mugla Milas Bodrum	Malatya
Adana	Mus
Trabzon	Samsun Carsamba
Nevsehir Kapadokya	Sivas
Erzurum	Sanlıurfa
Gaziantep	Tekirdag
Bursa Yenisehir	Van Ferit Melen
Denizli Cardak	

The measurement of efficiency is based on the relationship between output produced and inputs required for production.

In the general DEA method, the number of DMUs observed should be at least twice the sum of the number of input and output variables or the number of airport observations be equal or larger than the product of the number of airport input and output variables for this study [21,5,2].

In this paper we consider x_1: the number of check – in counters, x_2: the number of employees, x_3: total expenses and x_4: the number of aprons as inputs. y_1: the number of passengers, y_2: total revenues, y_3: aircraft traffic and y_4: baggage traffic consider as outputs.

A summary of the descriptive statistics related to the airport input and output variables for 25 airports are presented in Table 2 for the period of 2010 – 2014.

Table 2: Descriptive statistics about Turkish airports

		Outputs				**Inputs**			
		y_1	y_2	y_3	y_4	x_1	x_2	x_3	x_4
2010	Mean	3605930,4	61666,8	31405,8	52137,0	40,0	249,1	23212,6	19,4
	St.Dev.	7506423,9	167860,5	62498,2	123996,9	65,6	284,6	23457,6	26,3
	Max	32143819,0	717728,0	288246,0	477120,0	320,0	1174,0	92306,0	98,0
	Min	74404,0	702,0	1281,0	1034,0	5,0	46,0	4261,0	2,0
2011	Mean	4116639,4	77272,5	35378,0	59095,6	44,4	258,4	27239,9	20,1
	St.Dev.	8655091,5	211408,2	70152,1	143178,3	69,7	288,1	28058,1	26,3
	Max	37394694,0	920636,0	325209,0	555721,0	320,0	1202,0	123532,0	98,0
	Min	43120,0	906,0	1804,0	1463,0	5,0	49,0	4870,0	2,0
2012	Mean	4531175,2	77513,4	36953,1	57244,4	33,4	259,0	33782,4	22,6
	St.Dev.	9960183,3	212100,7	76909,3	143093,9	45,4	291,9	35106,7	31,1
	Max	45091962,0	958795,0	364322,0	670330,0	169,0	1206,0	146567,0	104,0
	Min	26257,0	1469,0	1812,0	1053,0	5,0	51,0	6607,0	1,0
2013	Mean	5110355,9	92301,8	40841,8	64412,1	47,8	268,8	35841,3	23,9
	St.Dev.	11188787,8	254550,7	85098,8	164607,3	72,0	290,6	38167,5	28,1
	Max	51297790,0	1169358,0	406317,0	782952,0	320,0	1170,0	157216,0	102,0
	Min	66929,0	1729,0	2175,0	854,0	5,0	56,0	7412,0	3,0
2014	Mean	5692514,7	124023,0	44722,5	71700,8	53,0	272,6	43736,7	26,3
	St.Dev.	12443101,0	342596,5	92979,9	186280,3	75,3	289,7	50822,9	32,7
	Max	56695166,0	1584442,0	439532,0	877148,0	320,0	1149,0	213382,0	129,0
	Min	74108,0	2139,0	2294,0	1008,0	6,0	62,0	9081,0	3,0

To ensure the validity of the DEA model specification, all intercorrelations between inputs and outputs was calculated. If the correlation of the selected input and output factors is positive, the factors can be included in the analysis. Also, when the correlation is negative, then the variable should be omitted from DEA analysis. In this paper, correlation coefficient for selected input and output factors are positive and they are presented in Table 3.

Table 3: Correlation matrix between inputs and outputs

	Output_1	Output_2	Output_3	Output_4	Input_1	Input_2	Input_3	Input_4
Output_1	1	,983**	,989**	,981**	,823**	,736**	,884**	,948**
Output_2	,983**	1	,969**	,986**	,777**	,610**	,797**	,908**
Output_3	,989**	,969**	1	,949**	,883**	,753**	,884**	,923**
Output_4	,981**	,986**	,949**	1	,710**	,641**	,819**	,939**
Input_1	,823**	,777**	,883**	,710**	1	,766**	,823**	,757**
Input_2	,736**	,610**	,753**	,641**	,766**	1	,945**	,810**
Input_3	,884**	,797**	,884**	,819**	,823**	,945**	1	,920**
Input_4	,948**	,908**	,923**	,939**	,757**	,810**	,920**	1

**. Correlation is significant at the 0.01 level (2-tailed).

The correlation matrix calculated by SPSS 20 Package Program.

3. Results

We used input oriented CCR model to measure the relative efficiencies by using Max – DEA ultra software package. The results given in Table 4 provide efficiency performance indicators of 25 airports for the years 2010 - 2014.

Results of DEA from model specification in Equation (5) are presented in Table 4 for the efficiency scores and average efficiency values between 2010 and 2014.

A value equal to 1 represents an airport with zero slacks, i.e. the corresponding DMU lies on the efficient frontier. Only Antalya, Diyarbakır and İstanbul Atatürk airports are fully efficient in all five years of analysis. Individual efficiency scores for each year can be found in the Table 4.

The performance assessment can be carried out by comparing a particular system with key competitors having best performance within the same group or another group performing similar functions [22]. This process is called benchmarking [23].

Table 5 shows the results of efficiency analysis for the inefficient DMUs. Efficient DMUs can be selected by inefficient DMUs as best practice DMUs, making them a composite DMU instead of using a single DMU as a benchmark.

For example, detailed benchmarking of inefficient Ankara Esenboga is shown in Table 5, the composite DMU that represents the best reference composite benchmark DMU is formed by the combination of Antalya, Diyarbakır, İstanbul Atatürk and Tekirdag.

The lambda values are weights to be used as multipliers for the input levels of a reference airport to indicate the input targets that an inefficient airport should aim at in order to achieve efficiency [23]. The benchmark airports for the inefficient airports in the 2011,2012,2013 and 2014 are shown in Appendix A.

Table 4: The efficiency scores of the airports during the period of 2010 – 2014

No	Airports	2010	2011	2012	2013	2014
1	Adana	0,4126	0,9087	0,6360	0,9483	0,9813
2	Ankara Esenboga	0,5640	0,5654	0,4792	0,4839	0,4788
3	Antalya	**1,0000**	**1,0000**	**1,0000**	**1,0000**	**1,0000**
4	Bursa Yenisehir	0,2099	0,2487	0,2937	0,3610	0,3921
5	Denizli Cardak	0,1329	0,1439	0,1422	0,2115	0,2734
6	Diyarbakır	**1,0000**	**1,0000**	**1,0000**	**1,0000**	**1,0000**
7	Elazıg	0,4498	0,4493	0,3270	0,2832	0,2803
8	Erzurum	0,2922	0,3985	0,2760	0,3366	0,3544
9	Gaziantep	0,4793	0,5797	0,5149	0,7150	0,7046
10	Hatay	0,7445	0,5111	0,5418	0,3470	0,4326
11	İstanbul Atatürk	**1,0000**	**1,0000**	**1,0000**	**1,0000**	**1,0000**
12	İzmir Adnan Menderes	0,6072	0,6136	0,7992	0,9638	0,6546
13	Kayseri	0,4849	0,3901	0,3877	0,4220	0,4699
14	Konya	1,0000	0,8701	0,3764	1,0000	0,5725
15	Malatya	0,3694	0,3329	0,2830	0,4149	0,3624
16	Mugla Dalaman	0,4121	0,3579	0,4509	0,3491	0,4242
17	Mugla Milas Bodrum	0,3991	0,6998	0,3252	0,2933	0,3631
18	Mus	0,2722	0,2368	0,2484	0,2760	0,2962
19	Nevsehir Kapadokya	0,1049	0,1073	0,1142	0,1192	0,1606
20	Samsun Carsamba	0,3682	0,4347	0,3001	0,4676	0,5741
21	Sanlıurfa	0,1510	0,1529	0,1215	0,3394	0,3499
22	Sivas	0,1098	0,1249	0,6703	0,1444	0,1677
23	Tekirdag	1,0000	1,0000	0,6238	1,0000	1,0000
24	Trabzon	0,6994	0,4391	0,3998	0,4531	0,4430
25	Van Ferit Melen	0,5582	0,9043	0,3956	0,7116	0,6823
	Mean	**0,5129**	**0,5388**	**0,4683**	**0,5456**	**0,5367**

To obtain the net efficiency index we undertake a second stage of analysis and analyzed the effects of the number of check – in counters, the number of employees, total expenses and the number of aprons on efficiency using Tobit regression. The DEA efficiency measure has a lower bound of 1.

Thus we use the censored Tobit regression model [8, 24]. Table 6 reports the Tobit regression results for airport efficiency. In the airport efficiency regression we are trying to determine which variables have the most impact on the efficiency.

According to Table 6 while the number of check – in counters and the number of employees were found to be insignificant parameters, total expenses and the number of aprons were found as statistically significant parameters for 2010.

Table 5: The benchmark airports and values for inefficient airports in 2010

No	DMU (Airports)	Efficiency	Benchmark(Lambda)
1	Adana	0,4126	İstanbul Atatürk(0,0984); Tekirdag(0,0968)
2	Ankara Esenboga	0,5640	Antalya(0,0749); Diyarbakır(3,1516); İstanbul Atatürk(0,0511); Tekirdag(0,6085)
4	Bursa Yenisehir	0,2099	Diyarbakır(0,1773); İstanbul Atatürk(0,0015); Tekirdag(0,0716)
5	Denizli Cardak	0,1329	Diyarbakır(0,0760); İstanbul Atatürk(0,0030)
7	Elazıg	0,4498	Antalya(0,0018); Diyarbakır(0,2653); Konya(0,1023); Tekirdag(0,0160)
8	Erzurum	0,2922	Antalya(0,0335); Konya(0,0399); Tekirdag(0,0783)
9	Gaziantep	0,4793	Antalya(0,0089); Diyarbakır(0,5278); Konya(0,1868); Tekirdag(0,0944)
10	Hatay	0,7445	Antalya(0,0082); Diyarbakır(0,2395); Konya(0,0987); Tekirdag(0,0496)
12	İzmir Adnan Menderes	0,6072	Antalya(0,0246); Diyarbakır(2,2577); İstanbul Atatürk(0,1173); Tekirdag(0,0051)
13	Kayseri	0,4849	Antalya(0,0198); Diyarbakır(0,2438); İstanbul Atatürk(0,0048); Tekirdag(0,0733)
15	Malatya	0,3694	Antalya(0,0068); Diyarbakır(0,1337); İstanbul Atatürk(0,0054); Tekirdag(0,0916)
16	Mugla Dalaman	0,4121	Antalya(0,0685); İstanbul Atatürk(0,0708)
17	Mugla Milas Bodrum	0,3991	Antalya(0,0380); İstanbul Atatürk(0,0775)
18	Mus	0,2722	Diyarbakır(0,1096); İstanbul Atatürk(0,0011); Tekirdag(0,0095)
19	Nevsehir Kapadokya	0,1049	Diyarbakır(0,0839); İstanbul Atatürk(0,0027)
20	Samsun Carsamba	0,3682	Antalya(0,0115); Diyarbakır(0,4388); İstanbul Atatürk(0,0024); Tekirdag(0,0942)
21	Sanlıurfa	0,1510	Antalya(0,0036); Diyarbakır(0,0443); İstanbul Atatürk(0,0023); Tekirdag(0,0457)
22	Sivas	0,1098	Antalya(0,0033); Diyarbakır(0,0224); Konya(0,0070); Tekirdag(0,0236)
24	Trabzon	0,6994	Diyarbakır(1,3515); İstanbul Atatürk(0,0085)
25	Van Ferit Melen	0,5582	Antalya(0,0165); Diyarbakır(0,3696); İstanbul Atatürk(0,0001); Tekirdag(0,0610)

The number of check – in counters, the number of employees and total expenses were found to be significant parameters and the number of aprons were found as statistically insignificant parameters for 2011.

The number of check – in counters, the number of employees, total expenses and the number of aprons were found to be insignificant parameters for 2012, 2013 and 2014.

Table 6: Tobit Regression Results for 2010 – 2014

		Coefficient	s.d.	z - value	Prob.
2010	(Intercept):1	0,396400	0,102100	3,883000	0,000103
	(Intercept):2	-1,165000	0,165800	-7,027000	0,000000
	x1	-0,000765	0,001738	-0,440000	0,659995
	x2	-0,001408	0,000799	-1,762000	0,078141
	x3	0,000040	0,000016	2,563000	0,010385
	x4	-0,020150	0,007309	-2,757000	0,005831
2011	(Intercept):1	0,240200	0,100800	2,383000	0,017170
	(Intercept):2	-1,365000	0,161400	-8,456000	0,000000
	x1	-0,011510	0,004024	-2,860000	0,004240
	x2	-0,002765	0,000842	-3,284000	0,001020
	x3	0,000059	0,000015	3,993000	0,000065
	x4	-0,002269	0,005614	-0,404000	0,686090
2012	(Intercept):1	0,417100	0,078750	5,296000	0,000000
	(Intercept):2	-1,292000	0,152100	-8,494000	0,000000
	x1	-0,002360	0,002712	-0,870000	0,384000
	x2	-0,000003	0,000934	-0,004000	0,997000
	x3	0,000002	0,000009	0,221000	0,825000
	x4	0,003571	0,004213	0,848000	0,397000
2013	(Intercept):1	0,549400	0,127900	4,294000	0,000018
	(Intercept):2	-1,027000	0,169400	-6,063000	0,000000
	x1	0,001062	0,004419	0,240000	0,810000
	x2	-0,000164	0,001476	-0,111000	0,912000
	x3	0,000003	0,000016	0,200000	0,842000
	x4	-0,003670	0,005464	-0,672000	0,502000
2014	(Intercept):1	0,549800	0,085520	6,429000	0,000000
	(Intercept):2	-1,269000	0,156100	-8,131000	0,000000
	x1	0,004949	0,002849	1,737000	0,082400
	x2	-0,000199	0,000696	-0,285000	0,775400
	x3	-0,000002	0,000005	-0,346000	0,729100
	x4	-0,004484	0,003917	-1,145000	0,252400

4. Conclusions

Airports play a significant role in the aeronautics chain, linking airlines with their passengers and freight customers. This paper measures and compares the efficiency of 25 Turkish airports for the period 2010-2014. Tobit regression model investigated whether the number of check – in counters, the number of employees, total expenses and the number of aprons have a significant influence on the efficiency of Turkish airports.

The findings indicated that the efficiency of the Turkish airports increased during the period under investigation. 2011 has been a good year for the DHMI referring to the air traffic volume. The growth was strongly driven by additional international traffic and also by substantial growth in the domestic segments. Growth in 2011 was particularly strong in Turkey in the medium term 12 % average annual growth rate in domestic movements , 14 % growth in international movements by DHMI We can say a significant decline in mean of efficiency scores for the period of 2011–2012. The main reason of this stagnation is the significant increase in the traffic capacity of the Turkish airports in 2011. According to the DHMI Annual Report, in 2012 the number of total traffic is +11 % compared to 2011. With the increase of traffic in Turkey, there is a continuously growing demand for capacity at major Turkish airports especially İstanbul Atatürk and Antalya. Due to an imbalance between the demand for these airports and the availability of adequate airport infrastructure and airspace systems have been distributed in an equitable, non-discriminatory and transparent way by DHMI since June 2010. To be operationally successful, DHMI ensures close co-operation and coordination with airport authorities and airlines.

As a result, in spite of declining in the period of 2011–2012, efficiency scores of Turkish airports have increased again since 2013. As an extension of this study, it may be meaningful to include more Turkish airport data such as health and security variables that may have a significant impact on efficiency.

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Appendix A

Table 7: The benchmark airports and values for inefficient airports in 2011

No	DMU (Airports)	Efficiency	Benchmark(Lambda)
1	Adana	0,9087	Antalya(0,0238); Diyarbakır(1,5150); Tekirdag(0,4295)
2	Ankara Esenboga	0,5654	Antalya(0,0901); Diyarbakır(3,2193); İstanbul Atatürk(0,0164); Tekirdag(0,7750)
4	Bursa Yenisehir	0,2487	Diyarbakır(0,2354); İstanbul Atatürk(0,0009); Tekirdag(0,0859)
5	Denizli Cardak	0,1439	Diyarbakır(0,0983); İstanbul Atatürk(0,0028)
7	Elazıg	0,4492	Antalya(0,0033); Diyarbakır(0,2682); Tekirdag(0,0127)
8	Erzurum	0,3984	Antalya(0,0031); Diyarbakır(0,4169); Tekirdag(0,0662)
9	Gaziantep	0,5796	Antalya(0,0102); Diyarbakır(0,6075); Tekirdag(0,1277)
10	Hatay	0,5110	Diyarbakır(0,3174); İstanbul Atatürk(0,0059)
12	İzmir Adnan Menderes	0,6136	Antalya(0,0413); Diyarbakır(1,9058); İstanbul Atatürk(0,1118); Tekirdag(0,0267)
13	Kayseri	0,3900	Diyarbakır(0,1606); İstanbul Atatürk(0,0269)
14	Konya	0,8701	Antalya(0,0021); Diyarbakır(0,3139); Tekirdag(0,0776)
15	Malatya	0,3328	Antalya(0,0003); Diyarbakır(0,1288); İstanbul Atatürk(0,0089); Tekirdag(0,0939)
16	Mugla Dalaman	0,3578	Antalya(0,0930); İstanbul Atatürk(0,0385)
17	Mugla Milas Bodrum	0,6998	Antalya(0,1501); Tekirdag(0,1393)
18	Mus	0,2367	Diyarbakır(0,0854); İstanbul Atatürk(0,0013); Tekirdag(0,0079)
19	Nevsehir Kapadokya	0,1072	Diyarbakır(0,0744); İstanbul Atatürk(0,0027); Tekirdag(0,0043)
20	Samsun Carsamba	0,4346	Antalya(0,0055); Diyarbakır(0,5850); Tekirdag(0,0675)
21	Sanlıurfa	0,1529	Antalya(0,0018); Diyarbakır(0,1065); Tekirdag(0,0298)
22	Sivas	0,1248	Diyarbakır(0,0299); İstanbul Atatürk(0,0048); Tekirdag(0,0167)
24	Trabzon	0,4391	Antalya(0,0101); Diyarbakır(0,6898); İstanbul Atatürk(0,0221); Tekirdag(0,0467)
25	Van Ferit Melen	0,9043	Diyarbakır(0,6079); Tekirdag(0,0781)

Table 8: The benchmark airports and values for inefficient airports in 2012

No	DMU (Airports)	Efficiency	Benchmark(Lambda)
1	Adana	0,6360	İstanbul Atatürk(0,1060)
2	Ankara Esenboga	0,4791	Diyarbakır(2,9932); İstanbul Atatürk(0,1440)
4	Bursa Yenisehir	0,2937	Diyarbakır(0,3019); İstanbul Atatürk(0,0082)
5	Denizli Cardak	0,1421	Diyarbakır(0,0567); İstanbul Atatürk(0,0065)
7	Elazıg	0,3269	Diyarbakır(0,2179); İstanbul Atatürk(0,0094)
8	Erzurum	0,2759	İstanbul Atatürk(0,0201)
9	Gaziantep	0,5148	Diyarbakır(0,5966); İstanbul Atatürk(0,0174)
10	Hatay	0,5418	Diyarbakır(0,2512); İstanbul Atatürk(0,0083)
12	İzmir Adnan Menderes	0,7992	İstanbul Atatürk(0,2074)
13	Kayseri	0,3876	Diyarbakır(0,1722); İstanbul Atatürk(0,0248)
14	Konya	0,3764	İstanbul Atatürk(0,0196)
15	Malatya	0,2829	Diyarbakır(0,1071); İstanbul Atatürk(0,0159)
16	Mugla Dalaman	0,4508	İstanbul Atatürk(0,0845)
17	Mugla Milas Bodrum	0,3251	İstanbul Atatürk(0,0799)
18	Mus	0,2484	Diyarbakır(0,1098); İstanbul Atatürk(0,0016)
19	Nevsehir Kapadokya	0,1141	Diyarbakır(0,0797); İstanbul Atatürk(0,0031)
20	Samsun Carsamba	0,3001	Diyarbakır(0,2288); İstanbul Atatürk(0,0120)
21	Sanlıurfa	0,1215	Diyarbakır(0,0303); İstanbul Atatürk(0,0084)
22	Sivas	0,6702	Diyarbakır(0,2192); İstanbul Atatürk(0,0001)
23	Tekirdag	0,6237	İstanbul Atatürk(0,0454)
24	Trabzon	0,3998	Diyarbakır(0,5320); İstanbul Atatürk(0,0384)
25	Van Ferit Melen	0,3955	Diyarbakır(0,2144); İstanbul Atatürk(0,0166)

Table 9: The benchmark airports and values for inefficient airports in 2013

No	DMU (Airports)	Efficiency	Benchmark(Lambda)
1	Adana	0,9483	İstanbul Atatürk(0,0586); Konya(1,5372); Tekirdag(0,2849)
2	Ankara Esenboga	0,4839	Diyarbakır(0,2126); İstanbul Atatürk(0,2309)
4	Bursa Yenisehir	0,3610	İstanbul Atatürk(0,0155); Tekirdag(0,0107)
5	Denizli Cardak	0,2115	Diyarbakır(0,1155); İstanbul Atatürk(0,0090)
7	Elazıg	0,2832	Diyarbakır(0,0193)
8	Erzurum	0,3366	İstanbul Atatürk(0,0112); Konya(0,3599)
9	Gaziantep	0,7150	İstanbul Atatürk(0,0290); Konya(0,4005); Tekirdag(0,0181)
10	Hatay	0,3470	İstanbul Atatürk(0,0194); Tekirdag(0,0017)
12	İzmir Adnan Menderes	0,9638	İstanbul Atatürk(0,1824); Konya(1,0474)
13	Kayseri	0,4220	Diyarbakır(0,2078); İstanbul Atatürk(0,0269)

15	Malatya	0,4149	İstanbul Atatürk(0,0163); Tekirdag(0,0228)
16	Mugla Dalaman	0,3491	Antalya(0,0424); İstanbul Atatürk(0,0566)
17	Mugla Milas Bodrum	0,2933	İstanbul Atatürk(0,0739)
18	Mus	0,2760	İstanbul Atatürk(0,0039); Konya(0,0794)
19	Nevsehir Kapadokya	0,1192	Diyarbakır(0,0144); İstanbul Atatürk(0,0054)
20	Samsun Carsamba	0,4676	İstanbul Atatürk(0,0236); Konya(0,1406); Tekirdag(0,0210)
21	Sanlıurfa	0,3394	İstanbul Atatürk(0,0076); Konya(0,1827); Tekirdag(0,0045)
22	Sivas	0,1444	İstanbul Atatürk(0,0071); Tekirdag(0,0025)
24	Trabzon	0,4531	İstanbul Atatürk(0,0481); Konya(0,1785)
25	Van Ferit Melen	0,7116	İstanbul Atatürk(0,0194); Konya(0,1492); Tekirdag(0,0201)

Table 10: The benchmark airports and values for inefficient airports in 2014

No	DMU (Airports)	Efficiency	Benchmark(Lambda)
1	Adana	0,9813	İstanbul Atatürk(0,0816); Tekirdag(0,4727)
2	Ankara Esenboga	0,4788	Diyarbakır(3,5681); İstanbul Atatürk(0,1025)
4	Bursa Yenisehir	0,3921	İstanbul Atatürk(0,0170); Tekirdag(0,0027)
5	Denizli Cardak	0,2734	Diyarbakır(0,1699); İstanbul Atatürk(0,0087)
7	Elazıg	0,2803	Diyarbakır(0,1005)
8	Erzurum	0,3544	Tekirdag(0,0254)
9	Gaziantep	0,7046	Tekirdag(0,0351)
10	Hatay	0,4326	Diyarbakır(0,2319); İstanbul Atatürk(0,0147)
12	İzmir Adnan Menderes	0,6546	Diyarbakır(0,6595); İstanbul Atatürk(0,1724)
13	Kayseri	0,4699	Diyarbakır(0,3588); İstanbul Atatürk(0,0207)
14	Konya	0,5725	İstanbul Atatürk(0,0206); Tekirdag(0,0353)
15	Malatya	0,3624	İstanbul Atatürk(0,0144); Tekirdag(0,0124)
16	Mugla Dalaman	0,4242	Antalya(0,0338); İstanbul Atatürk(0,0591)
17	Mugla Milas Bodrum	0,3631	İstanbul Atatürk(0,0772)
18	Mus	0,2962	İstanbul Atatürk(0,0055)
19	Nevsehir Kapadokya	0,1606	Diyarbakır(0,0692); İstanbul Atatürk(0,0046)
20	Samsun Carsamba	0,5741	Tekirdag(0,0307)
21	Sanlıurfa	0,3499	Tekirdag(0,0240)
22	Sivas	0,1677	Diyarbakır(0,0410); İstanbul Atatürk(0,0068)
24	Trabzon	0,4430	Diyarbakır(0,1235); İstanbul Atatürk(0,0452)
25	Van Ferit Melen	0,6823	Tekirdag(0,0015)