Total Factor Productivity Changes of Turkey's Regional Air Transportation Using Dea With Malmquist Index

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ABSTRACT

In this study, the efficiency of the airline transportation, a fast growing sector in Turkey, was examined for 12 different regions of Turkey. The changes in the total factor productivity were evaluated by data envelope analysis (DEA) and Malmquist Index approach. Within scope of the study, 12 different regions were selected as decision maker. By collecting the necessary data of all airports in these regions, the variations in the total factor productivity values were calculated and discussed for both domestic and international lines. It is considered that the results are valuable as they offer numerical contribution to the future policies developed to make some progress in the airline transportation sector of the region.

Keywords: Airport, Efficiency, Productivity change, DEA

1. INTRODUCTION

Today, different cooperation, e.g., technical, economical, financial, commercial, administrative and institutional, are established between countries and cities regardless of how far the distances are. The safe and comfortable transportation of people and goods within a short period can be achieved by airline transportation. It is well-known that airline transportation accelerates the economic and technological developments in local, regional, national and international scales. Besides, it is thought that airline transportation allows different people to come together and lets them know each. Thus, it also makes social and cultural contributions to the communities.

Within the scope of this study, relative performance evaluation was performed by applying DEA approach so as to determine if 12 regions of Turkey were using their airline transportation effectively or not. Meanwhile, to monitor the variation of the performance with time, total factor change of the airline transportation was examined by Malmquist Index approach. During EU harmonization process of Turkey, these analysis will help Turkey to follow new developments and tendencies appearing under the "Transportation" headline and present some numerical data to the legislations developed for transportation policies.

In recent years, in all around the world, the share of the airline transportation, for people and freight, has increased nearly at the same levels with Gross Domestic Product (GDP). The same relation also holds for Turkey. However, it was observed that, in Turkey, increases and decreases in GDP affected the airline transportation sector more strongly than the other countries. Turkey has been one of the countries with fastest growing airline transportation sector in the recent years. On the other hand, for people and freight, the share of the airline transportation was lower than share of the road transportation. Annually, almost 200 million passengers are transported in Turkey. It is known that nearly 10 % of them are transported by means of airline, while this value reaches to 30 % in European countries having well-developed airline transportation sectors.

Similar to the changes observed in the world, there was an increase in airline transportation of people and freight in Turkey between 2004 and 2010, see Fig. 1-3. As seen from the graphs, each region has an increasing trend. Especially, the annual variations of Marmara Region are notable, see Fig. 4 and 5. It is highly probable that rapid industrialization of this region was the primary reason for this. For the other 11 regions, while the airline transportation demonstrated a decrease in some years, increasing trend was maintained for the period of 2004-2010.

In order to have sustainable developments in airline transportation, regional plans should be made and applied correctly. In this study, it was aimed to contribute the development of domestic and international airline transportation in Turkey and to help the development of airline transportation-related strategies about alignment to the EU acquis.

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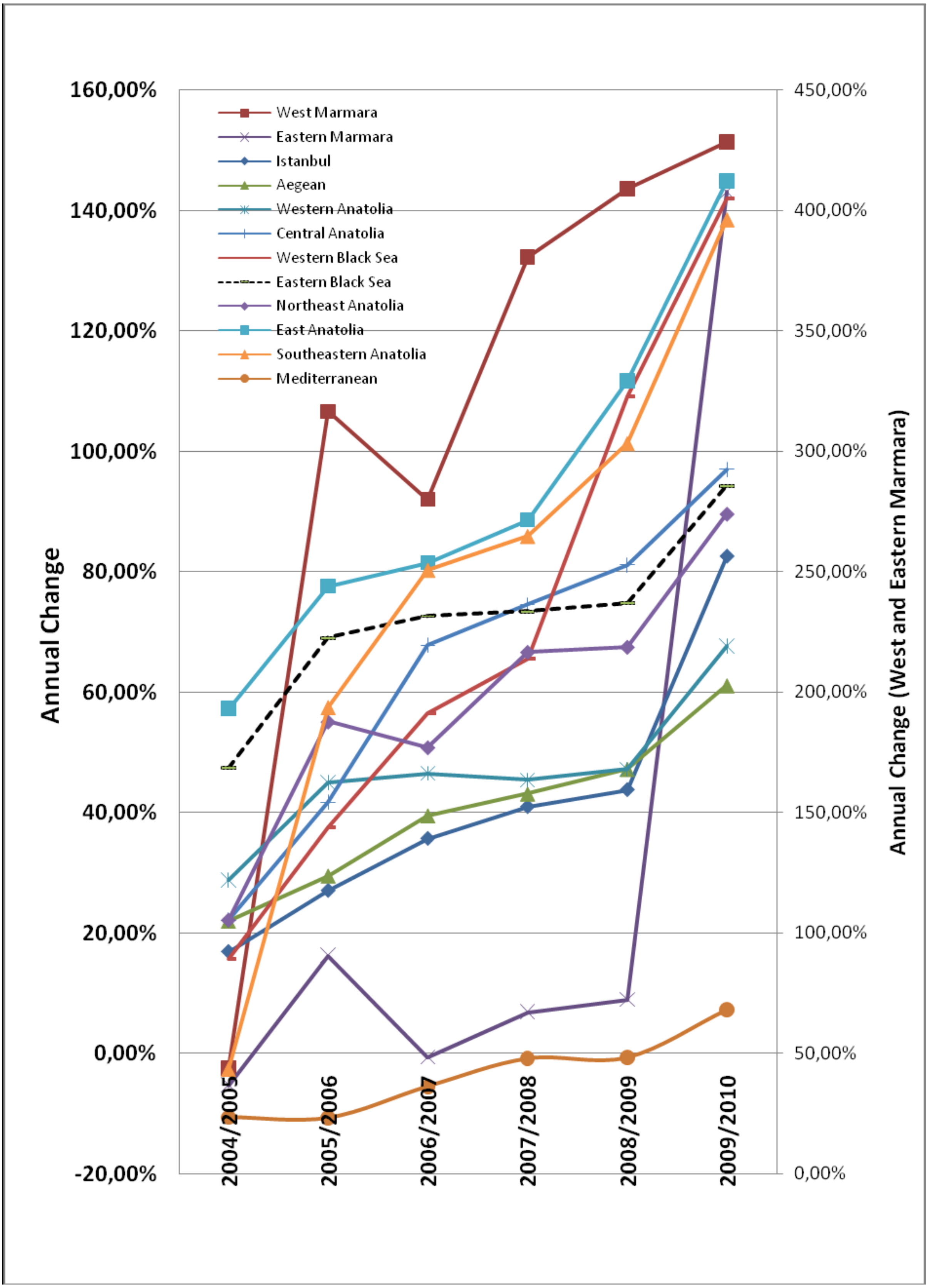

Figure 1. The annual change in the air traffic, for both arrivals and departures, between 2004-2010.

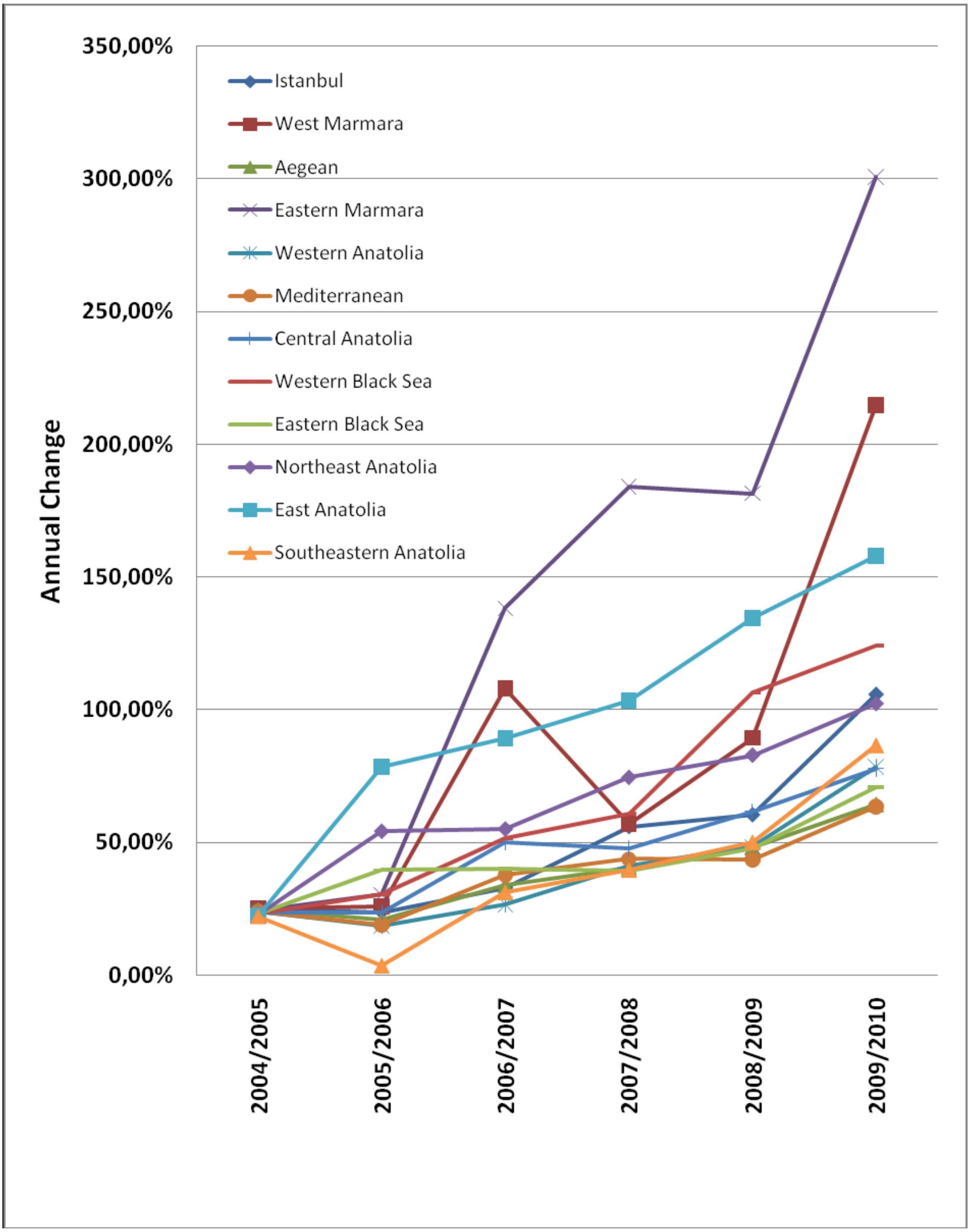

Figure 2. The annual change in the number of passengers between 2004-2010.

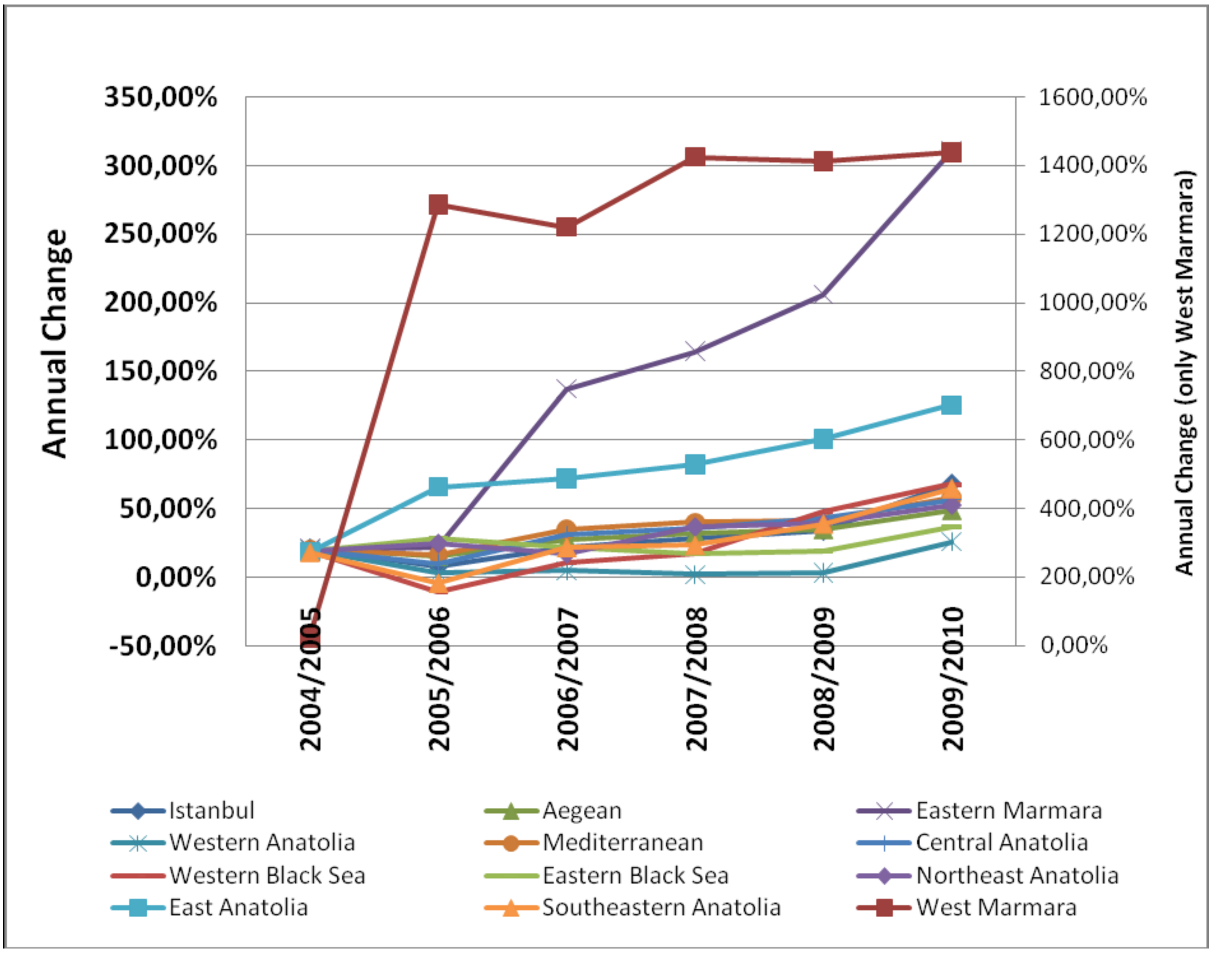

Figure 3. The annual change in the freight carried (tone) by airline in different regions of Turkey

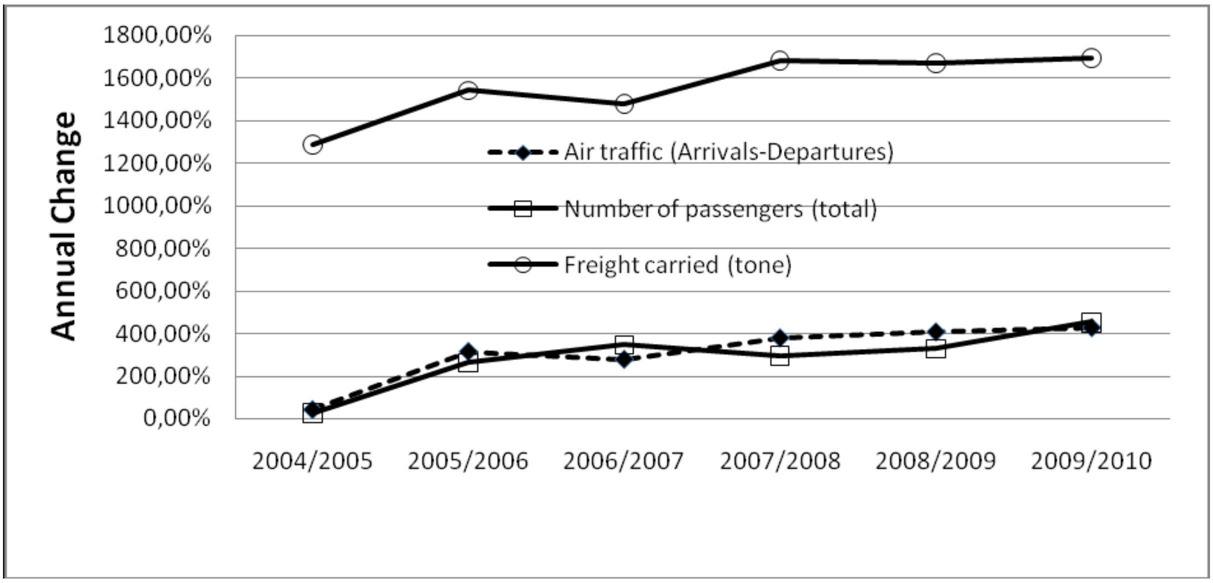

Figure 4. The annual change in the main airway indicators for Western Marmara Region

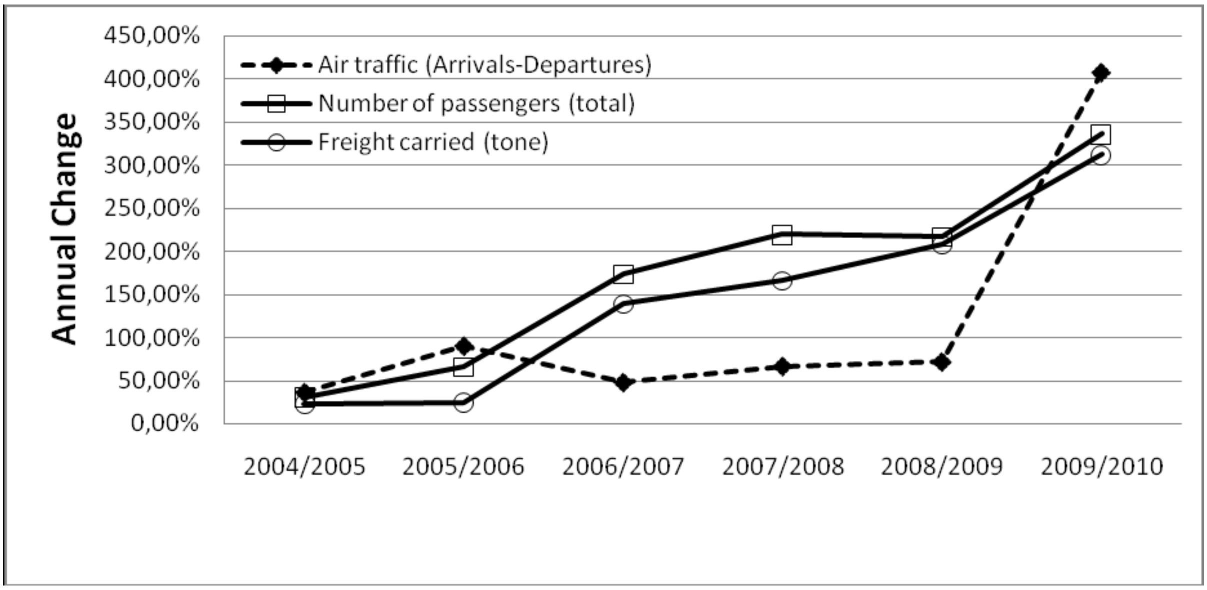

Figure 5. The annual change in the main airway indicators for Eastern Marmara Region

2. METHODOLOGY

2.1. Material

In this study, Data Envelopment Analysis (DEA), was employed to determine the air transportation performance of 12 regions of Turkey. Using the DEA models of CRS (CCR) and VRS (BCC), a section (cross-section) analysis was performed and subsequently efficiency scores were ranked. In calculations, the main air transport indicators were used as variables and regional areas were regarded as decision making units (DMU). In order to determine the efficiency, three different efficiency models were formulated taking into consideration nine input and various output variables. These models were analyzed according to their input and output values, as presented in Table 1. The aim of each model is;

Model 1: Determining the efficiency that uses the total air traffic as input and yields the number of total passengers and total freight carried as output,

Model 2: Determining the efficiency that uses the domestic air traffic as input and yields the number of domestic passengers and domestic freight carried as output,

Model 3: Determining the efficiency that uses the international air traffic as input and yields the number of international passengers and international freight carried as output

2.2. Data Envelopment Analysis and Malmquist Index

Data envelopment analysis (DEA) is a nonparametric technique to calculate productive efficiency of decision making units, comparable homogeneous organizations (Emrouznejad et al., 2008; Ray, 2004; Cook and Seiford, 2009; Charnes et al., 1978, Sozen et al., 2012, Sozen et al., 2011). DEA is commonly applied to estimate the relevant technology or production function over the production possibility set defined as the feasible combinations of inputs and outputs. Here, the production function the maximum amount of output for a specified

Table 1. Input and output variables used in the analysis **Indicators**	**MODEL 1 (Input/ Output)**	**MODEL 2 (Input/ Output)**	**MODEL 3 (Input/ Output)**
Total Air traffic (arrivals-departures)		I	
Number of passengers (total)		O	
Freight carried (total)		O	
Domestic Air traffic (arrivals-departures)		I	
Number of passengers (domestic)		O	
Freight carried (domestic)		O	
International Air traffic (arrivals-departures)		I	
Number of passengers (international)		O	
Freight carried (international)		O	

set of inputs, given the existing technology. Since it affects decision-making, the efficiency score for the given decision-making unit can be calculated.

The Malmquist index (MI) is an index based on production function used to measure productivity change over time (Malmquist, 1953; Caves et al. 1982; Fare et al.1994). In the output-oriented MI, the production technology (P) shows the transformation of inputs x into output y in time t. The output possibility set is then;

$$P_t(x) = \{y_t, x_t \text{ can produce } y_t\} \quad (1)$$

Figure 6 illustrates production technology for period t and t+1. Technical efficiency of a DMU can be measured by an output distance function, which measures the distance of an economy from the production function. The output distance function can be related to production technology through the following equation:

$$d_t(x_t, y_t) = \min \{\theta: (x_t, y_t/\theta) \in P_t(x)\} \quad (2)$$

where, θ defines a set of real numbers. The minimum of θ needs to be found such that input/output combination is a part of the production technology. This is illustrated in Fig. 6 as one input and one output assumption exhibiting constant return scale (CRS). In the figure, points A and A' represent the input/output combinations of DMUo in periods t and t+1, respectively. The efficient frontier (EF) is determined by the best performing unit. When the economy is operating at point A, it produces output b. This shows that xt, yt is technically inefficient, since the efficiency is measured by Oc/Ob (CCR (CRS) DEA model, inefficient). If production was on the frontier, then the efficiency would be 1 (CRS DEA model, efficient). Assume that at time t+1, point A shifted to point A' and the efficient frontier EF(t) shifted to EF(t+1). Then the efficiency change in DMUo is the ratio of the efficiency at t+1 to the efficiency at t. DEA CCR output-oriented Malmquist TFP index can be constructed based on t and t+1 technology as;

$$MI_o(x_t, y_t, x_{t+1}, y_{t+1}) = \sqrt{\frac{d_t^o(x_{t+1}, y_{t+1})}{d_t^o(x_t, y_t)} x \frac{d_{t+1}^o(x_{t+1}\ y_{t+1})}{d_{t+1}^o(x_t, y_t)}} \quad (3)$$

or graphically,

$$MI_o(t, t+1) = \sqrt{\frac{Of/Od}{Of/Og} x \frac{Ob/Oc}{Ob/Oe}} \quad (4)$$

Fare et al. (1983) defined that MI >1 indicates productivity gain; MI <1 indicates productivity loss and MI=1 indicates the status quo from period t to t+1, i.e., no change in productivity. They showed that this index is equivalent to:

$$MI_o(x_{t+1}, y_{t+1}, x_t, y_t) = \frac{d_{t+1}^o(x_{t+1}, y_{t+1})}{d_t^o(x_t, y_t)} \sqrt{\frac{d_t^o(x_{t+1}, y_{t+1})}{d_{t+1}^o(x_{t+1}, y_{t+1})} x \frac{d_t^o(x_t\ y_t)}{d_{t+1}^o(x_t, y_t)}} \quad (5)$$

As seen from the equation, the index is composed of two parts. The first term on the right measures the change in technical efficiency, also called Catch-Up (CU) index, which is the distance function from time period t to t+1. The second term measures the technical change, also called Frontier Shift (FS) index, between time period t and t+1. In Fig.6, two components of the MI as in the last equation are represented by:

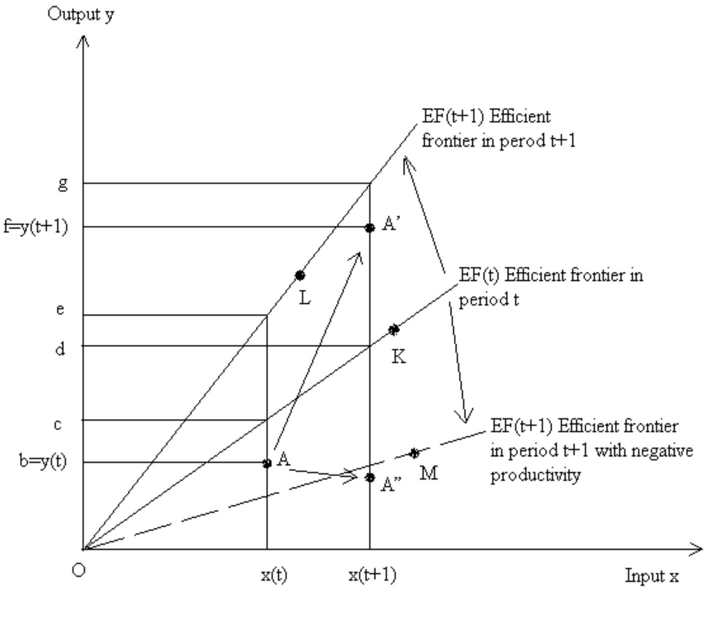

Figure 6. DEA and MI decomposition with the Efficient Frontier(EF) (Sozen et al. 2011)

Efficiency change (EFFCH) = $\dfrac{Of\,/\,Od}{Ob\,/\,Oc}$ (6)

Technical change (TECCH) = $\sqrt{\dfrac{Of\,/\,Od}{Of\,/\,Og} x \dfrac{Ob\,/\,Oc}{Ob\,/\,Oe}}$ (7)

The condition CU>1 suggests that DMU_o has moved closer to the period EF (t+1) than to the period EF (t). CU=1 and CU<1 indicate the same distance or more has been covered respectively. Referring to Fig. 6, the condition FS>1 shows that there is more output than input, indicating a positive shift in the frontier. A value of FS equal to one and less than 1 demonstrates no shift and negative shift, respectively (Hashimoto et al, 2008).

In CRS model, any radial increase in input vector, the increase of all input components at the same rate, creates a radial increase in the output vector. CCR DEA model cannot be applied globally in many economies, since it assumes that the output and input change by the same amount. Therefore, it is rather restrictive. As an extension of this approach, production technology may exhibit increasing, constant and diminishing returns to scale on the production frontiers, which are reflected in variable returns to scale (VRS) assumption, see Fig. 7. In decreasing return to scale (DRS) model, any radial increase in the input vector creates a radial increase in the output vector at a lower rate. In increasing return to scale (IRS) model, any radial increase in the input vector creates a radial increase in the output vector at a higher rate.

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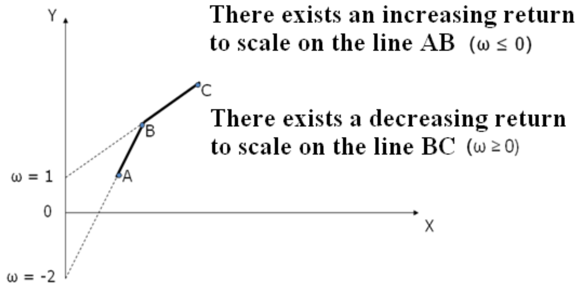

Figure 7. Variable Returns to Scale (VRS) model

Suppose that, in an economic situation where production frontier moved to OM from OL at time t+1, see Fig. 6. In this case, DMU has a positive change in technical efficiency but a negative progress. In VRS technology, efficiency change is described as the product of pure efficiency change (PECH) and scale efficiency change (SECH):

EFFCH = PECH x SECH (8)

$$\text{PECH} = \frac{d_{t+1}(x_{t+1},\, y_{t+1})}{d_t^{o}(x_t,\, y_t)} \quad (9)$$

$$\text{SECH} = \frac{d_{t+1}^{c}(x_{t+1},\, y_{t+1})}{d_{t+1}^{v}(x_{t+1,}\; y_{t+1})} \Big/ \frac{d_t^{c}(x_t,\, y_t)}{d_t^{v}(x_t,\, y_t)} \quad (10)$$

where, the subscripts ***c*** and ***v*** represent CRS and VRS technologies, respectively (Chen et al. 2008).

Various DEA models have been proposed measuring efficiency in different ways. These models are basically categorized into two: input-oriented and output-oriented. In order to find out the input-oriented efficiency of a DMU, examination of possibilities to reduce the input(s) without reducing the output(s) should be evaluated. A model is configured to determine how much the input use of a DMU decrease in a 100% efficiency condition at a constant output level. The condition for pare to efficiency is realized when it is not possible to reduce the amount of any input without increasing some other input or reducing some output.

In contrast to input-oriented efficiency, to determine the output-oriented efficiency of a DMU, a model is configured to determine how much output increase in a 100% efficiency condition at a given input level. In this approach, pare to efficiency condition occurs when it is not possible to increase the amount of any output without decreasing some other output or increasing some input. See Fig. 8 for demonstration of the input- and output-oriented efficiencies of DMUs.

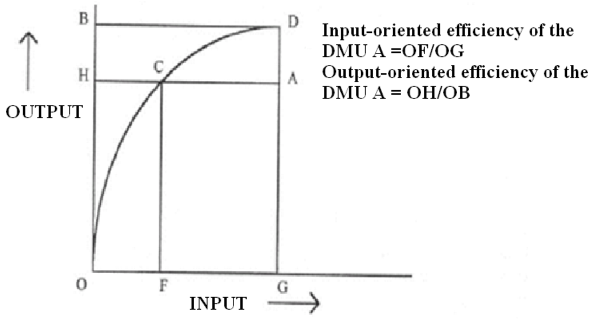

Figure 8. Input- and output-oriented efficiency

3. RESULTS

In this study, efficiency measurement system (EMS) and data envelopment analysis (DEA) (Coelli, 1996) were used for efficiency measurement. CRS and VRS output-oriented models were used to determine technical efficiency by maximizing outputs at a given input. The CRS efficiency scores of the regions for each model are given in Fig. 9. It should be noted that, in determination of the efficiencies, VRS efficiency analysis did not yield reliable results. For this reason, it was more reasonable to compare CRS efficiency scores. According to CRS efficiency scores of Model 1, the efficient region was the Eastern Marmara for the selected period. On the other hand, according to CRS efficiency scores of Model 2 and Model 3, the efficient region was the Western Marmara. Note that, year 2010 for Model 2 and year 2004 for Model 3 did not fit these results.

Within the scope of this study, scores of efficiency change (effch), technical change (techch) (innovation), pure technical efficiency change (pech), scale efficiency change (sech) and total factor productivity change (tfpch) were calculated. The overall efficiency of the airline transportation for 12 regions was performed through the evaluation of tfpch. It was considered that different values of tfpch indicate different conditions. For example, if the value is equal to 1 for a region, this implies that productivity of the region was the same with respect to its inputs and outputs. The value of tfpch greater than 1 indicates an increase in productivity while, values lower than 1 implies a regression in productivity.

Malmquist Index results of the Model 1 are given in Fig. 10-14 for each efficiency change. Note that, the year 2005 was considered as the base year in these diagrams. According to effch given in Fig. 10, the region with most apparent efficiency change was the Western Marmara. While this highly industrialized region demonstrated a decrease in 2006-2007, a nearly constant efficiency change was calculated for it for the rest of the period. This can be considered as the effect of the economical crises occured in 2007. The region, whose efficiency change altered in the positive direction with respect to the other years, was the Western Black Sea.

The variation of Techch for Model 1 is given in Fig. 11. As seen form the figure, the most significant changes in the techch were observed in the Western and Eastern Marmara Regions. In contrast to decreases in 2007 and 2009, these regions showed an increase in 2010. The other regions were in a decreasing trend between 2008 and 2010.

While in Model 1 changes in pech and techch were similar to each other, the efficiency change of West

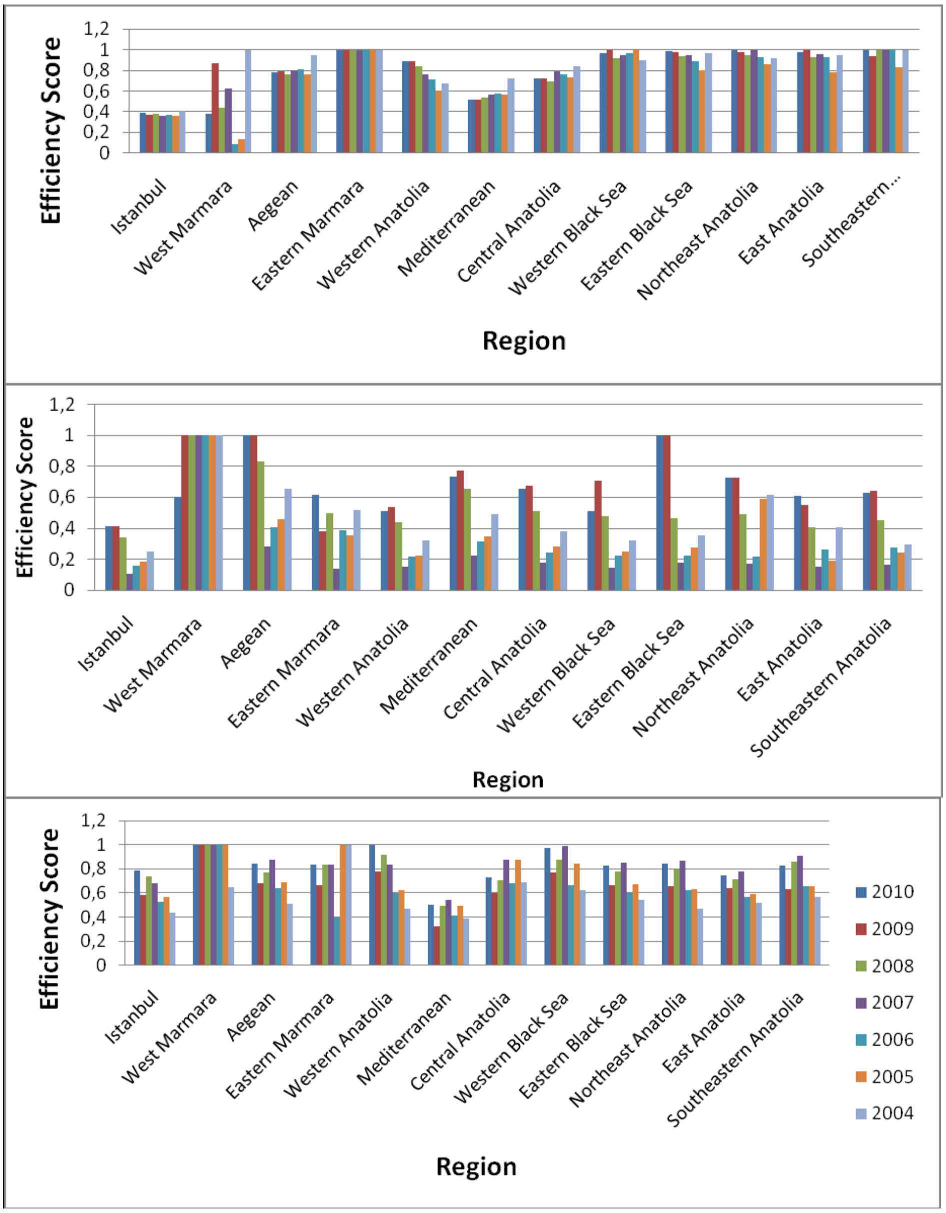

Fig.9. Efficiency scores for CRS output-oriented Model 1

Marmara Region was in the positive direction for 2009-2010 period, see Fig. 12. The efficiency change values of Mediterranean and Eastern Marmara Regions were 0 for all years. This shows that these regions maintained their efficiencies in the whole selected period.

According to scale efficiency change values of Model 1, the efficient region was the Eastern Marmara Region and the efficiency changes were 0, see Fig. 13. As the scale efficiency of the Eastern Marmara region was 1 for all years, it was taken as the reference region for others. All other regions increased their efficiency changes in 2010.

When the total productivity change values of the Model 1 are examined, see Fig. 14, it can be seen that tfpch values of the Mediterranean Region was positive for all years examined. Total productivity changes values of both Marmara Regions were more variable than others. In Model 1, the average tfpch values of Western and Eastern Marmara Regions for the selected period were found to be smaller than 1, i.e., there was a decreasing trend, see Table 2.

Efficiency changes obtained for Model 2 and Model 3 are given in Table 3 and Table 4, respectively. Meanwhile, total factor productivity change values for both model are given in Fig. 15 and Fig. 16, respectively. It can be revealed form Table 3 that regions with efficiency change values were smaller than 1 demonstrated decreasing trend in their efficiencies. Detailed analysis of Fig. 15, obtained by taking 2005 as the base year, shows that efficiency value were fluctuating for Western Marmara Region with a decreasing trend. While the efficiency results were fluctuating for Eastern Region, an increasing trend was maintained. A similar result was also obtained for Model 3 (domestic efficiency), see Fig. 16

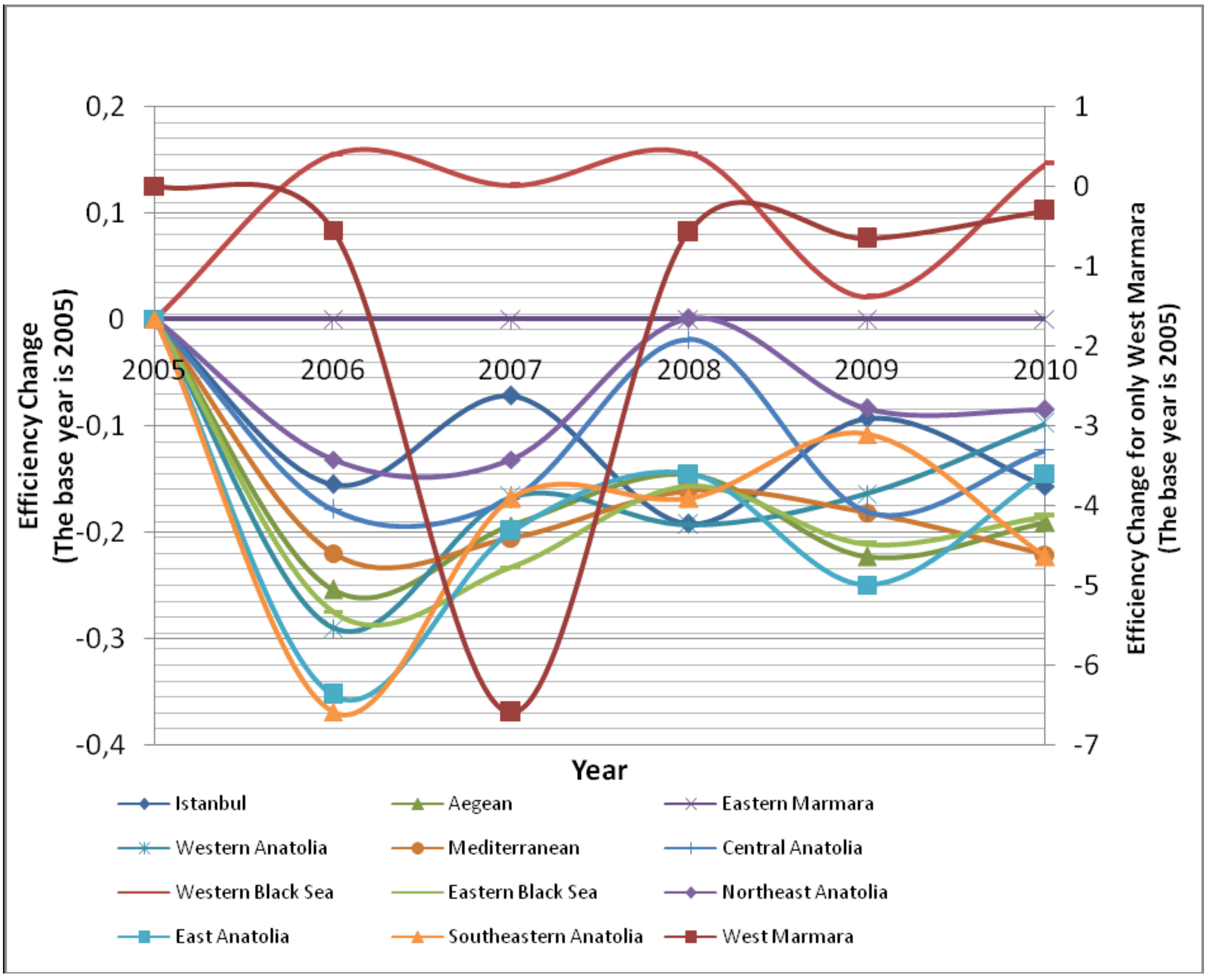

Figure 10. The results of the annual efficiency change for Model 1.

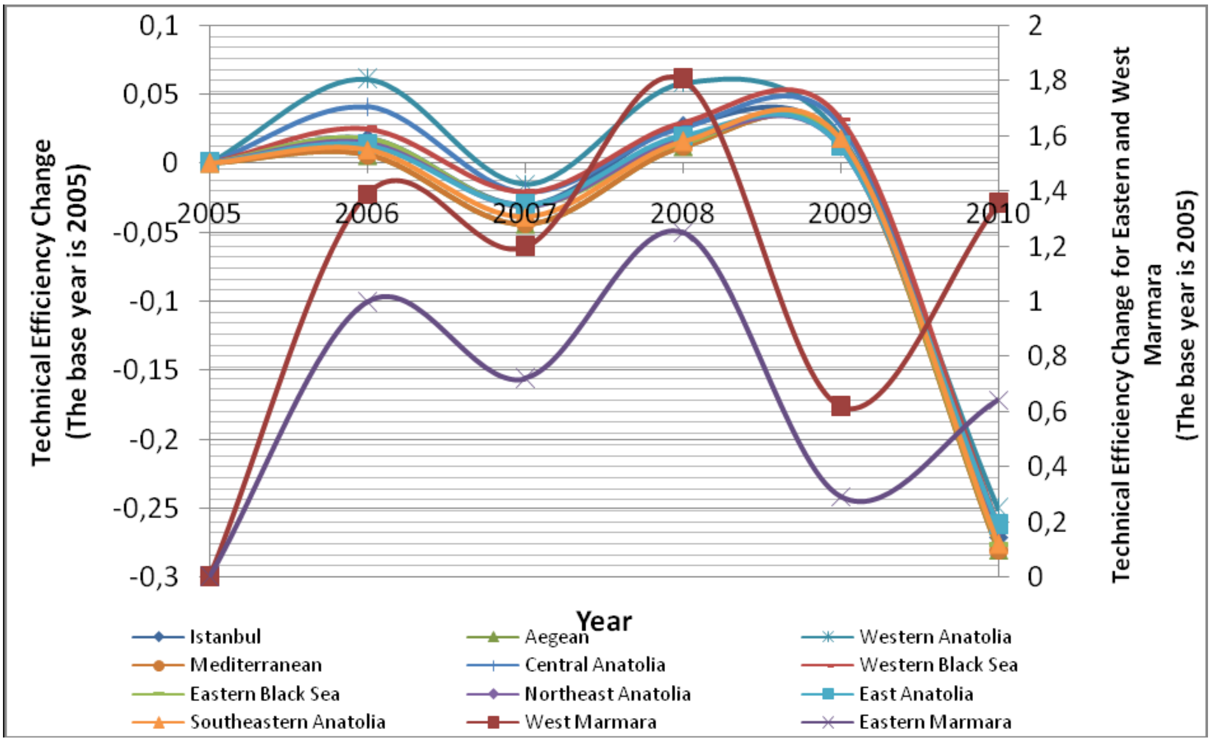

Figure 11. The annual techch results for Model 1.

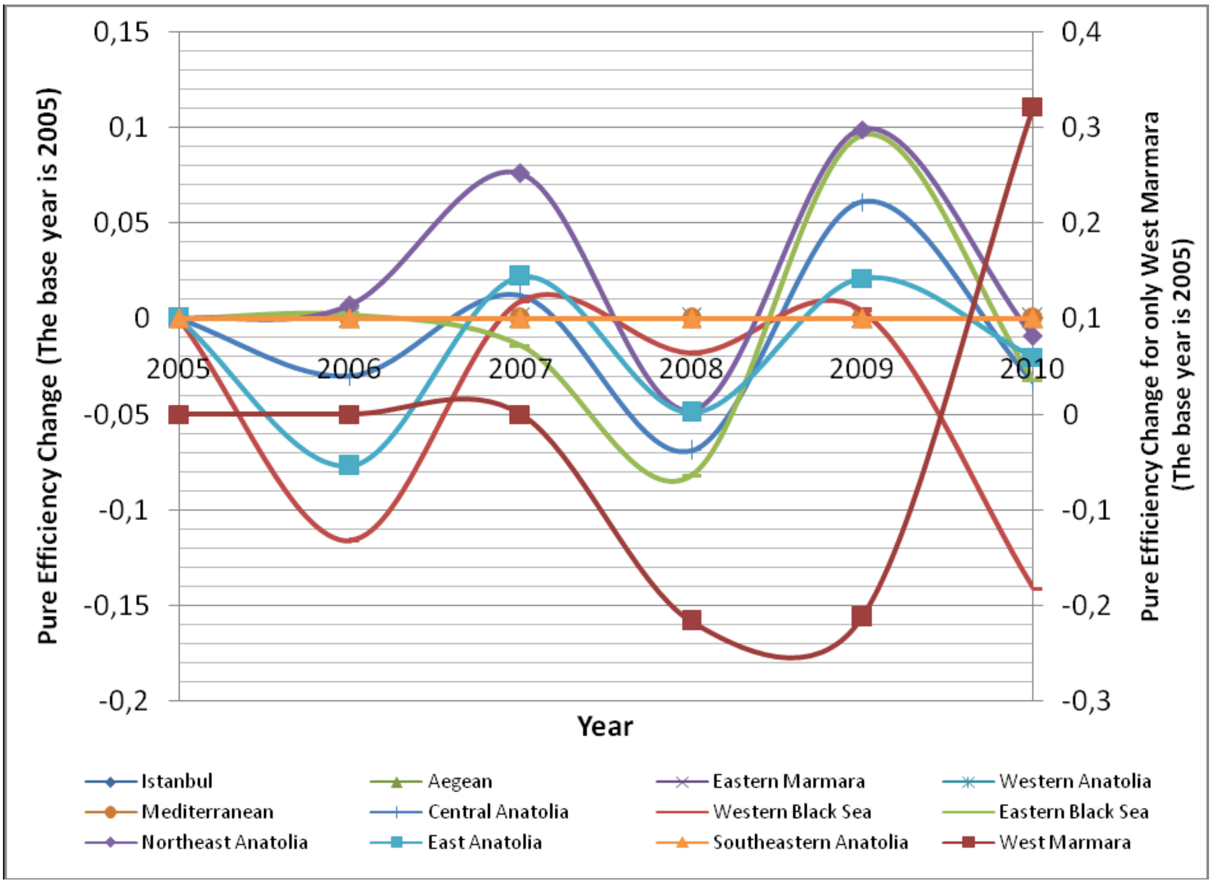

Figure 12. The annual pech results for Model 1.

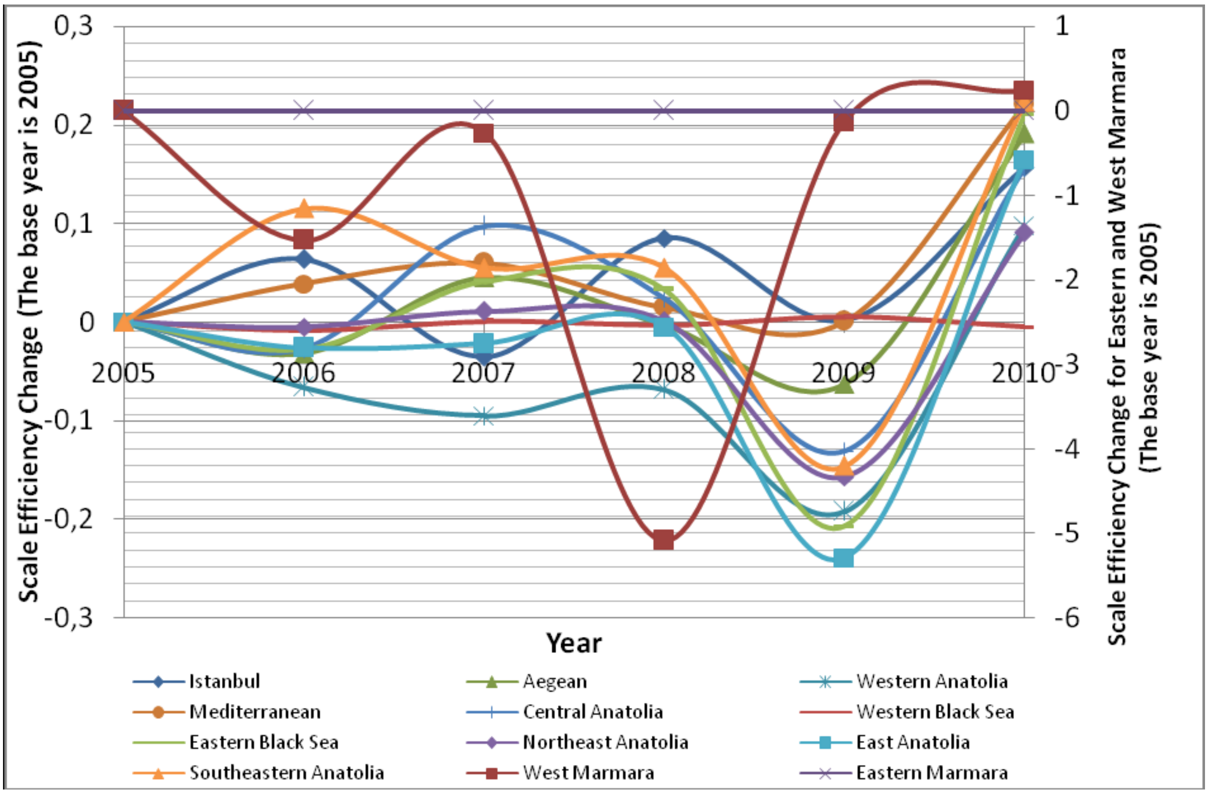

Figure 13. The annual sech results for Model 1.

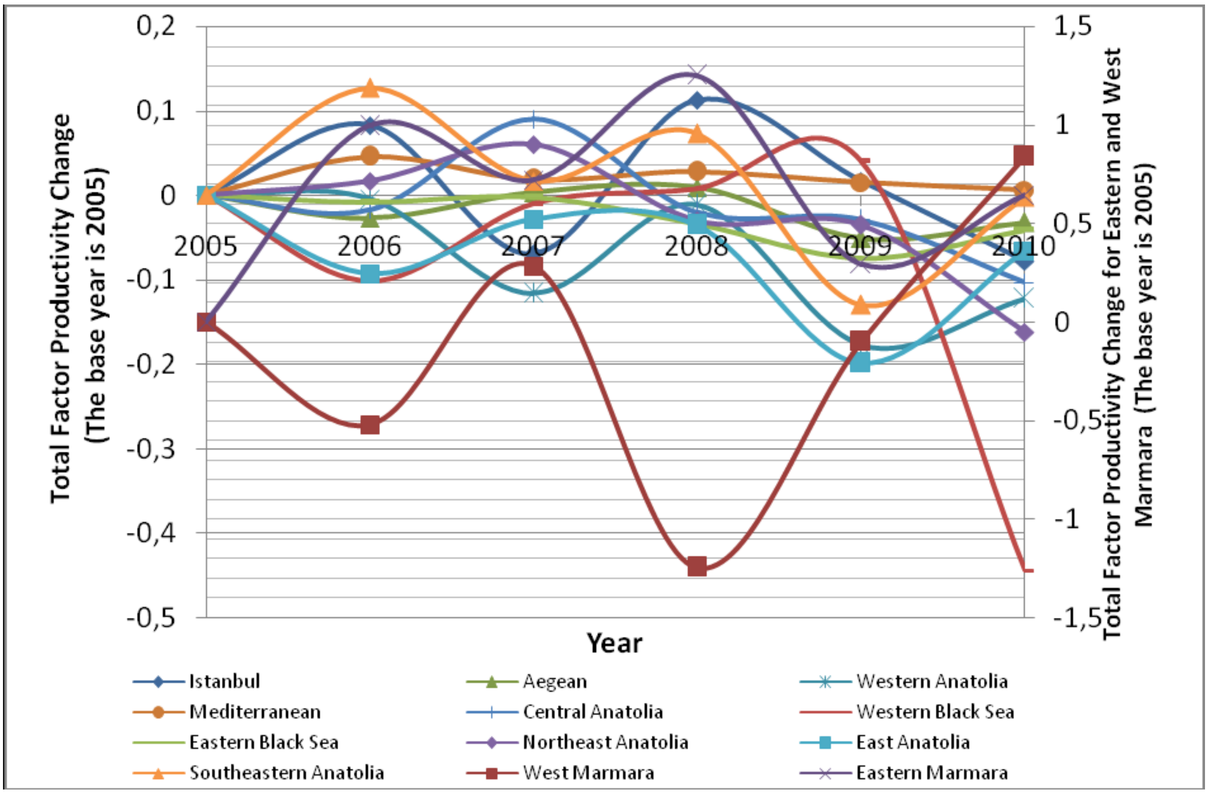

Figure 14. The annual tfpch results for Model 1.

Table 2. Malmquist Index summary of regions for Model 1 **Region**	**effch**	**techch**	**pech**	**sech**	**tfpch**
Istanbul	0,993	1,064	1	0,993	1,056
West Marmara	0,853	0,909	1	0,853	0,775
Aegean	0,969	1,068	1	0,969	1,035
Eastern Marmara	1	0,989	1	1	0,989
Western Anatolia	1,048	1,06	1	1,048	1,111
Mediterranean	0,946	1,068	1	0,946	1,01
Central Anatolia	0,974	1,065	0,974	1	1,037
Western Black Sea	1,013	1,069	1,013	1	1,084
Eastern Black Sea	1,004	1,065	1,004	0,999	1,069
Northeast Anatolia	1,015	1,065	1,006	1,009	1,081
East Anatolia	1,005	1,066	0,997	1,008	1,071
Southeastern Anatolia	0,999	1,068	1	0,999	1,067
MEAN	0,984	1,045	0,999	0,984	1,028

Table 3. The efficiency change scores for Model 2

REGION		2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010
Istanbul	**effch**	0,749	0,839	0,66	3,31	1,228	0,999
West Marmara		1	1	1	1	1	0,601
Aegean		0,702	0,886	0,695	2,94	1,208	1
Eastern Marmara		0,678	1,104	0,358	3,572	0,77	1,623
Western Anatolia		0,696	0,945	0,711	2,879	1,236	0,953
Mediterranean		0,713	0,905	0,697	2,969	1,181	0,952
Central Anatolia		0,743	0,858	0,727	2,92	1,321	0,97
Western Black Sea		0,784	0,898	0,645	3,288	1,475	0,719
Eastern Black Sea		0,784	0,809	0,779	2,682	2,154	1
Northeast Anatolia		0,957	0,362	0,792	2,897	1,471	1,004
East Anatolia		0,468	1,393	0,557	2,74	1,372	1,097
Southeastern Anatolia		0,812	1,133	0,605	2,753	1,408	0,983
Istanbul	**techch**	1,431	1,116	1,406	0,345	0,842	1,016
West Marmara		2,155	1,087	1,075	0,844	0,187	0,739
Aegean		1,431	1,116	1,406	0,345	0,842	1,017
Eastern Marmara		1,431	1,116	1,406	0,345	0,724	1,016
Western Anatolia		1,431	1,116	1,406	0,345	0,809	1,018
Mediterranean		1,431	1,116	1,406	0,345	0,842	1,016
Central Anatolia		1,431	1,116	1,406	0,345	0,832	1,017
Western Black Sea		1,431	1,116	1,406	0,345	0,798	1,017
Eastern Black Sea		1,733	1,116	1,406	0,391	0,513	1,007
Northeast Anatolia		1,431	1,116	1,406	0,345	0,753	1,015
East Anatolia		1,431	1,116	1,406	0,345	0,785	1,017
Southeastern Anatolia		1,431	1,116	1,406	0,345	0,835	1,017
Istanbul	**pech**	1	1	1	1	1	1
West Marmara		1	1	1	1	1	0,622
Aegean		1	1	1	1	1	1
Eastern Marmara		0,825	0,958	0,502	2,113	0,849	1,397
Western Anatolia		0,827	1,125	1,223	0,933	0,815	0,886
Mediterranean		1	1	1	1	1	1
Central Anatolia		1,045	0,94	1,043	1,046	1,116	0,973
Western Black Sea		1,078	0,92	0,946	1,279	1,302	0,701
Eastern Black Sea		1	0,66	1,515	1	1	1
Northeast Anatolia		1,135	0,391	1,076	1,487	1,739	1
East Anatolia		0,189	5,292	0,317	1,495	1,339	1,046
Southeastern Anatolia		1,038	1,016	1,131	1,036	1,224	0,987
Istanbul	**sech**	0,749	0,839	0,66	3,31	1,228	0,999
West Marmara		1	1	1	1	1	0,966
Aegean		0,702	0,886	0,695	2,94	1,208	1
Eastern Marmara		0,822	1,153	0,713	1,691	0,907	1,162
Western Anatolia		0,841	0,84	0,581	3,086	1,515	1,076
Mediterranean		0,713	0,905	0,697	2,969	1,181	0,952
Central Anatolia		0,711	0,912	0,697	2,79	1,183	0,996
Western Black Sea		0,727	0,975	0,682	2,571	1,132	1,026

Eastern Black Sea		0,784	1,225	0,514	2,682	2,154	1
Northeast Anatolia		0,843	0,926	0,736	1,949	0,846	1,004
East Anatolia		2,477	0,263	1,754	1,833	1,025	1,049
Southeastern Anatolia		0,783	1,115	0,535	2,656	1,151	0,996
Istanbul	**tfpch**	1,072	0,936	0,928	1,143	1,035	1,014
West Marmara		2,155	1,087	1,075	0,844	0,187	0,444
Aegean		1,004	0,988	0,978	1,015	1,018	1,017
Eastern Marmara		0,971	1,232	0,503	1,234	0,557	1,65
Western Anatolia		0,995	1,054	1	0,994	1	0,97
Mediterranean		1,021	1,01	0,98	1,025	0,994	0,967
Central Anatolia		1,064	0,957	1,021	1,008	1,1	0,986
Western Black Sea		1,122	1,002	0,907	1,135	1,177	0,731
Eastern Black Sea		1,358	0,902	1,095	1,048	1,105	1,007
Northeast Anatolia		1,37	0,404	1,113	1,001	1,109	1,019
East Anatolia		0,67	1,554	0,783	0,946	1,077	1,115
Southeastern Anatolia		1,163	1,265	0,851	0,951	1,176	1

Table 4. The efficiency change scores for Model 3

REGION		2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010
Istanbul	**effch**	1,315	0,921	1,301	1,074	0,79	1,354
West Marmara		1,547	1	1	1	1	1
Aegean		1,343	0,93	1,363	0,882	0,879	1,239
Eastern Marmara		1	0,394	2,121	0,997	0,801	1,255
Western Anatolia		1,319	0,971	1,387	1,099	0,845	1,286
Mediterranean		1,259	0,829	1,324	0,916	0,66	1,537
Central Anatolia		1,271	0,782	1,286	0,806	0,849	1,218
Western Black Sea		1,344	0,79	1,486	0,887	0,876	1,263
Eastern Black Sea		1,239	0,896	1,41	0,918	0,855	1,234
Northeast Anatolia		1,35	0,98	1,393	0,915	0,831	1,287
East Anatolia		1,147	0,962	1,37	0,92	0,901	1,164
Southeastern Anatolia		1,159	1,002	1,374	0,949	0,741	1,302
Istanbul	**techch**	0,899	1,249	0,774	1,134	1,239	0,829
West Marmara		2,564	0,309	0,3	2,105	1,213	0,551
Aegean		0,899	1,249	0,774	1,134	1,239	0,831
Eastern Marmara		0,892	1,249	0,524	1,134	1,239	0,816
Western Anatolia		0,899	1,249	0,774	1,134	1,239	0,831
Mediterranean		0,899	1,249	0,774	1,134	1,239	0,829
Central Anatolia		0,899	1,249	0,774	1,134	1,239	0,831
Western Black Sea		0,899	1,249	0,774	1,134	1,239	0,831
Eastern Black Sea		0,899	1,249	0,774	1,134	1,239	0,831
Northeast Anatolia		0,899	1,249	0,774	1,134	1,239	0,831
East Anatolia		0,899	1,249	0,774	1,134	1,239	0,831
Southeastern Anatolia		0,899	1,249	0,774	1,134	1,239	0,831
Istanbul	**pech**	1	1	1	1	1	1
West Marmara		1	1	1	1	1	1
Aegean		1	1	1	0,917	1,054	0,933
Eastern Marmara		1	0,482	2,074	0,871	0,852	1,348
Western Anatolia		0,961	1,047	1	1,047	1	1
Mediterranean		1	0,758	1,012	0,972	0,737	1,244
Central Anatolia		1	1	0,926	0,827	0,998	0,959
Western Black Sea		1,058	1,009	1,028	0,948	1,029	0,998
Eastern Black Sea		0,978	0,994	1,018	0,91	1,009	0,965
Northeast Anatolia		1,064	1,165	0,989	0,935	0,978	1,012
East Anatolia		0,939	1,093	0,987	0,916	1,063	0,91
Southeastern Anatolia		0,897	1,115	1	0,933	0,875	1,015
Istanbul	**sech**	1,315	0,921	1,301	1,074	0,79	1,354
West Marmara		1,547	1	1	1	1	1
Aegean		1,343	0,93	1,363	0,962	0,834	1,328
Eastern Marmara		1	0,818	1,023	1,145	0,94	0,931
Western Anatolia		1,373	0,928	1,387	1,05	0,845	1,286
Mediterranean		1,259	1,094	1,308	0,942	0,895	1,236
Central Anatolia		1,271	0,782	1,388	0,975	0,851	1,27
Western Black Sea		1,271	0,783	1,445	0,936	0,851	1,266
Eastern Black Sea		1,268	0,901	1,385	1,009	0,848	1,278
Northeast Anatolia		1,27	0,842	1,409	0,979	0,85	1,272
East Anatolia		1,221	0,88	1,387	1,005	0,847	1,28
Southeastern Anatolia		1,292	0,899	1,374	1,018	0,846	1,282

Istanbul	tfpch	1,182	1,15	1,007	1,218	0,979	1,123
West Marmara		3,967	0,309	0,3	2,105	1,213	0,551
Aegean		1,208	1,161	1,055	1	1,09	1,029
Eastern Marmara		0,892	0,493	1,111	1,13	0,993	1,024
Western Anatolia		1,187	1,213	1,074	1,247	1,048	1,069
Mediterranean		1,133	1,035	1,025	1,038	0,818	1,275
Central Anatolia		1,143	0,976	0,995	0,914	1,052	1,012
Western Black Sea		1,209	0,986	1,15	1,006	1,085	1,05
Eastern Black Sea		1,115	1,119	1,092	1,041	1,06	1,026
Northeast Anatolia		1,215	1,224	1,079	1,037	1,03	1,07
East Anatolia		1,031	1,201	1,06	1,043	1,116	0,968
Southeastern Anatolia		1,043	1,251	1,063	1,077	0,918	1,082

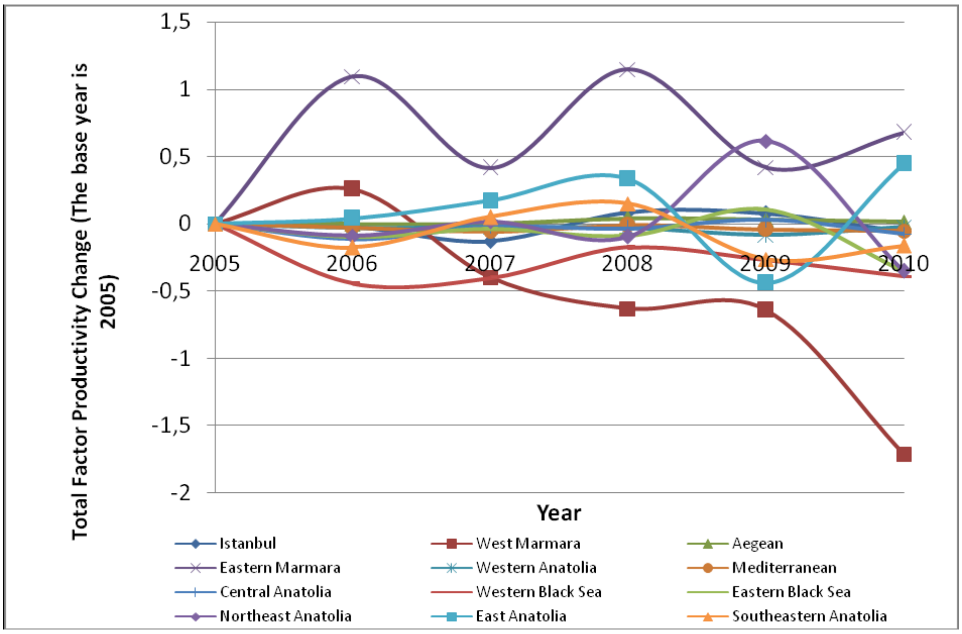

Figure 15. The results of the total factor productivity change for Model 2.

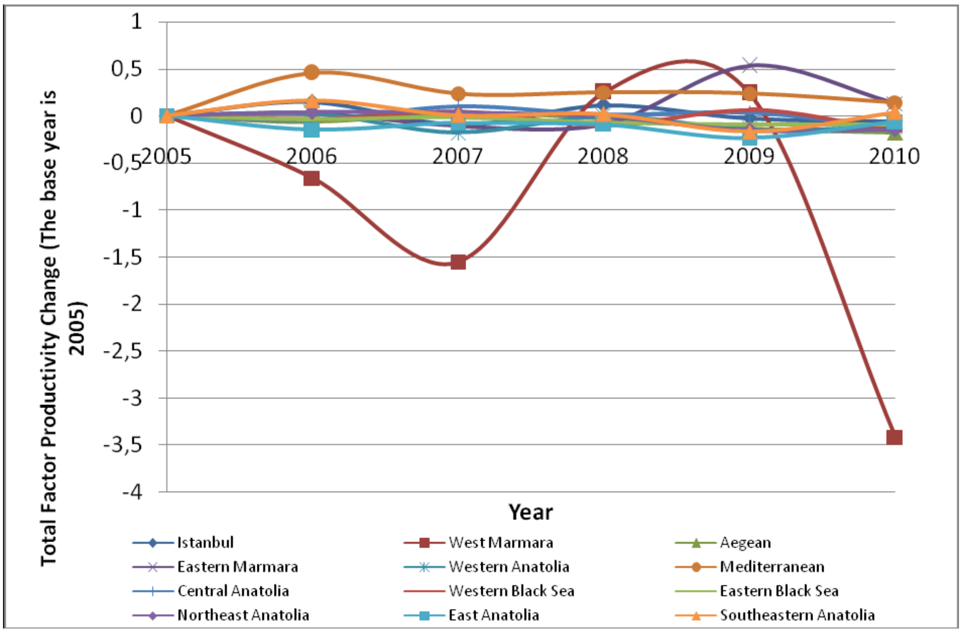

Figure 16. The results of the total factor productivity change for Model 3.

4. CONCLUSIONS

In this study, airline transportation performance of 12 different regions of Turkey was examined by using Data Envelopment Analysis (DEA) with Malmquist Index (MI). By this way, it was aimed to identify performance of airline transportation and use the obtained results in preparation of different strategies and policies for harmonization of Turkey to EU. Meanwhile, it is expected that the subjective results presented in this study will be helpful to increase the level of performance of airline transportation sector in Turkey.

DEA is used to determine the management performance of many companies as well as to specify policies developed to improve them. In this study, it was aimed to ascertain the relative performance of the basic airline indicators and by this way the utilization efficiency of the airline transportation in Turkey was identified. Using subjective calculation results, it was aimed to inform reader about the strategies and targets to be followed so that the performances of the transportation indicators were maintained in their highest level.

By *Output Oriented Model*, inputs belonging to the measured decision making unit and those having the highest number of output were investigated. In order to calculate the efficiencies of the regions, three models were developed by varying the input and output variables. The changes in the efficiencies of the domestic, international and overall airline transportation were evaluated for the selected period.

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