Evaluating Turkish Airports Efficiencies Using Data Envelopment Analysis

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ABSTRACT

After the second half of the 20th century, airline transportation increased very rapidly and constituted today's the most important transportation sector. In addition, increasing globalization all over the world raised the consumer demand for transportation services. Therefore, consumer demand for airline transportation has increased over the few decades. Accordingly, airports which are the infrastructure of the aviation sector became crucially important for maintaining such growing demand. In this context, efficiency of Turkish airports becomes more important with the increasing demand and air transaction movements. In this thesis Turkish airports' efficiency will be evaluated through the Data Envelopment Analysis. The policy which is developed at the end of this thesis is that, government function on the airport management should be revised or airport managements should be transferred from the state administration to private sector through privatization. Thus, appropriate ground will be ensured for the more efficient Turkish aviation infrastructure.

Keywords: Data envelopment analysis, Decision Making Units, Efficiency, Airports.

ÖZ

Yirminci yüzyılın ikinci yarısından sonra, havayolu taşımacılığı çok hızlı bir şekilde artarak günümüzün en önemli taşımacılık sektörünü oluşturmaktadır. Diğer bir tarafta ise, tüm dünya genelinde artan küreselleşme ile taşımacılık sektörüne olan tüketici talepleri artmaktadır. Bunun neticesinde havayolu taşımacılığına olan talep de özellikle son on yılda giderek artmıştır. Bu bağlamda havacılık sektörünün altyapısı konumunda bulunan havaalanlarıda artan talepleri karşılamakda çok önemli bir noktadadır. Bu yüzden, Türkiye'de bulunan havaalanlarının verimliliği artan talep ve hava trafiğine bağlı olarak çok daha önem kazanmıştır. Bu nedenlerden dolayı, bu tezde Türkiye'deki havaalanlarının verimlilikleri Veri Zarflama Analizi kullanılarak değerlendirilecekdir. Bu tezde geliştirilen çözüm önerisi, Türkiye'deki havaalanlarını özelleştirme veya kiralama yöntemi ile devlet kontrolünden özel sektöre devredilmesidir. Böylece Türkiye'deki havaalanlarının verimliliğinin sağlanması için uygun zemin sağlanmış olacaktır.

Anahtar Kelimeler: Veri Zarflama Analizi, Karar Birimleri, Etkinlik, Havaalani.

To My Family

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I owe quite a lot to my family for their support and I would like to dedicate this study to them as an indication of their significance in this study as well as in my life.

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CRS: Constant Returns to Scale

DEA: Data Envelopment Analysis

DMU: Decision Making Units

VRS: Variable Returns to Scale

Chapter 1

INTRODUCTION

1.1 Importance of Infrastructure

Transportation infrastructures have been the building blocks of the cities and countries. Harbors, railroads, roads and finally airports have been playing a vital part of the development process of the countries. Ribeiro and Kobayashi (2007) pointed out that "*transport activity is a key component of development and human welfare*". Few centuries ago, seaway transportations were the only way for intercontinental transportation and trade. According to mercantilist economic view, country's economic development depends on exports and imports. Therefore, harbors were the first and most important transportation infrastructure of the countries. Railroad and road transportation were the key internal transportation services of the countries so they were the second most important transportation infrastructure of the countries. But, from past to present with the increasing trade, globalization and human needs, airline transportation became the most important transportation services of today's world. Especially after the second half of the 20^{th} century, airports have been crucial transport infrastructure for the development of commercial, social and political relations in the global context. Furthermore, airports became gates for foreign relations of the country.

On the other hand, airports are very important for the region and the country as well. They provide direct or indirect economic contributions to the region and the country.

The main economic contributions of airports are employment opportunities and tourism.

As all other transportation sectors, airports provide a lot of employment opportunities to inhabitants in the region. Also, the role of the airports in the tourism sector has a positive contribution to the national economy. Therefore, increasing productivities of airports become important in terms of economic view. In other words, increasing passenger and cargo transportation will bring more economic contribution to region and country. Brueckner(2003) indicated that there is a relation between airline traffic and employment. According to his conclusion increasing aircraft movements and airline traffic leads more job opportunities. Airports have become the engine of local economic development because it creates opportunities for employment, trade and tourism industry.

Depending on the aviation sector developments around the world, air traffic is inevitably growing with the rising passenger and cargo transportation. Increasing air traffic raises the importance of airports. Therefore, operating airports more effectively become a new phenomenon in the near future. Results of all these things bring the airports in the center of the attention. Because continuous growth in the air traffic and network expansions depends on the physical structure of the buildings, runways, technological situation and operation of the airports.

1.2 Aim of the Study

This study aims to analyze efficiencies and overall performance of the Turkish airports under the global and national context. In the second half of the 20th century

economic growth, consumer demand and technological improvements accelerated the growth of the aviation sector all around the world.

Efficiency is mainly determined by the optimal use of inputs to create the optimum output, and the optimum utilization of the improved technology. Airports' efficiency is crucial as Martin and Roman (2001) pointed out that, "*It is necessary to evaluate if a fixed physical capacity, is able to provide services to more air transaction movements and passengers"*. Regarding technological improvements, since Turkish airports are under the control of the State Airport Authority (except Sabiha Gökçen, Eskişehir and Zonguldak Airports), SAA has a monopoly power on the operation of airports. Therefore, although consumer demand and air traffic increased very rapidly, Turkish airports were modernized only twice (in 1950s USA financial aid under the Marshall Plan and build operate and transfer (BOT) by private sector in 2000s) in the last 60 years. The main reason behind the late modernization investments is the lack of financial resources of the government. Therefore since Turkish airports could not follow the technological improvements, efficiency was lacked behind the modern airports all around the world and this influenced the optimum use of the inputs.

In addition to the rising consumer demand and economic growth, network expansion also affected the airports' operation and efficiency negatively. Between 2005 and 2010, fifty-eight new international and domestic routes were opened by THY alone while the infrastructure improved very slowly.

Despite the importance of airports' operation in reaching efficiency, there is no academic study which determines the level of efficiency of the Turkish airports in the

literature and therefore, being the first in kind, this study attempts to help fill this gap.

1.3 Methodology of the Study

In order to determine Turkish airports efficiency, Data Envelopment Analysis (DEA) will be used in the study. Data Envelopment Analysis is most widely used for the last decades to determine efficiencies of profit and non-profit institutions. The main areas of DEA method are schools, hospitals, banks, and airports. The DEA method has been the top method in the academic research for determination of efficiencies of institutions like this kind. In the last few decades there is plenty of academic research which used DEA and it is possible to see an expansion of the application areas of DEA. Thus, it is appropriate to use DEA for this study.

1.4 Structure of the Study

In Chapter 2, previous aviation sector studies will be reviewed and general problems will be analyzed.

In Chapter 3, the historical and current situation of the World and Turkish aviation sector will be explained.

In Chapter 4, Data Envelopment Analysis method will be introduced with its main characteristics and importance for this study will be explained.

In Chapter 5, Turkish airport's efficiency will be examined by using Data Envelopment Analysis.

In the final chapter, the main findings of the study will be summarized and based on these findings, solutions will be presented.

Chapter 2

LITERATURE REVIEW

In this chapter, studies conducted on the efficiencies of the airports in the last few decades will be presented. Although, the purpose of some studies was not the same, inputs and outputs used in the different methods were very similar. These studies are presented in the Table – 1. On the other hand, studies on the efficiencies of airports show up differences in terms of methods used. All the differences, strengths and weaknesses of the methods used will be explained as well.

2.1 Airports Efficiency Studies

In the 1970s, export oriented regime was the widely accepted popular opinion for the country's economic development in the entire world. In this context, many developed and developing countries have adopted liberal policies in order to remove the factors which prevent international trade. Thus, a lot of countries have joined the world economy by changing closed economic structures to liberal. Turkey has joined in this process in the beginning of the 1980s.

With the increasing liberalization understanding all around the world, new structure of the economy allows the private sector to be more active in the market. In other words, services and productions in the market will be more heavily presented by private sector. For this reason, government-owned and operated firms' productivity and efficiency have been started to be discussed. Furthermore, the idea of

privatization of non-productive and inefficient state-controlled enterprises started to be accepted. Moreover, in order to determine non-productive and inefficient state-controlled enterprises academic studies have been started. For instance, state-run banks, factories, mines, electric plants, railways, telecommunications, airways and airports productivity and efficiencies have been important for testing in the academic environment.

After the World War II, aviation industries have been developed under the state control all around the world. Depending on this process, airport operations have been under the state monopoly as well. Hence, there have been productivity biases for state owned and operated airports. Because, the government does not behave like the private sector, the priority of the government investments does not depend on "demand", and it depends on "equality" principle (Özenen, 2003). Therefore, especially at the end of 1990s, airports efficiencies attracted the attentions of researchers and academicians. Thus, academic studies for state operated airport's efficiency have started with Gillen and Lall. (1997).

As it is seen from the Table – 1, most of the studies about airport efficiencies have been done after 2000. Only three of them, Gillen and Lall (1997), Parker (1999) and Murillo-Melchor (1999) were made before 2000. This indicates that, airports' efficiencies became more important in the last decades. One of the reasons behind the rising importance of airport efficiencies has been the changes in the people's pace of life. The pace of life has been accelerated with the technological improvements and the globalization process. Especially after the millennium years, the acceleration of the pace of life has been rising much faster and it is becoming faster compared to the previous decades. The pace of life is crucial in terms of explaining the airport's

importance in the globalized world. Depending on the globalization and the pace of life, people have become more mobile. For instance, in order to fulfill the sport activities, business and political relations people are moving from one place to another as part of their life. In other words people are moving more compared to the past. For this reason, in today's world transportation sector is crucially important. Especially for long distance transportations, due to better services of aviation sector compared to the other sectors, air transportation attracts more passengers than the other sectors. Airport which is the key infrastructure of the aviation sector becomes more important in terms of productivity and efficiency. Therefore, testing productivities and efficiencies of airports have been very important in the last decade under these circumstances.

In the Table 1 ahead, necessary inputs, outputs and methods are listed for the determination of the airport's efficiency. All the previous studies conducted on the efficiencies of airports are shown as well.

Table 1: Researches About Airport Efficiency

	METHODS	INPUTS	OUTPUTS
		Terminal Services	
Gillen and Lall (1997)	DEA- BCC model	a) Number of runways	1) Passengers
		b) Number of gates	2)Cargo
		c) Terminal Area	
		Movement model	
		a)Airport area	1) Air cargo movements
		b)Number of Runways	2) Commuter movements
		c)Runway area	
		d)Number of emplooyes	
Parker 1999	DEA- BCC and CCR models	a)Number of employees	1) Passenger
		b)Operating Cost	2) Turnover
		c)Capital Input	3)Cargo
Murillo-Melchor (1999)	DEA Malmquist Index	a)Number of Employees	1)Passenger
		b)Intermediate Expenses	
		c)Accumulated Capital Stock	

Sarkis(2000)	DEA-CCR and BCC	a)Number of employees	1)Operating Revenues
		b)Operating costs	2)Aircraft movements
		c)Gates	3)Passenger
		d)Runways	4)Cargo
Fernandes and Pacheco (2002)	DEA	a)Terminal size	1)Passenger
		b)Departure Lounge	
		c)Number of Check in desks	
		d)Number of vechileparks	
		e)Numberof baggage claims	
		Terminal Services	
Pelset al. (2003)	DEA-BCC model	a)Terminal size	1)Aircraft movements
		b)Number of aircraft parks	
		c)Number of runways	
		Movement Model	
		a) Number of check in desks	1)Passenger
		b)Nimberof baggage claims	

		Terminal services	
Pelset al. (2003)	SFA	a)Terminal size	1)Aircraft movement
		b)Number of aircraft parks	
		Movement model	
		a)Number of Check in desks	1)Passenger
		b)Numberof baggage claims	
Oum et al (2003)	VFP	a)Labor	1)Passenger
		b)Price of Capital	2)Cargo
			3)Aircraft movements
			4)Non-Aeronautical services
Barros and Sampaio (2004)	DEA	a)Number of employees	1)Passengers
		b)Book valueof physical asset	2)Number of Planes
		c)Price of Capital	3)Cargo
		d)Price of labour	4)Sales toplanes
			5)Sales to passengers
Yoshida (2004)	Endogeneous Method	a)Runway length	1)Passenger
		b)Terminal size	2)Cargo
			3)Aircraft Movement

Yoshida and Fujimoto (2004)	DEA-CCR and BCC	a)Runway Length b)Terminal size c)Number of employees d)Monetary access cost e)Time access cost	1)Passenger 2)Cargo 3)Aircraft movement
Barros and Dieke (2007)	DEA	a)Number of employees b)operationalCost c)Capital invested	1)Passenger 2)Cargo 3)Number of plane 4)Commercial Sales 5)Aeronautical sales
Fung et al. (2007)	DEA Malmquist Index	a)Runway Length b)Terminal size	1)Passenger 2)Cargo 3)Aircraft movement
Barros (2008)	SFA	a)Operating Cost b)Price of capital c)Price of Labor	1)Passenger 2)Sales to planes 3)Non-aeronautical fee.
Barros and Weber (2009)	DEA Malmquist Index	a)Labor b)Capital c)othercosts	1)Passenger 2)Cargo 3)Aircraft Movements

Hsu-Hao Yang (2010)	DEA and SFA	a)Number of employee b)Number of Runway c)Operating Cost	1) Operating Revenues

Source : Partly adapted from Barros and Dieke(2008)

As seen from the Table 1, in the first decade of the 21st century many academic studies have been conducted on the efficiency of airports and became a popular issue among the researchers. These studies are divided into two groups in terms of methods used. These methods are known as, parametric and non-parametric methods.

Stochastic Frontier Analysis (SFA) has been used to determine airports efficiencies under parametric method. Stochastic Frontier Analysis first introduced by Aigner and Chu in 1968 under the name of On Estimating the Industry Production Function, against the Farrell's study in 1957. Afterwards, SFA method developed by Afriat (1972), Richmond (1974) and Aigner, Lovell , Schimidt(1976). Then, it became widely used method for the efficiency tests. But although, there are so many studies for testing efficiencies of profit and non-profit organizations or firms under the Stochastic Frontier Analysis, in the last decade there are fewer Stochastic Frontier Analysis methods used for determination of airports efficiency. As seen from the Table 1 these are Pelset al. (2001, 2003), Oum et al. (2003), Oum and Yu (2004), Yoshida (2004), Yoshida and Fujmoto (2004), Barros (2008), and finally Yang H.H. (2010). Stochastic Frontier Analysis used from time to time and between few researchers. Thus, it is not very widely used method. But on the other hand, one of the non-parametric methods Data Envelopment Analysis has been most used method among the researchers in the last decade. The reason of the DEA's being used more,

it is suitable to test different aspects of airports efficiencies (Yang, 2010). For example, Gillen and Lall (1997) tested the overall performance of the 21 US airports. Parker (1999) tested technical efficiencies of UK airports before and after privatization. Sarkis(2000) tested operational efficiencies of 44 US airports.

On the other side, although there are different methods used in order to test airport efficiencies, some researchers have been testing airport's efficiency into segments. These segments are known as *terminal services* and *movement model*. For each segment they used different inputs and outputs (Gillen and Lall 1997; Pelset al, 2001, 2003). For example, Pelset al (2003) tested airport efficiencies into two segments - terminal services and movement model. He used terminal size and number of aircraft parks as an input and aircraft movements as an output for testing terminal services. For testing movement model he used number of check-in desk and number of baggage claims as an input and passenger as an output. Whereas, most of the other researchers didn't separate their work into segments and also used common inputs and outputs.

Another important contribution from the researchers is the comparison of the Data Envelopment Analysis against the Stochastic Frontier Analysis. Both studies of the Pelset al (2003) and Yang (2010) tried to explain the differences between the methods by using same inputs and outputs in the two different methods – DEA and SFA. According to the conclusion of these studies; results of both methods are roughly in the same order.

Even though researchers use two different methods (parametric and non-parametric) there are some similarities between the methods. In general, both methods use almost

same inputs and outputs. For instance, number of employees, runway lengths and terminal size are the common inputs for DEA and SFA. From the output side, the number of passenger, cargo and number of aircraft movements are the same outputs for both methods.

As shown in the Table 1, there have been many studies and researches done about the efficiencies of airports and some studies have provided a very important contribution. Such as Gillen and Lall (1997) indicate that, demand for airport services are inelastic because airports have limited potential to attract other airports customers. In other words, an airport holds the monopoly power in the region in terms of transportation. Especially if there is only one airport in the city or region, it is not possible for the costumer to prefer other airport services. For this reason, monopolistic power of the airports has eliminated the competition and lack of competition among the airports might be the reason behind the airports inefficiencies. And also Oum et al (2003) pointed out, ignoring non-aeronautical services in the research, leads biased empirical result because in some airports those services have very big share from the total revenue.

Another major contribution from Yoshida and Fujimoto (2004), regional airports expected to be less efficient, because demand for regional airports is small compared to international airports. But, most of the studies usually concentrated on the efficiencies of airports in the single country. For instance, Fernandes and Pacheco (2002) studied the efficiencies of Brazilian airports and Gillen and Lall (1997) studied US airport's efficiency etc. Almost all studies ignored this situation. Therefore, rather to compare domestic airports with each other, it is more rational to compare similar countries' regional airports.

Other important contribution from Barros (2008), state owned and operated airports are less efficient because there is no pressure above managers to demonstrate positive financial results. It is very clear that, pressures over the years above the managers of both state controlled and private firms have not been same. Thus, it is inevitable for state controlled firms to be less efficient compared to the private firms.

Concerning all the studies about airport efficiencies, there is two types of methods have been used –DEA and SFA- and it is clear that, Data Envelopment Analysis preferred more compared to the Stochastic Frontier Analysis. In general most of the studies conclude that state owned and operated airports are less efficient compared to privatized airports. Therefore, privatization of state owned airports is the one of the best way to reach desired level of quality and efficiency.

Chapter 3

BRIEF OVERVIEW OF AVIATION SECTOR

In this chapter, development and current situation of the aviation industry will be explained under two main subtitles. In the first section, milestone of aircraft developments, the effect of increasing passenger and cargo transportation demand in the aviation sector around the world will be explained. In the second section, historical developments and upcoming problems of the Turkish aviation sector will deeply explained. Also the effect of rising growth in the air traffic and importance of airports in the future of the aviation sector and furthermore, its importance for the region and country will be explained.

3.1 Aviation Sector in the World

Today’s aviation sector has a very deep history. For hundreds of years people's flight desire and inventions in this way, composes today's world aviation sector. They made dozens of unsuccessful aircraft to fly and they have tried various ways to fly but until the beginning of the twentieth century no one achieves to fly. The first years of the twentieth century human desire of flying was fulfilled with Wright brothers. They achieve to fly with their own made airplane.

The invention of the airplane first attracted the attention of militaries, since airplanes give an advantage of air dominance in the battle field, and they provided a significant contribution to the development of airplanes. In other words, it is quite important for determination of the winning side in the war. Thus, first investments in the

developments of the aircraft were started with the military investments. Military investments in the aircraft industry has been the starting point of modern aircrafts while at the same time it also started a new era for the modern armies. Thus, First application areas of aircrafts were the battle fields. When other countries recognize air dominance become the key point of victory, after that they started to supply funds for military aircrafts too. Therefore, all these investments accelerate the developments of the aircraft industry.

In order to get air dominance in the World War I, militaries spent a huge amount of funds for the warplane production and these investments returned as a significant aircraft improvement. All these successful developments of planes attracted the attention of the private sector. After the World War I, planes were integrated into the private sector and created a new airmail business. Because of aircrafts are much faster than train or any other vehicles so airmail transportation becomes more attractive than other type of mail transportation. Thus, second application areas of aircrafts were the airmail transportation. So that, the first airmail route was opened in 1918, between New York and Washington (U.S. Centennial of Flight Commission).

Research and developments for aircrafts continued under the military investments with a great pace. When it comes to World War II, countries can able to produce very fast aircrafts and those planes could able to fly long distances. This feature of the planes again attracted private sector for passenger transportation.

Aircrafts not used for passenger transportation until the second half of the twentieth century. Because all the aircrafts were produced for military needs but after the World War II, people realize it is possible for aircraft to transport passengers for long

distance places. Second half of the 20th century opened a new era for transportation sector because faster, safer and comfortable transportation was possible with the aircrafts. After 1950's passenger transportation by aircraft started and become very popular all around the world.

Passenger transportation with the aircrafts, increased the peoples' interest and demand for air transportation. Increasing demand created the pressure over the development of air transportation thus investments for infrastructure and new routes have been made over the years. Especially new routes between the countries increased the air traffic all around the world and at the beginning of the 21st Century distant places become closer in terms of time. World becomes smaller like village with increasing air traffic and makes distant places to be more accessible. One of the main causes of increasing flights is the result of increasing flight demands for business, political and holiday purposes. According to the International Air Transport Association (IATA) report (2010), global passenger traffic growth was 8.2% in 2010. Especially for long-distance travels people prefer planes because faster, safer and comfortable transportation is more attractive. This is one of the core reasons of why aviation sector is the most preferred sector in the last decade all around the world.

Not only passenger transportation increases in the aviation sector, also cargo transportation increasing as well. As a result of globalization, increasing relations between countries make transportation sector more important. In today's world, transportation plays a very important role in the development of a country. For instance most of the developed countries like Germany, United States of America, Japan, England, and United Arab Emirates etc. make a very important contribution to economic development through trade. For the last few decades, airline transportation

becomes monopoly power for long distance cargo transportation. The primary reason of raising cargo transportation is the development of the internet trade at the end of the 20th and the beginning of the 21st century. Internet sales in 1995 were essentially zero, but in 1999 sales reached up to 7$ billion (Kasarda, 2001). According to US Census Bureau, internet sales in 2009 were $145 billion in the US and in 2010 $572.5 billion in the world. Thus increasing sales on the internet is the reason of raising demand for freight transportation in the nation and worldwide. So that, after the millennium years freight transportation starts to follow the parallel growth to internet sales. Retail trade sector reshaped with the internet trade and this new understanding of trade brings the importance of "accessibility" rather to "location" (Kasarda 2001). In the business world, time has a value so that accessibility becomes valuable if delivery time of cargo becomes less. Therefore, because of aviation sector much faster than other transportation sectors, it is one step further than other sectors for cargo transportation. Hence, the aviation sector has a very important place for both passenger and cargo transportation.

3.2 Turkish Aviation Sector

The process of globalization in today's world increases the importance of the transportation sector. In the last few decades, as a result of increasing commercial and political relations between the countries, transportation becomes necessary infrastructure for the development process of the country. For a country to compete economically with other countries, transport networks will first need to have advanced enough for this competition. Therefore, airline transportation which is the most important one over the last decade becomes more important for developing countries like Turkey. Today, the Turkish aviation sector is the most important gates for international connection of Turkey. For instance, almost all of the Turkish

political and business people use air transportation for foreign relations like the rest of the world. Although aviation sector is very important for Turkey's development and integration with the world, last fifty years infrastructure investments and modernizations are not enough. Considering the history of the Turkish aviation sector, Turkey has experienced two different development stages. Turkish aviation sector split into two main parts in terms of development process; before liberalization (before 1980s) and after liberalization (after 1980s).

Developments in the Turkish aviation sector before 1980s;

At the beginning of the second decade of the 20th century, Turkish military came face to face, with the Italian planes in the battle at Tripoli for the first time. Aircraft have been firstly used in the Tripoli battle (U.S. Centennial of Flight Commission) and provided important benefits to Italian army such as air dominance in the battle field. After losing war at the Tripoli, the Turkish military has been started to give more importance to aircrafts. Thus, first investments for aircrafts and aviation sector have been started under the Turkish military control. Beyond the military importance of aviation, the reason of military investments and control over the aviation developments was the absence of Turkish civil aviation institution. Depending on Western countries air force threat, Turkish air force established 1 June 1911 (THK) before the establishment of Turkish civil aviation institution. After the establishment of the Republic of Turkey, Turkish civil aviation institution established in 1925 (SHGM) and they have started to produce aircrafts. The first civil aviation transport began in 1933 with five planes (SHGM). There have been no notable developments in Turkish civil aviation in the 1940s because of Second World War. Important developments in the Turkish civil aviation sector have been started after the Second World War like the rest of the world. 1950s were the modernization years of planes

and also new airports constructions (V. Korul and H. Küçükönal, 2003). Turkey was not economically stronger in those years and needed foreign borrowings and aids to build modern aviation infrastructure. Therefore, in 1950-1951 under the Marshall Plan, USA donated $147.5 million for the modernization of Turkish airports and aircrafts (BarisErtem, 2009).

In those years Turkish aviation sector was in the development process and totally under the control of the government but government administration had to be reshaped because of rapid developments in the aviation sector. Therefore, in 1955 airport and airline administration separated and at the same year airline management linked to Presidency of Civil Aviation Department (V. Korul and H. Küçükönal, 2003). In 1956, airport management linked to State Airport Authority (DHMI) (V. Korul and H. Küçükönal, 2003). Despite the separation of airport and airline managements, government had the total control over the aviation sector. As a result of all these developments until the liberalization process in 1980s, Turkish Airlines became a monopolistic power in the aviation transportation. In the paragraph ahead, the developments of the Turkish aviation sector after the liberalization process will be explained.

Developments in the Turkish aviation sector after the 1980s;

In 1980s, liberalization spread all around the world and Turkey was in that process. Depending on the liberalization process, Turkey had to change some laws. For this reason, in 1983, to increase competitiveness among the airline firms and to create perfectly competitive airline market law numbered 2920 allow private sectors to join in the monopolistic Turkish aviation market. In addition to airline companies, also in 1986 sixteen military airports also opened to civil aviation (V. Korul and H.

Küçükönal, 2003). And today 46 airports are serving for civil aviation and 43 of them under the control of Presidency of Civil Aviation Department. 14 of these airports are eligible for international flights and 32 of them eligible for domestic flights (SHGM, 2009).

With the new law approved by parliament, after 1983 new airline firms have started to enter into aviation sector and today 16 different airline firms exist in the Turkish aviation sector (SHGM). Despite the increased number of airline firms in the Turkish aviation sector and even the competitiveness increased, but still Turkish Airlines has the largest share from the sector and leading position in the Turkish aviation. According to 2010 Annual Report of Presidency of Civil Aviation Department 16 airline companies operating and 148 planes belong to Turkish Airlines out of 306 planes. Almost half of the total planes in civil aviation belong to the Turkish airlines.

Technological improvements and also entry of private airline companies raised the competition and lowers the fares in the Turkish airline transportation, so that demand for air travels increased over the years. In the Figure 1 below, shows the passenger growth over the last five years.

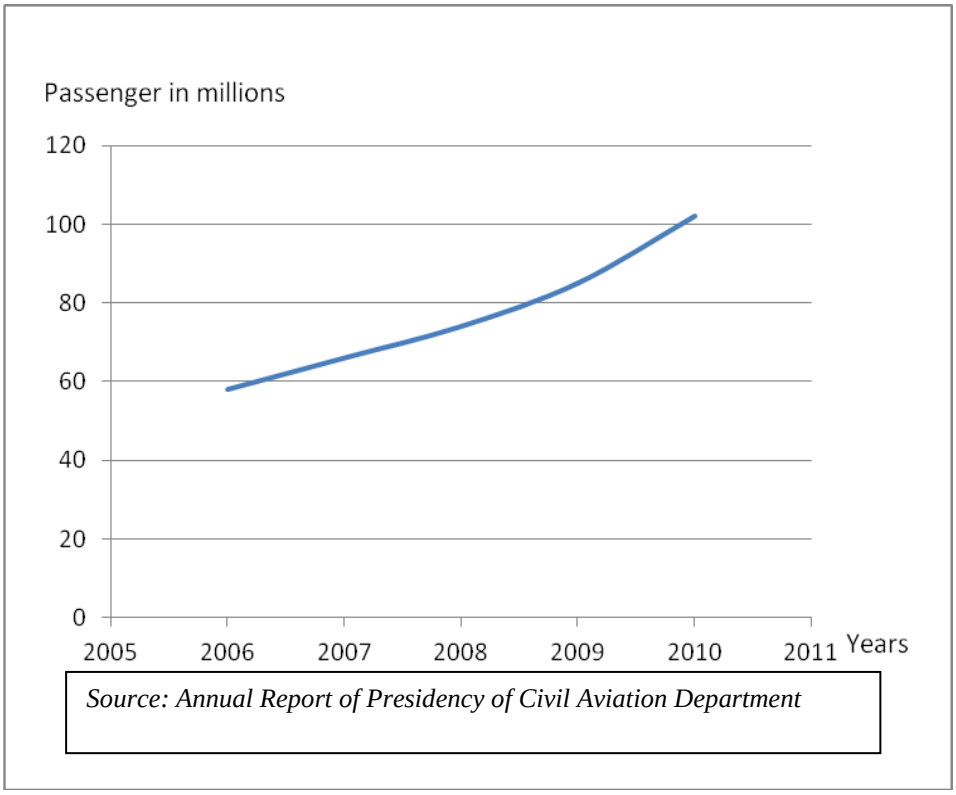


Figure 1: Turkish Airline Passenger Growth

According to the 2009 annual report of Presidency of Civil Aviation Department, in 2006 total passenger 58 million, in 2007 raised to 66 million, in 2008 raised to 74 million, in 2009 raised to 85 million and 2010 it raised to 102 million. As seen from the numbers and the Figure 1 above, Turkish airline passenger transportation have been growing fast. Passenger growth increased approximately %75 in the last five years.

Depending on increasing passenger growth, air traffic growing as well and growing air traffic will be the upcoming issue of the next few decades. In order to satisfy the growing air traffic, airport management and efficiency becomes crucially important. For this reason, it is necessary to determine Turkish airport efficiencies and

according to result of this test future plan needed to be decided for better and healthy aviation sector.

Despite the airports become very important for the aviation sector in the future according the expected air traffic growth it is also important for the regional developments as well. Airports not only important because of passenger and cargo transportation, it is also important for regional and countrywide developments.

First of all, having an airport is an employment opportunity for the region's inhabitants. The airports provide jobs to the lots of people at the cafes, restaurants, control desks and duty free shops. Besides the airports direct job opportunities there are also indirect opportunities as well, such as city center - airport and airport - city center transportation. According State Airport Authority 2010 annual report, there are 18,741 staff working at the Turkish airports. Therefore, airports contribute economic, social and cultural developments in the region. Secondly, it is a kind of development and prestige symbol for the region. Because, the condition of the substructure of a region is the main indicator of the regions level of development. Finally, in the 21st century airports are as much as important like, automobile roads in the 20th century, railroads in the 19th century and harbor in the 18th century (Kasarda, 2001). Because in the 18th century, transportation between the continents and countries were mainly depends on shipments. Therefore, harbors played a key role in the provision of transport. In the 19th century with the invention of the train made railroads very crucial in terms of provision of transport especially between the cities. In the 20th century automobiles and vehicles provided solutions to urban transport therefore roads became very important. And in the 21st century as a result of globalization, travel between the countries and cities becomes part of people life.

Aviation sector can make travel faster, comfortable and safer than other sectors. For this reason airport becomes very important place in the aviation sector for the provision of 21st century's transportation.

Chapter 4

METHODOLOGY

In this chapter, DEA method, which is used to test Turkish airport's efficiency, will be presented with technical details. Beside technical details, advantages and disadvantages will be presented as well. Moreover, information about data such as types and sources will be described in the final section of the chapter.

4.1 Data Envelopment Analysis

In this study, in order to assess the levels of Turkish airport's efficiency, we apply the widely used Data Envelopment Analysis (DEA). There has been increasing interest to the DEA in the last few decades. According to Seiford's study in 1994, there was more than 470 academic research and PhD dissertation about the DEA. And in 2002 a new study by Tavares presented increasing trends in the DEA. According to Tavares results, new studies using DEA have been continuously increased over the years and the number of published researches and dissertations in the literature increased above 3180. This actually shows that DEA analysis is being widely accepted as a useful and important tool.

There had been fundamental changes in the economic structures of the countries almost all around the world in the 1980s. Liberalization process in 1980s, led to rising competition in the both domestic and global markets. As a result of increasing competition among the firms, lots of efficiency tests have been held in the last twenty years. In this context, DEA becomes the most preferred method. Especially after the

1990's DEA method has widely accepted in the academic environments and became a useful method for profit and nonprofit organization's efficiency tests. Furthermore, DEA is being used in many different fields such as; evaluating departments of different universities (Wong and Beasley 1990), evaluating Greece banking sector (Vassiloglou and Giokas1990), measuring university library efficiency (Gerhard Reichmann 2004) and especially after the 2000 DEA has been widely used for measuring the efficiencies of the airports.

Another reason of the application of Data Envelopment Analysis in this study, airports have very different number of inputs and outputs. Following Table shows the 2010 yearly data for 5 international airports.

Table 2: Turkish Airports Inputs and Outputs

Airports	Outputs			Inputs	
	Passenger	Cargo	Aircraft Movements	Runway Lenghts	Terminal Area
Istanbul Ataturk	32.143.819	452.146	273.826	426.000	330.500
Izmir Adnan Menderes	7.485.098	17.725	57.848	291.600	136,199
Mugla Dalaman	3.785.779	186	23.690	135.000	118.045
Adana	2.841.170	8.460	22.495	123.750	9.061
Ankara Esenboga	7.763.914	15.095	63.391	393.750	182.000

As seen from the Table 2, each airport has different amounts of inputs and outputs. For instance, Istanbul Ataturk Airport has the highest input and output levels. On the other hand Adana Airport has the lowest input level but higher output on cargo compared to Mugla-Dalaman Airport. Under these conditions, it is very complicated and difficult to compare airports with each other. Therefore, it is appropriate to use Data Envelopment Analysis in this study.

DEA is a non-parametric method of measuring the efficiency of a Decision Making Units (will be referred to as 'DMU' hereafter) such as public sector and non-profit organizations. DEA was firstly introduced by Farrel (1957) and his study accepted as the starting point of the DEA. Afterwards, Charnes, Cooper and Rhodes reshaped the Farrell's study in 1978 under the constant returns to scale and this study has been accepted as the basic method of DEA. Charnes, Cooper and Rhodes's study is known as CCR method (due to the initials of their names) in the literature. Later, Charnes, Cooper and Rhodes's study, was extended to variable returns to scale by Banker, Charnes and Cooper in 1984. And this new study in 1984 passed through the literature as a BCC method. In the next section, technical details of the model will be presented.

4.2 Technical interpretation

The DEA analysis has been developed for determining the efficiency of a group of profit and non-profit institutions (DMUs).DEA analyzes the efficiency of a DMU by comparing it with the best DMU in the group under evaluation.

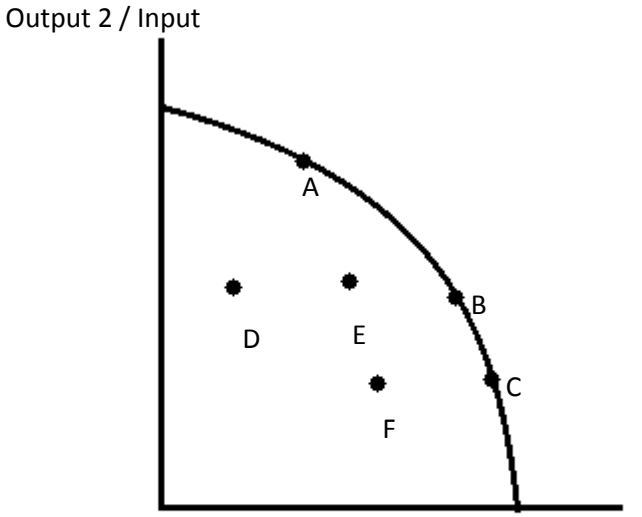
The main idea in DEA is to produce an efficiency score for each DMU by evaluating the inputs used to produce the output. The starting point is the assumption that if a specific amount of output can be produced by one DMU with a certain amount of inputs, then, other DMUs should be able to produce that specific amount also with the same amount of inputs. However if they use more inputs to produce the same amount, then they are not efficient, and thus must reduce the inputs. Similarly, a given amount of inputs should be able to produce the same amount of output in each DMU. If with same inputs, a smaller amount of output is produced, then that DMU is not efficient and must find ways to increase the output to be efficient. So a certain

DMU is said to be efficient if when compared to other DMUs, its inputs cannot be improved without decreasing its outputs (or its outputs cannot be increased without increasing its inputs), hence the technical efficiency. This definition of efficiency does not necessitate a full set of strict and formal assumptions. To be able to conduct a data envelopment analysis the required assumption is that the data reveal the performance of the DMU in the most accurate way and the returns to scale in the production is accurately determined. Determination of returns to scale is necessary to decide the envelopment of the data under analysis.

Data envelopment analysis creates a frontier (an envelope) which passes through the strictly dominating DMUs. Performance of each DMU can be compared with those of the ones on the frontier.

In Figure 2 and 3 below each point refer to a DMU's output/input ratio for two outputs.

Figure 2 is an illustration of output maximization approach. It shows the efficient and inefficient DMUs. (Diagrams are taken from Banker et al (1984), and Pachedo and Fernandes (2002))

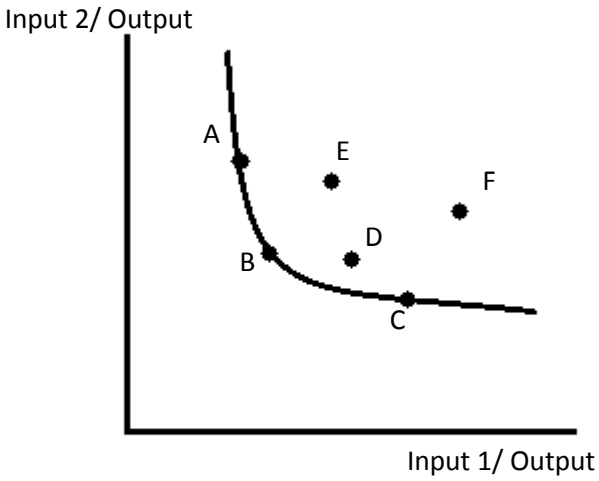


Partly Adapted from Fernandes and Pacheco (2002)

Figure 2:Efficiency Envelope; For Output Maximization

Points A, B and C reflect the efficient DMUs, whereas points D, E and F are inefficient. The frontier that joins A, B and C represents full efficiency.

Figure 3 below is an example of graphical illustration of input minimization approach. Each DMU uses the same amount of inputs and produce different level of outputs.



Partly Adapted from Fernandes and Pacheco (2002)

Figure 3: Efficiency Envelope; For Input Minimization

In Figure 3, points A, B and C are the most efficient points compared to points D, E and F under the input minimization approach.

Suppose that each point on Figure (a) shows a DMU and A, D, E, and F lie on the efficiency frontier, whereas DMUs B and C fall inside the frontier.

An inefficient DMU (which falls inside of the envelope) can be compared with another one which is on the frontier and also on the same activity line.

This can be illustrated with the diagrams below:

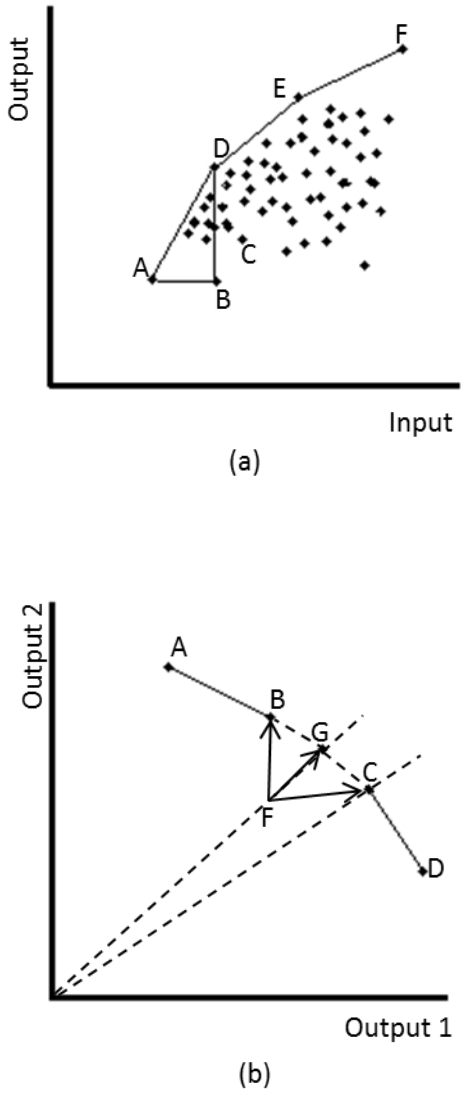


Figure 4: Reaching Efficiency Envelope

Then DMU_B can reach the efficient DMU_A on the frontier, by decreasing inputs or the efficient DMU_D by increasing its outputs.

Figure (b) shows DMUs producing outputs 1 and 2 and using exactly the same inputs. Figure shows that A, B, C and D are strictly dominating DMUs and are efficient ones. DMU_F is inefficient but can increase its output to reach DMU_C on the same activity line. DMU_F is not strictly dominated by either of B or C but can be

shown to be relatively inefficient. DMU_F can be compared with the hypothetical DMU_G, which is a combination of B and C with certain weights, created by DEA and this way it can be seen that DMU_F is relatively inefficient.

DEA utilizes three approaches to produce the efficiency scores. These approaches are 'input oriented', 'output oriented' and 'output/input oriented'. For each of these approaches a linear programming model is constructed. Model used in this thesis is input oriented; it shows how a DMU should move towards the efficient frontier by reducing its inputs proportionally to those of an efficient DMU.

It uses inputs and outputs in order to find efficiency results. In more technical illustration under output oriented maximization;

$$\text{DMU} = \frac{\text{Weighted Sum of Outputs}}{\text{Weighted Sum of Inputs}}$$

For input oriented minimization;

$$\text{DMU} = \frac{\text{Weighted Sum of Inputs}}{\text{Weighted Sum of Outputs}}$$

In the output oriented model optimization is done by maximizing the objective function, the ratio of weighted sum of outputs to the weighted sum of inputs of the DMU whose efficiency will be calculated. According to Charnes et al. (1978), the constraints are stated in such a way that the ratio of sum of weighted outputs to sum of weighted inputs for all DMUs should be less than or equal to one. In more precise form the problem is formulated as;

$$\text{Max} h_0 = \frac{\sum_{r=1}^{s} u_r y_{r_0}}{\sum_{i=1}^{m} v_i x_{i_0}}$$

Subject to;

$$\frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{i_j}} \leq 1$$

$$u_r, v_i \geq 0$$

for $j = 1, \dots, n \quad r = 1, \dots, s \quad i = 1, \dots, m$

$y_r = output$

$x_i = input$

$u_r, v_i = weights$ that will be determined by the model.

In the input oriented model, the dual problem of maximization, optimization is done by minimizing the objective function, the ratio of sum of weighted inputs to the sum of weighted outputs of the DMU whose efficiency will be calculated. Parallel to the primal problem, the constraints of the dual problem requires the ratio of sum of weighted inputs to the sum of weighted outputs to be not less than 1.

Under the input oriented efficiencies DMU determined according to the ratio of weighted sum of the inputs to the weighted sum of outputs and efficiency scores take values between 0 and 1. For the technical interpretation reciprocal model of the output oriented efficiency gives inputs oriented efficiency.

Here is the dual illustration of the model shown above;

$$\text{Min } f_0 = \frac{\sum_{i=1}^{m} v_i x_{i_0}}{\sum_{r=1}^{s} u_r y_{r_0}}$$

Subject to;

$$\frac{\sum_{i=1}^{m} v_i x_{i_j}}{\sum_{r=1}^{s} u_r x_{r_j}} \geq 1$$

$$u_r, v_i \geq 0$$

for $j = 1, \ldots, n \quad r = 1, \ldots, s \quad i = 1, \ldots, m$

Technical illustration of the model shown above, based on Constant Returns to Scale (CRS) and it can be extended to Variable Returns to Scale (VRS).

Creating an example similar to Coopers et al. (2004) will be helpful for better illustration of the model. For example, we have five DMUs named as A, B, C, D and E respectively. Each DMUs have two types of inputs and one type of output. These are listed in the Table 3 below;

Table 3: Inputs and Outpus

DMU	INPUTS		OUTPUT(000)
	X	Y	Z
A	2	5	3
B	2	3	3
C	3	1	3
D	5	1	3
E	6	2	3

In order to evaluate the efficiency of E (DMU), following input oriented CCR method will be used;

$$Min\ \theta$$

Subject to ;

$$2\lambda_1 + 2\lambda_2 + 3\lambda_3 + 5\lambda_4 + 6\lambda_5 \leq 6\theta$$
$$5\lambda_1 + 3\lambda_2 + 1\lambda_3 + 1\lambda_4 + 2\lambda_5 \leq 2\theta$$
$$3\lambda_1 + 3\lambda_2 + 3\lambda_3 + 3\lambda_4 + 3\lambda_5 \leq 3$$
$$\lambda_1 + \lambda_2 + \lambda_3 + \lambda_4 + \lambda_5 = 1$$
$$\lambda_1, \lambda_2, \lambda_3, \lambda_4, \lambda_5 \geq 0$$

By applying this model efficiency results have been found and all the efficiency results are presented in the Table 4 below;

Table 4: Efficiency Scores

DMU	Efficiency
A	1,00
B	1,00
C	1,00
D	1,00
E	0,50

According to the efficiency results, only E is the less efficient DMU which is 0.5. This indicates that DMU E should reduce inputs in order to catch up other DMUs' efficiency level. In more technical explanation Figure 5 ahead is presented;

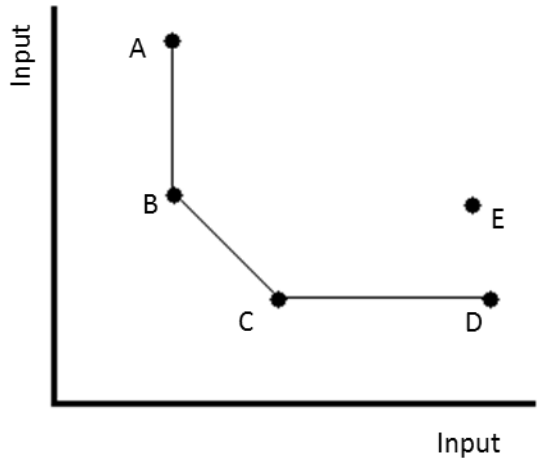


Figure 5: Input Minimization; Example

As seen from the Figure 5, DMUs A, B, C and D are all on the frontier which means they are efficient compared to the point E which is not on the frontier. But on the other hand, DMU- D uses more inputs compared to DMU- C, for producing the same number of outputs. For this reason, DMU- D is weakly inefficient.

4.3 Advantages and Disadvantages of DEA

In this study DEA method used because it has major advantages over the other methods. First of all, it is possible to use multiple of inputs and outputs to calculate efficiency scores of the profit and non-profit organizations. Because, DEA method based on the set of inputs and outputs in order to determine efficiency scores of the DMUs. Whereas, that is not possible with the Stochastic Frontier Analysis method. Another advantage according to Graham (2005), DEA method more attractive than other methods because it has less demanding data requirements.

On the other hand DEA has several disadvantages as well. According to Berg (2010), result of the efficiency scores may change with respect to input and output selection. In other words, the results are sensitive to the inputs and outputs. Another

disadvantage is the determination of weights because efficiency scores depend on the ratio of weighted outputs to weighted inputs. But there is no accurate and accepted method for determination of weights. For this reason, the lack of accurate and accepted method in the literature may lead selection of the weights to be wrong and misleading conclusions.

4.4 Description of Data

In this study, total 20 Turkish airports included for efficiency and comparison test. 20 airports were selected because, after 2000 Turkish airports began to modernize. In this context between 2007 and 2010 some of the airports were under the modernization. Therefore, data of those airports are lack. The following Table 4 lists the complete name and other characteristic information of the airports that are used in the study. All of the required information and data is taken from the annual reports of the Turkish State Airport Authority (DHMI).

Table 5: Turkish Airports

1	Istanbul Ataturk	International
2	Izmir Adnan Menderes	International
3	MuglaDalaman	International
4	Adana	International
5	Erzurum	International
6	Ankara Esenboga	International
7	Antalya	International
8	Mugla, Milas, Bodrum	International
9	Trabzon	International
10	Gaziantep	Regional
11	Adiyaman	Regional
12	Diyarbakir	Regional
13	Hatay	Regional
14	Kars	Regional
15	Konya	Regional
16	Mardin	Regional
17	Van FeritMelen	Regional
18	Elazig	Regional
19	Kayseri	Regional
20	Mus	Regional

Data sets that we used in the study composed of two kinds of inputs and three kinds of outputs. All the data are handled according to annual basis. For the input side, there are two factors are chosen in the analysis; terminal size (square meter) and runway length (m). From the output side, there are three factors are chosen; number of passengers, number of aircraft movements and tons of cargo carried.

Chapter 5

DATA ANALYSIS

In this study, an input oriented method used for determination of efficiency scores of the Turkish airports. Input oriented method was chosen because in input oriented method, you are testing whether the same number of inputs is able to produce more output. In our case, airports inputs are fixed because we used terminal size and runway lengths as an input. Therefore, it is not possible to change any inputs. For this reason, an input oriented method was chosen. Whereas in output oriented method you are testing the possibility of producing the same number of outputs by using less inputs. In addition to input oriented method, both Constant Returns to Scale (CRS) and Variable Returns to Scale (VRS) calculated for each airport.

For the calculation of efficiency scores of the Turkish airports, "DEA Frontier Software- DEAFrontier" was used.

In the section ahead, the efficiency results of 20 Turkish airports will be presented from 2007 to 2010 in terms of VRS and CRS.

Table 6 : Efficiency Scores Under CRS

DMU	DMU Name	2007	2008	2009	2010
1	Istanbul Ataturk	1,00000	1,00000	1,00000	1,00000
2	Izmir Adnan Menderes	0,44198	0,40490	0,44132	1,00000
3	MuglaDalaman	0,39396	0,35461	0,35437	0,37165
4	Adana	1,00000	1,00000	1,00000	0,75715
5	Erzurum	0,40325	0,34556	0,35694	0,23140
6	Ankara Esenboga	0,33018	0,32355	0,32353	0,35610
7	Antalya	1,00000	1,00000	1,00000	1,00000
8	Mugla,Milas, Bodrum	0,81049	0,84697	0,82355	0,65514
9	Trabzon	0,47148	0,43837	0,46079	0,42785
10	Gaziantep	0,44036	0,46350	0,50349	0,18997
11	Adiyaman	0,17068	0,26747	0,23700	0,06614
12	Diyarbakir	1,00000	1,00000	1,00000	0,32896
13	Hatay	0,00243	0,11544	0,24173	0,17463
14	Kars	0,17354	0,44057	0,43626	0,08009
15	Konya	0,29815	0,32969	0,34778	0,15342
16	Mardin	0,35661	0,33582	0,38380	0,12775
17	Van FeritMelen	1,00000	1,00000	1,00000	0,27186
18	Elazig	0,21097	0,23537	0,39653	0,13310
19	Kayseri	0,67193	0,60238	0,66537	0,27052
20	Mus	0,10337	0,33518	0,39322	0,04540

According to results of CRS in Table 5, most efficient airports are; Istanbul Ataturk, Adana, Antalya, Diyarbakir and Van-Ferit-Melen Airports. Least efficient airports are; Hatay, Adiyaman and Mus Airports respectively. In general, from 2007 to 2009 most of the airport’s efficiency scores increased by small amounts but in 2010 especially regional airports efficiency results decreased very sharply. As seen from the Figure 7 in the next page, some of the international airport's efficiency increased but on the other side all of the regional airport's efficiency decreased.

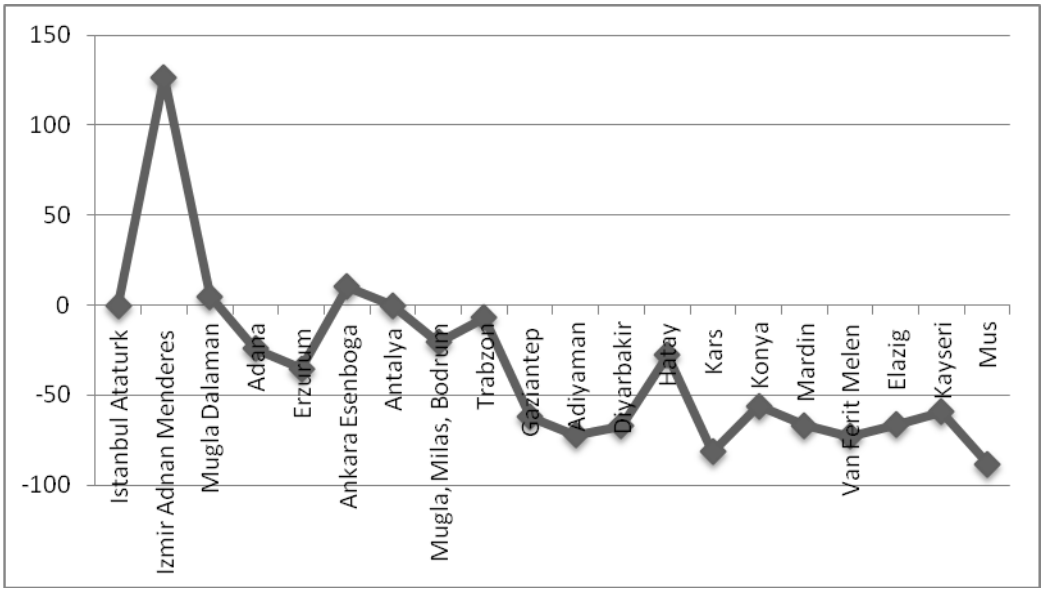


Figure 6: % Changes of CRS Efficiency Results in 2010

Table 7: Efficiency Scores Under VRS

DMU	DMU Name	2007	2008	2009	2010
1	Istanbul Ataturk	1,00000	1,00000	1,00000	1,00000
2	Izmir Adnan Menderes	0,53440	0,48757	0,50814	1,00000
3	MuglaDalaman	0,88317	0,84865	0,84884	0,86187
4	Adana	1,00000	1,00000	1,00000	1,00000
5	Erzurum	0,76055	0,73520	0,74328	0,75694
6	Ankara Esenboga	0,38329	0,36928	0,37281	0,41537
7	Antalya	1,00000	1,00000	1,00000	1,00000
8	Mugla, Milas, Bodrum	0,92776	0,92910	0,90470	0,89970
9	Trabzon	0,83245	0,78451	0,79115	0,81807
10	Gaziantep	0,50707	0,52369	0,53762	0,43573
11	Adiyaman	1,00000	1,00000	1,00000	1,00000
12	Diyarbakir	1,00000	1,00000	1,00000	0,69343
13	Hatay	0,56444	0,57135	0,59326	0,62866
14	Kars	0,67101	0,75326	0,73921	0,63746
15	Konya	0,60290	0,60560	0,61269	0,58865
16	Mardin	0,91505	0,88541	0,90507	0,89419
17	Van FeritMelen	1,00000	1,00000	1,00000	0,79338
18	Elazig	0,62487	0,61422	0,69212	0,63714
19	Kayseri	0,80256	0,75066	0,78677	0,69998
20	Mus	1,00000	1,00000	1,00000	0,98277

According to the efficiency results of VRS in Table 6, most efficient airports are; Istanbul Ataturk, Adana, Antalya, Adiyaman, Diyarbakir, Van-Ferit-Melen and Mus Airports. Least efficient airports are; Ankara Esenboga, Gaziantep and Izmir Adnan Menderes Airports respectively.

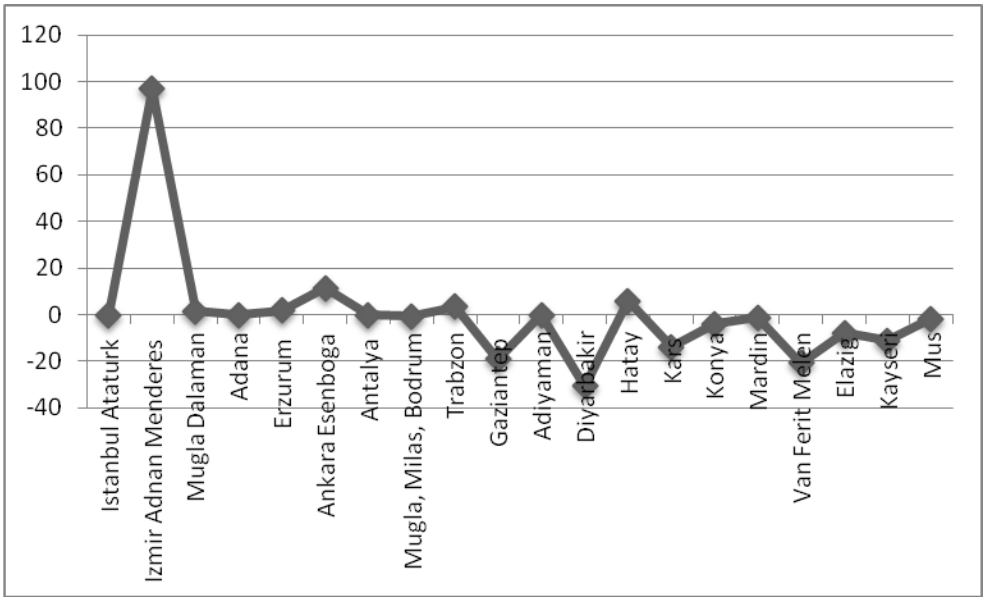


Figure 7: % Changes of VRS Efficiency Results in 20101

As seen from the Figure 8 above, some airports showed a negative trend in the VRS efficiency scores in 2010. The reason behind the negative trend in efficiency scores in both CRS and VRS, some outputs such as cargo and aircraft movement shows decline in 2010 compared to the previous years. Moreover, passenger transportation is limited with the inhabitants of the region and also very few numbers of non-Turkish citizens in the regional airports whereas millions of non-Turkish citizens have been using Turkish international airports. For this reason, especially regional airports showed negative efficiency scores.

To sum up, there are some airports performed lower efficiency results and some perform higher. In order to less efficient airports to catch up higher efficiency scores,

they should take reference airports which have higher efficiencies. In order to take as a reference there should be some similarities between the airports otherwise it will not be realistic. In this context, regional airports are more similar to each other in terms of inputs and outputs relative to international airports. For instance, Konya Airport is very similar to Diyarbakir Airport in terms of inputs, but because of huge differences in the outputs, their efficiency scores perform differently. So, in order to catch up Diyarbakir Airport's efficiency level, Konya Airport should increase output levels. But this is not likely to happen under government management because government pursues a political interest in the public institutions. Furthermore, in the public institution managers are not under pressure to demonstrate positive financial results. On the other hand, because of management of the airports has been done by the government, Turkish airports became traditional sector and showing little openness to innovation. Moreover, Turkish airports modernized two times in 60 years because of lack of capital.

Up to this point, what we see is the common problems of the government operated institutions. With the increasing air traffic in the Turkish aviation sector, these problems are expected to increase in the next decade. The solution of these problems then will necessitate a clear understanding of the current structure, suitably based on an efficiency analysis. However until now the efficiency analysis of Turkish airport infrastructure has not been elaborated yet. Accordingly, our main aim in this thesis is to analyze efficiencies and overall performances of the Turkish airports, to construct the aforementioned basis. Policy suggestion for the solutions to these problems is outside of the aim of this study. But still, I would like to present my opinion in this issue. Inefficiency problem of the Turkish regional airports is not a specific case to Turkey only, it is a common problem almost in all countries and some of the

countries had overcome this problem with the correct policies. For example, privatizations of the Argentina's airports to Aeropuertos Argentina 2000 (AA2000), London Supply and Aeropuertos del Neuqen in the 1998 were the optimal policy. Because there are some advantages of the privatization such as; private sector abundant in terms of capital compared to the public sector and technological improvements are usually related to capital improvements. So, technological improvements will be adapted to airports simultaneously with the rest of the world. And according to results of the Barros (2008) study, privatized public airports efficiency scores have been increased. In this context, Turkish government has a privatization policy option for regional airports like Argentina government in 1998 and by privatizing least efficient regional airports Turkish government may get the same result. Therefore, privatization policy of the least efficient regional airports is an option in the hands of the government.

Chapter 6

CONCLUSION

This study aimed to evaluate the efficiencies of Turkish aviation infrastructure and it is the first study of this kind. In this context, a total of twenty (among 43) international and regional Turkish airports are taken. For the evaluation of Turkish airports efficiencies, Data Envelopment Analysis (DEA) input oriented method was used. The results of the efficiency scores had been found in terms of Constant Return to Scale (CRS) and Variable Returns to Scale (VRS). In both approaches some of the airports (especially regional airports) showed inefficient performance.

According to CRS efficiency results in 2007 to 2010 most efficient airports are, Istanbul Ataturk Airport and Antalya Airport. Least efficient airport in 2007 to 2010 is Hatay Airport. According to VRS efficiency results in 2007 to 2010 the most efficient airports are, Istanbul Ataturk Airport, Adana Airport, Antalya Airport, Adiyaman Airport, Diyarbakir Airport, Van-Ferit-Melen Airport and Mus Airport . Least efficient airport in 2007 to 2010 is Ankara Esenboga Airport. Most efficient Airport with CRS and VRS methods, is the Istanbul Ataturk Airport. The analysis has shown significant disparities in efficiencies among the airports over the period examined. However, the overall average efficiencies of Turkish airports haven't indicated considerable fluctuations over the four-year period analyzed.

In conclusion, Turkish international airports' efficiency scores are higher as compared to the regional airports. In other words, international airports are more efficient relative to regional airports and this result is consistent with the study of Gillen and Lall (1997) who found that international airports operated at a higher level of efficiency than the regional airports. One of reasons behind the inefficient scores of the regional Turkish airports might be the government control (like in the examples given above) over the Turkish aviation sector since Turkish airports are under the state control. State control on the Turkish airports has a great impact on efficiency scores of the Turkish airports because it creates monopolistic power in the aviation sector. In addition to the monopolistic power of the government, they pursue political interest rather than economic interest. For this reason, lower efficiency level of government-operated institutions is not an unexpected outcome. Therefore, role of the Turkish government on the airport management needs to be revised. However, proposing a solution to this problem is outside this thesis study. For this reason, I presented my personal opinion at the end of the chapter 4 and according to my opinion inefficient airports managements should be transferred from the state administration to the private sector through privatization, such as Argentina's privatization as mentioned at the end of the chapter 4. By applying this policy, monopolistic aviation market will be eliminated and become more competitive. Thus, with the competitive market in the aviation sector, appropriate ground will be ensured for the more efficient Turkish aviation infrastructure. And also validity of this proposition can be tested in couple of years after the privatization.

It should be noted that our estimates of airports efficiency were dependent on the data that were available. We did not include labor and capital inputs in this study because those data were not available for 2007 and 2008. Therefore, our estimates

should only be interpreted as an assessment of the efficiency levels of the aviation infrastructure in Turkey. When quality data become available in the future, reassessment of efficiency will be necessary to verify the finding in this study.

For further research I recommend a new study about the optimal policy for the least efficient regional airports. In order to increase least efficient regional airports efficiency, optimal policy option needed to be developed.

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