Erasmus University Rotterdam

MSc in Maritime Economics and Logistics

2008/2009

Private Container Terminal Efficiency in Turkey

by

Barış Demirel

Acknowledgment

Apart from my own efforts and commitment to complete this dissertation in a demanding year in MEL, I would like to express my special thanks to the people who provided support and assistance to me throughout the research.

First of all, I would like to express my profound and heartfelt thanks to my wife for her constant support and patience during my presence in Holland. This thesis would have never been completed without her endless self sacrifice.

I would like to express my sincere thanks to my supervisor Professor Kevin Cullinane for his assistance and support in the course of the research and provision of a desk in Transport Research Institute at Edinburgh Napier University during period of my stay in Scotland. His critical recommendations and comments on various drafts of this dissertation have been of great value.

I also would like to express my deepest gratitude to Professor Hercules Haralambides who guided me on the right directions and provided me help and encouragement to go to Scotland in order to make further research and get support from Professor Kevin Cullinane.

All I have learnt from MEL contributed a lot to my professional background. Therefore, I owe special thanks to the professors teaching at MEL, whose lectures were precious in making the academic basis of this dissertation and completing it with a holistic approach, and to the business executives in MEL corporate network, who gave invaluable practical information and shared their success stories.

I would like to reserve my personal thanks to my friends in MEL. We have spent marvelous times together in Holland. Special thanks to Chris, his wife Mykka, Enrique, his wife Michele, Rickard and Kajal.

I would like to express my special thanks to my Turkish colleague in Holland, Isa and his wife Elmas for their friendship, hospitality and support. Thank to their being with me, I have never felt alone in Holland.

I cannot omit my family in Turkey without mentioning here for their supports and loving I felt during the research.

Last, but not least, I owe special thanks to Turkish Customs Authority and Government for providing me with the opportunity and scholarship to study in Holland.

Barış Demirel

28.09.2009

Abstract

The main objective of this paper is to investigate the possible impact of private sector involvement in container terminal operations on port (terminal) efficiency in Turkey in a regional perspective. The analysis of efficiency of the container terminals has included the most important container terminals in Turkey and in the Eastern Mediterranean region. The efficiency evaluations have been performed applying a non-parametric approach called Data Envelopment Analysis (DEA), and the impact of the private sector involvement in container terminals has been assessed applying a Tobit regression model, with the inputs of DEA scores as independent variable, and some other possible factors which may influence the efficiency in port sector. Apart from private sector involvement, scale (throughput), hub or gateway function, nautical distance from trunk route, and efficiency and effectiveness of customs and other border procedures at country level have been set as the possible factors influencing the technical efficiency scores in the Tobit regression model. It has been found that the private sector involvement in container terminals is one of the statistically significant factors together with scale (throughput), so there is sufficient evidence at least not to reject the hypotheses that private sector involvement in the operation of container terminals and scale effect are associated with higher efficiency. It has also been found that private terminals in Turkey are almost 22 and 17 percent more efficient on average than public container terminals under CCR and BCC models, respectively. The hub status of the terminals, the nautical distance from East West route, and the efficiency and effectiveness of customs and other border procedures have been found statistically insignificant.

Table of Contents

List of Tables

List of Figures

List of Abbreviations

APEC	Asia Pacific Economic Cooperation
BCC	Banker, Charnes and Cooper (1984)
BOT	Build-Operate-Transfer
CCR	Charnes, Cooper and Rhodes (1978)
CRPA	Directorate General of Construction of Railways, Ports and Airports, Ministry of Transport
DEA	Data Envelopment Analysis
DMU	Decision Making Unit
FDH	Free Disposable Hull
IMF	International Monetary Fund
IPOSOC	Industrial Ports of State Owned Companies
LPI	Logistic Performance Index, the World Bank
MOPF	Ministry of Public Finance
MOT	Ministry of Transport
MPWS	Ministry of Public Works and Settlement
PCA	Principal Component Analysis
PPI	Private Participation in Infrastructure, the World Bank database
Ro-Ro	Roll on-Roll off
SFA	Stochastic Frontier Approach
SPO	State Planning Organization
TEU	Twenty-foot Equivalent Unit

TMO	Turkish Maritime Organization
TSR	Turkish State Railways
UK	United Kingdom
UMA	Undersecretariat of Maritime Affairs
UNCTAD	United Nations Conference on Trade and Development
US	United States

Chapter 1 Introduction

1.1 Introduction

Ports, as an important part of transport network, perform critical functions varying from serving local, transit and transshipment traffic to creating employment opportunities.

In the last century, the port sector has experienced significant developments. Historically, ports tended to be state monopolies and the competition between ports was minimal at best. The cargo handling and port specific costs were also minimal compared to the high cost of ocean and inland transport (World Bank, 2003). Consequently, there was almost no reason to improve port efficiency.

That situation has changed however, currently; there is a fierce completion in the sector. With the remarkable gains in productivity in ocean transport achieved over the past several decades, ports now appear to be the remaining component in improving the efficiency of logistics chains (World Bank, 2003). Besides, with the development in containerization, the capital intensive nature of liner shipping and the need for maximum capacity utilization in order to achieve adequate rates of return on investment, increased pressures on ports for further improvements in labor productivity and operational efficiency (Haralambides, 1997). This created a stimulus afterwards to enhance port efficiency.

Governments are increasingly realizing the importance of efficiency in port sector and now willing to take radical steps to improve the performance of their ports. In this regard, new capacity and labor-saving cargo-handling equipment have replaced outdated facilities, port workers training has been intensified, customs procedures have been simplified; information technology has been widely adopted and management structures have been commercialized (Haralambides, Ma, Veenstra, 1997; Haralambides, 2002).

It is also empirically found by Cullinane and Khanna (1999) that vessel operations, and therefore the size of the container vessels are critically dependent on port productivity, and worldwide improvements in port productivity will so fundamentally change the container shipping costs that optimum vessel sizes for all routes will gradually increase over time. Additionally, the efficiency of ports has been found to be a critical factor for a country's competitiveness and its trade prospects (Tongzon, 1995, Cullinane, 2002, Park and De, 2004). Greater port efficiency is likely to bring about lower export prices which, consequently, help to ensure a nation's products are more competitive in global markets.

Since the operation efficiency in port sector is so important for a country to gain a competitive advantage, private sector involvement in ports is considered an effective way to help governments to win in the competition (World Bank, 2003, Tongzon and Heng, 2005). Because public ports are generally known to suffer deficiencies as a result of governmental hierarchies which control them, goal displacement, lack of clarity in corporate objectives and operative responsibility, and excessive ministerial intervention in operational decisions (Cullinane, Ji, and Wang, 2005), it has been widely demonstrated that the involvement of private sector companies in port operations provides an opportunity to remove traditional, bureaucratic operating procedures and controls and renew the port facilities and equipment by means of new financing opportunities.

Today, the extent and nature of private sector involvement in ports varies drastically. Baird (2002) associates this diversity, to the different methods applied to bring about greater private sector participation in the port sector. However, the author notes that while the influence of private sector actors in ports is growing, the role of public sector agencies also remains significant.

The aim of the dissertation is to investigate the possible impact of private sector involvement in container terminal operations on port (terminal) efficiency in Turkey. The efficiency evaluations will be performed applying a non parametric approach called Data Envelopment Analysis (DEA), and the impact of the private sector involvement in container terminals will be assessed applying a Tobit regression model, with the inputs of DEA scores obtained in DEA models. In addition, the analysis of efficiency of the container terminals will cover the most important container terminals in the Eastern Mediterranean region, where economic and social similarities prevail due to the regional proximity.

1.2 Research Questions

The study investigates the existence of causality between the greater private sector involvement in container terminals and higher efficiency. In this regard, it is specifically aimed to prove empirically that the public ports in Turkey (and in the Eastern Mediterranean region) are relatively less efficient in technical terms than the privately operated container terminals. As in the rest of the world, the inefficiency of public port sector in Turkey is widely discussed in parallel to the discussions on the privatization policies. Even though they are not based on empirical evidence, Gunaydın (2006) and Oral et al. (2007) argue that though the public ports in Turkey are located at strategic points between Asia and Europe transport network, they have not been able to develop accordingly due to the lack of national port strategy and a single port authority preserving the national and regional economic interests; poor infrastructure and superstructure facilities; management by a publicly owned company whose core business and priorities does not cover specifically port operation, complex bureaucratic procedures; non-flexible tariff structure adoptable to market conditions; insufficient draft in order to accommodate the increasingly large vessels, and inefficient port operations (Gunaydın, 2006, Oral et al., 2007).

Container terminals have been chosen specifically rather than the whole port sector, for the applicability of analysis on relative efficiency (comparisons can only be made between similar organizations) and the popularity of the industry in terms of the growing interest of the local and international private sector actors. Besides, according to World Bank records, terminal operation is one of the most attractive infrastructure investment in terms of port services. Of the 220 port privatizations recorded in the World Bank Private Participation in Infrastructure (PPI) database, 124 have been concessions or management contracts involving existing terminal operations. It is roughly estimated by

World Bank (2003) that the available revenue from container terminal operation is on the order of 38-40 billion US dollars annually.

The basic research question of the dissertation is as follows:

1. *Does the greater private sector involvement in container terminal operations have a positive impact on terminal efficiency in Turkey?*

The question will be examined both at national level (Turkey) and at regional level (Eastern Mediterranean region). The implications at regional level will be used to support the hypothesis based on this research question that greater private sector involvement is associated with higher efficiency in Turkey.

Related to efficiency levels in port sector, the other research questions to be investigated are as follows:

2. *Does the size or scale of the terminal have a positive impact on port efficiency?*

3. *Are high levels of technical efficiency associated with transshipment (hub status) as opposed to gateway ports or terminals?*

4. *Do the container terminals being far from the trunk route offer higher efficiency to compensate extra voyage time?*

These research questions will be investigated in the analysis over the determinants of port efficiency, and the causality will be discussed separately for each question subject (scale, transshipment, deviation distance). The second and third research questions will be analyzed both at national and regional level.

1.3 State of the Field

Though productivity is critical in evaluation of the performance of ports in administrative, economic, and financial terms, the practitioners in the port sector rarely apply the overall efficiency methods to compare and determine exactly the position of their ports in terms of performance. They still rely on simple partial indicators of port productivity, which may be misleading in overall performance evaluations (Estache, Gonzales and Trujillo, 2002).

The widely applied methodology for the comparison of overall efficiencies among organizations is DEA. However, Emrouznejad, Parker and Tavares (2008) found that most published DEA applications arose in the US, UK, and other developed nations. There are just a few attempts done to cover the developing countries like Korea, India, and in Latin America.

Besides, the research on efficiency of the port industry is relatively a new topic of interest among the specialists as the majority of the studies have been done after the 1980s, particularly compared with similar studies carried out for other public services like electricity, water, health, education, etc., including other transport modes (Gonzales and Trujillo, 2005).

Assessing the studies on port sector, it is also found that the majority of comparative research and studies on port sector have focused on the efficiency levels in specific ports or countries, and the studies specifically investigating the relationship between private sector participation and efficiency in port sector are relatively less and therefore the field is open to many research questions the answers of which are still not clearly known yet.

There is hardly any empirical research investigating the relative efficiencies of the ports in Turkey, either. In this regard, the dissertation is probably the first attempt not only to determine the efficiency level of the ports in Turkey and in the Eastern Mediterranean region but also to examine the existence of any relationship between private sector involvement and port (terminal) efficiency.

1.4 Thesis Structure

The structure of the dissertation is provided in Figure 1.

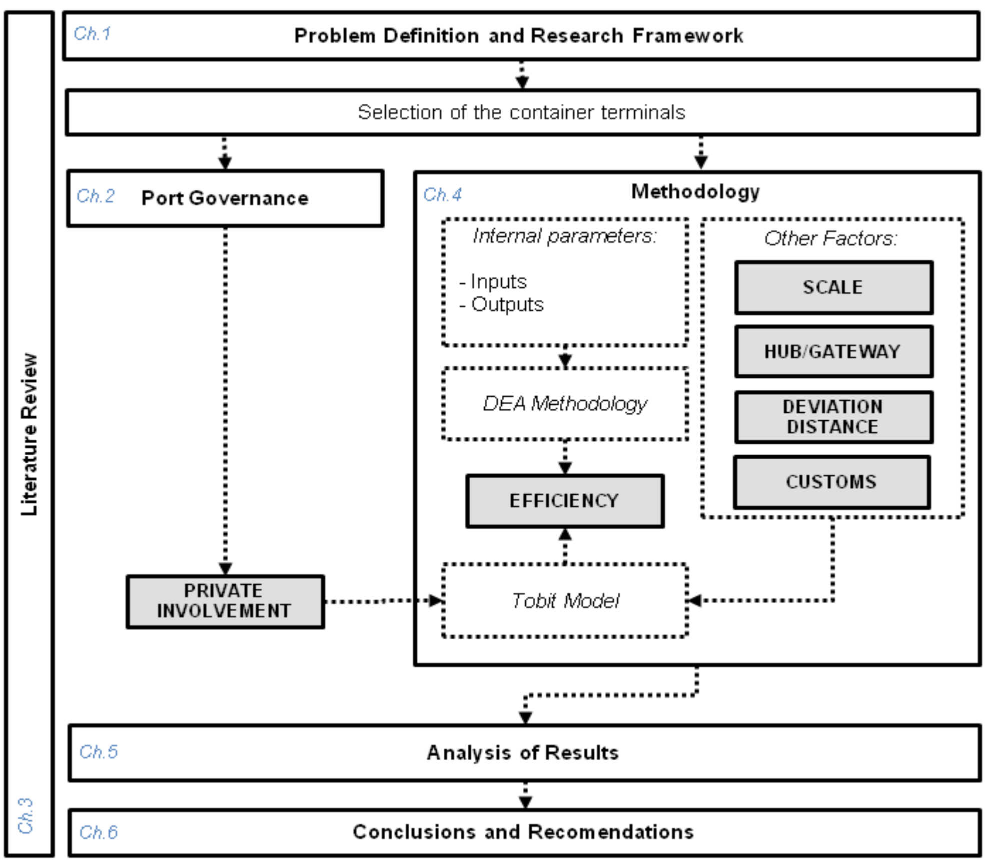

Figure 1: Structure of the Dissertation
Source: Own elaboration.

The dissertation consists of six chapters. In the introduction chapter, the research objective and the relevant research questions are elaborated and the outline of the study is provided. Following the introduction chapter, Chapter 2 presents the port governance models in general and the port administration system in Turkey is discussed. In this chapter, the reader understands the port governance models, the distinction between private and public ports in general and national port system, and privatization policy in Turkey. In addition, private public involvement in the selected container terminals in the Eastern Mediterranean region is also briefly provided. Chapter 3 present reviews on related literature on port efficiency studies. The chapter mentions about the empirical research done previously on port efficiency and the relationships between efficiency and private sector involvement, and other relationships (e.g. scale, transshipment). Chapter 4 introduces the methodology of the study and the data collected. In this Chapter, the methods used to measure relative efficiencies are briefly discussed, DEA methodology is elaborated, and the research methodology of the study is presented by including the Tobit regression model in order to investigate the determinants of port efficiency. The results and analysis are provided in Chapter 5. The results of DEA models are discussed, and the relationships between terminal efficiency and private sector involvement, terminal scale (size), transshipment activities, and deviation distances are investigated applying the Tobit regression model to the results of DEA models. Finally, Chapter 6 concludes the study through an articulation of the research findings, a discussion of the limitations of the study and the presentation of a set of recommendations.

Chapter 2 Port Governance

2.1 Introduction

The dissertation mainly focuses on private sector involvement in container terminal operations; therefore, in that respect, what is important in terms of the port governance structures is whether a container terminal is operated by the private or public sector. However, in order to understand this difference and principles of port governance approaches, the studies principally discussing the port governance models and their use in the reform policies are examined. Then, the port governance system in Turkey is discussed. Finally, the privatization policy in Turkey with respect to port sector is introduced. In this chapter, the governance structures of the selected container terminals in this study are also briefly mentioned.

It is intended to find answers to the following questions in this Chapter:

- What are the port governance models in general and the studies in this respect on governance structures in port industry?
- How the terminals covered in this study are governed in terms of public-private operations?
- How is the port sector structured and governed in Turkey?
- What is the trend of privatization in Turkey and which policies are being followed in this regard?

2.2 Literature on port governance

This thesis mainly focuses on private sector involvement in container terminal operations; therefore, what is important in terms of the port governance structures is whether a container terminal is operated by the private or public sector. However, in order to understand this difference and principles of port governance approaches, the studies principally discussing the port governance models and their use in the reform policies needs to be examined. This part is also important for further explanations of the port governance structure in Turkey.

The studies investigating the port governance or administration structures in the port sector back to 1990s. Among the studies attempting to classify the ports and establish port governance structures, those made by Goss (1990), UNCTAD (1992), Baird (1995, 1997) and the World Bank (2003) are worth discussing in order to understand the global port governance models. Goss (1990) provided probably the first attempt to discuss this issue. The author divided the ports into three types (comprehensive, landlord and hybrid ports in between) according to the role played by the port authority. UNCTAD (1992) made a further detailed classification by categorizing ports into three types: landlord port, tool port, and operating port. Baird (1995, 1997) provided a port function matrix, considering that all ports have 3 main functions (regulation, landlord, and operation) no matter whether they are public or private ports. Similar to studies made by Goss (1990) and UNCTAD (1992), the World Bank (2003) outlined four port administration models: service port, tool port, landlord port and private service port. All these models will be discussed later in this chapter.

A non-exhaustive list of studies investigating the private sector involvement in port sector is presented below chronologically:

- After investigating the situation in the UK, Baird (2000) concluded that the processes and methods that were used to implement the port privatization policy in the UK were fundamentally flawed. The author noted that there is a clear implication that within the UK at least, the hoped-for benefits from the initiation of port privatization policies largely did not materialized, simply because of the inappropriateness of the mechanisms and approaches for port privatization adopted. He pointed out that in terms of port productivity, from a port users perspective, there did not appear to have been any significant difference identified in performance between UK ports owned by private or the public sector since privatization. He mentioned that port users have maintained that changes in port productivity before and after privatization were not nearly as significant as the changes that took place after the abolition of the National Dock Labor Scheme. In other words, efficiency gains were not attributed to greater private-sector involvement in port sector.

- Based on the analysis of survey data, Baird (2002) investigated private-sector participation in the world's top 100 container ports. The author found that the extent and nature of private sector involvement in ports sector varied significantly, in part due to the different methods employed to bring about greater private sector participation in an industry that was traditionally characterized by public sector ownership and control. The author also concluded that, although the influence of private sector actors in the port sector is growing, the role of public sector also remains significant.

- Cullinane and Song (2002) investigated the theoretical underpinnings and practical validity of the claim that the transfer of ownership from public to private sector would ultimately lead to an improvement in economic efficiency and, hence, financial and operational performance and concluded that privatization was only a partial cure for what ails the world's ports and that, if implemented in isolation; it simply cannot bring the needed solution for the industry's woes.

- Oral et al. (2007) focused on Turkish port management and administration system and the possibilities for applying good governance in Turkish ports during the current process of privatization of public ports. The authors classified the ports in terms of whether they are operated by public sector, affiliated sector, regional municipalities or the private sector. The study concluded that the privatization process has not been completed yet and there are many legal and practical issues to be resolved.

- Brooks and Cullinane (2007) examined port governance models today, based on the research data collected by the Port Performance Research Network on 42 ports in nine countries, including Turkey. They found that the ports in Australia, Turkey and the UK exhibited the complete range of possible strategic objectives, with some ports pursuing solely economic objectives, others pursuing solely non-economic objectives and yet others pursuing a mix of economic and non-economic objectives. The paper noted that it was probably due to the transitional phase the sector found itself in as the result of an ongoing privatization process that was not yet complete that Turkey exhibited all different port management structures. The study identified key strategic objectives for port governance and concluded that the data did not validate the World Bank models or other models proposed, and that these models were oversimplified.

What is most striking out of these studies is that in terms of port governance models, they emphasize that the influence of private actors in the port sector is emergent and the structures in which the operation of the ports is performed by the private sector but the land is still owned by the public sector (or namely, landlord port model), are the common arrangement mostly used and referred.

2.3 Port Governance Models

The researches on port governance models started early 1990's. Goss (1990) provides probably the first attempt to discuss this issue. Goss (1990) divided ports into three types:

1. *Comprehensive port:* A port is defined as a comprehensive port if the port authority itself performs all, or almost all, of the activities carried on within the area of the port.
2. *Landlord port:* A port is regarded as a landlord port if the responsibility of the port authority is restricted to infrastructure, planning and controlling the port activities, the operations of services were broadly delegated to private sector. Goss (1990) argues that the landlord port is the opposite of the comprehensive port.
3. *Hybrid port:* The author defined the ports which belong to neither of the above mentioned types of ports, as hybrid port.

A similar classification of ports in terms of different port governance structures was elaborated by UNCTAD (1992). The study divided the ports as landlord port, tool port, and operating port.

1. *Landlord port:* It is a landlord port if the port authority is responsible for the provision of the infrastructure (land use, reservation of space for the port areas, and construction and use of public port works), while investment in the superstructure and the operation of port facilities is the responsibility of either public or private sector enterprises.
2. *Tool port:* a tool port is a variant of landlord port. If the port authority is responsible for the execution of works including ship control stations, handling equipment storage area, and warehouse equipment, equipment for ship repair and supply etc., the port is defined as a tool port. In general, the provision of

both infrastructure and superstructure is provided by the port authority, while provision of services is delegated to licensed private operators. Here, the main difference from the landlord port model, defined by Goss (1990) and below as well, is the provision of the port superstructure by the port authority.

3. *Operating port:* A port is defined as an operating port, if the port authority provides all port facilities and services including the operations within the port. In this regard, this type corresponds to the comprehensive port model defined by Goss (1990).

Another alternative for analyzing port administration and ownership was proposed by Baird (1995, 1997), and refers to a port function matrix as shown in Table 1. The author considers that all ports have 3 main functions no matter whether they are public or private ports:

1. *A regulatory function:* This function is related to granting mostly the legislative powers to the port's public or private sector management. This function is regarded as the primary role of a port authority by the author.
2. *A landowner function:* The essential tasks involved in this function would be to manage and develop the port estate; to implement policies and strategies for the port's physical development in terms of superstructure and infrastructure; to coordinate port marketing and promotion activities; to provide and maintain channels, fairways, breakwaters, locks, berths etc.; and to ensure or arrange for land and rail road access to the port facilities.
3. *An operator function:* This function involves the physical transfer of goods and passengers between sea and land.

Table 1: Port function matrix
Source: Baird (1995, 1997)

Port models	*Port functions*		
	Regulator	*Landlord*	*Operator*
PUBLIC	Public	Public	Public
PUBLIC/private	Public	Public	Private
PRIVATE/public	Public	Private	Private
PRIVATE	Private	Private	Private

Port administration and ownership models are divided into four types of port administration: the PUBLIC port, the PUBLIC/private port with the public sector dominant, the PRIVATE/public port with the private sector dominant, and the PRIVATE port. In a PUBLIC port model, all three functions are controlled by the government or public authority. In the PUBLIC/private port model, the operator function is controlled by the private sector, while both regulatory and landowner functions remain in the hands of the government or public sector authority. In the PRIVATE/public port model, both landowner and operator functions rest in private control, while the regulatory function remains within the public sector. Finally, in the PRIVATE port model, all three essential functions are controlled by the private sector.

The World Bank (2003) outlined four port administration models in its Port Reform Toolkit for governments: (public) service port, tool port, landlord port and private service port. As summarized in Table 2, in public service port model, the port authority is predominantly public administration and responsible for performing regulatory functions, developing infrastructure and superstructure, and executing operational activities. In tool port model, the public sector port authority owns, develops and maintains the port infrastructure and superstructure, including cargo handling equipment. The operation of equipment is usually performed by port authority labor, but other operations are performed by private cargo handling firms. In landlord port model, the port authority retains ownership of the port land while the infrastructure is leased to private operators. The private companies provide and maintain their own superstructure, employ the stevedoring labor. Finally, in private service port model, all regulatory, capital and operating activities are provided by the private sector. Port land is also privately owned by the private sector.

Table 2: Basic port management models
Source: World Bank Port Reform Toolkit, Module 3 (World Bank, 2003)

Port models	*Port functions*			
	Infrastructure	*Superstructure*	*Port Labor*	*Other functions*
Public service port	Public	Public	Public	Majority Public
Tool Port	Public	Public	Private	Public / Private
Landlord Port	Public	Private	Private	Public / Private
Private Service Port	Private	Private	Private	Majority Private

These models differ in several ways: by whether port services are provided by the public sector (the government), private sector or mixed ownership providers; their orientation (local, regional or global); who owns the superstructure and capital equipment; and who provides dock labor and management. The choice of model by government is influenced by the socio-economic structure of a country, the historical development of the port, the location of the port (urban area or isolated region) and the types of cargo typically handled (liquid or dry bulk, containers). Decisions about the balance of public sector and private sector participation are also a product of the strength of the capital markets in the country and the philosophy of the country with respect to alternative service delivery.

Public Service port: The port authority is predominantly public administration and responsible for performing regulatory functions, developing infrastructure and superstructure, and executing operational activities. There is also potential for inefficient port administration as a result of limited internal competition; there may also be little incentive for innovative management, and this may lead to services that are neither user-friendly nor market-oriented. Furthermore, the dependence of the authority on the government for funding may lead to a wasteful use of resources or under-investment.

The incentives for efficient operations may not be fully functional and non-economic motivations may dominate.

Tool port: The public sector port authority owns, develops and maintains the port infrastructure and superstructure, including cargo handling equipment. The operation of equipment is usually performed by port authority labor, but other operations are performed by private cargo handling firms. The approach aims to avoid duplication in port facilities because investment in both infrastructure and equipment is provided by the public sector. However, this approach also runs the risk of under-investment, and conflicting situations in sharing the cargo handling services between the port authority and private enterprise jointly.

Landlord port: The Port Authority retains ownership of the port land while the infrastructure is leased to private operators. The private companies provide and maintain their own superstructure, employ the stevedoring labor. In this model, private terminal handling companies generally are better able to cope with market requirements. However, this model has the risk of over-capacity as a result of pressure from various private operators, and misjudging the proper timing of capacity additions.

Private Service port: All regulatory, capital and operating activities are provided by the private sector. Port land is also privately owned by the private sector. This is the model used in many ports in the United Kingdom. This model has maximum flexibility with respect to investments and port operations, and no direct interference from government. However, government may need to create a port regulator to control monopolistic behavior, and also loses its ability to execute a long term economic development policy with respect to the port business.

Which of these models provides the best fit will depend on the way the ports are organized, structured and managed. These factors include the socio-economic structure of a country, the historical development of the port, the location of the port (urban area or isolated region) and the types of cargo typically handled (liquid or dry bulk, containers). Decisions about the balance of public sector and private sector participation are also a product of the strength of the capital markets in the country and the philosophy of the country with respect to alternative service delivery (World Bank, 2001). Brooks and Cullinane, 2007 made a contribution to these factors by arguing that the willingness of the private sector to invest in port activities in less than stable environments may be also related with the general investment climate as it has to do with the governance model in itself.

The extent of private sector participation in port or terminal sector varies significantly from one country to another. Baird (1999) studied world’s top 100 container ports and found that due to the different methods employed to bring about greater private sector participation in port industry, nature of private sector involvement in the port sector varies considerably. The study showed that 88 of the top 100 container ports conform to the private model in which only port operations are carried out by the private sector, with the public sector keeping the possession of port land and fulfilling the port authority regulatory functions.

Similar results were obtained by Juhel (2001) who conducted in 1997 a research about the world's top 100 container ports and revealed that 88 of these had been privatized to some extent (Juhel, 2001).

Tongzon and Heng (2005) showed that the best extent of private participation in container ports/terminals is between the Private/public (0.67) and the Private (1.00) mode, implying that it is better for port authorities to limit the private sector participation within the landowner and operator functions and take over the regulatory function.

Even though there has been made some studies in order to simplify and classify the port administrations and structure, the current port governance structures in the world are more complex than these simplified models constructed. In reality, infinite variety of administration structures of ports lie in between the structures where only the public interests are considered and the other extreme structures in which the only the objectives of private sector enterprises are followed. The fact that the models do not reflect the real picture was emphasized by Brooks and Cullinane (2007) noting that most ports in the world in fact fall into the mixed category (somewhere in between public and private category). However, the role of private sector in the port or terminal operations is growing, and the governments are in tendency towards keeping the only regulatory function in the port sector.

Though in the literature there are many studies about the port governance models, the governance concept in this dissertation will be limited simply to the operation of the ports. It is therefore stuck here to public and private sector involvement in operator function in the classification by Baird (1995, 1997) or superstructure in the World Bank classification of port models, because of their simplicity, wide variety of use, and appropriateness for this study.

2.4 Private sector involvement in the terminals covered

The dissertation mainly focuses on private sector involvement in container terminal operations; therefore, in that respect, what is important in terms of the port governance structures is whether a container terminal is operated by the private or public sector. Therefore, it is devoted simply to the operational perspective of port governance. The port governance structure of the container terminals in the sample and the average efficiencies are given in Table 3.

Table 3: Governance in the Container Terminals covered in the study
Source: Own elaboration.

Container Terminal	*Country*	*Governance*
Izmir	Turkey	Public
Haydarpaşa	Turkey	Public
Mersin	Turkey	Private*
Marport	Turkey	Private
Kumport	Turkey	Private
Gemport	Turkey	Private
Mardaş	Turkey	Private
Borusan	Turkey	Private
Evyapport	Turkey	Private
Constanta CSCT	Romania	Private
Haifa	Israel	Public
Thessaloniki	Greece	Public
Piraeus	Greece	Public
Novorossiysk	Russia	Private
Port Said SCCT	Egypt	Private
Damietta DCHC	Egypt	Public

**It was public port until April 2007.*

The port governance and the private sector involvement in port business in Turkey are discussed later in this chapter. While choosing the container terminals from the Eastern Mediterranean region, together with the importance and the size of the container terminals, special attention has also been paid to ensure a balanced distribution of public and private container terminals in the sample. Since the Turkish container terminals in the sample include many privately operated terminals, the sample includes more public terminals from the other countries in the region.

For the terminals operated by the companies which are owned both by public and private sector, they were assumed to be publicly operated terminals unless the private sector has the majority of the shares in the company (e.g. Damietta DCHC).

2.5 Port Governance in Turkey

Turkey is located close to one of the main transportation corridors (The Mediterranean Sea) between Far East Asia and Europe, with an 8333 kilometer costal line. In spite of the advantageous position in the Eastern Mediterranean region, it hasn't been able to benefit from this position and become a part of the main service network between Far East and Europe. Turkey has not got a hub port in the region yet. Gioia Tauro (Italy), Algeciras (Spain), and Malta (Malta) are the most important hub ports in the Mediterranean basin. Haifa (Israel), Port Said (Egypt) and Piraeus (Greece) are the main regional hub ports close to Turkey. Figure 2 shows the biggest ports in the

Mediterranean region. As seen on the graph, the only port from Turkey is Ambarlı port, which is composed of several private container terminals.

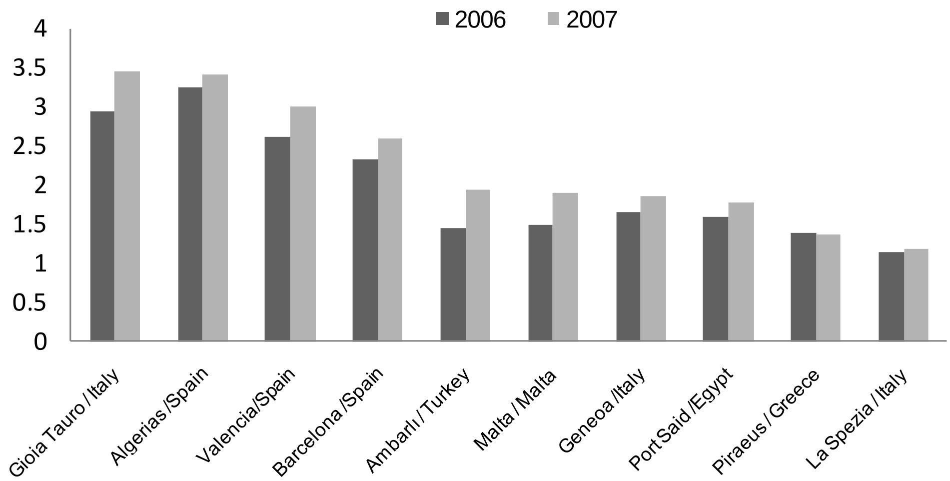

Figure 2: The Biggest container ports in the Mediterranean Region
Source: Ocean Shipping Consultant Ltd. UK, WorldNet Seminar Istanbul April 2008

When the international container movement through Turkey is overlooked, it is seen that containers from Northern Europe are transported through Northern Europe and the Mediterranean route to Port Said port in Egypt and then sent to Mersin, Izmir and Istanbul ports by means of feeder services. Containers from North America are shipped through the Pacific Mediterranean route to Gio Tauro, and then distributed to Mersin, Izmir, and Istanbul and Black Sea ports by feeders. Similarly the containers from the Far East are shipped through the Asia route to Port Said or Haifa ports and distributed to Mersin, Izmir and Istanbul ports.

Though the ports in Turkey are located at strategic points between the Asian and European transport networks, the port sector has not been able to develop accordingly due to the lack of national port strategy and a single port authority preserving the national and regional economic interests, poor infrastructure and superstructure facilities, complex bureaucratic procedures, non-flexible tariff structure adoptable to market conditions and insufficient draft in order to accommodate the increasingly large vessels. Even though they are not based on empirical evidence, Gunaydın (2006) and Oral et al. (2007) also argue that especially the public ports in Turkey are managed and operated inefficiently.

However, there are also some opportunities available for Turkish ports. The closeness to the landlocked states in Black Sea, Mediterranean region, Red Sea, Persian Gulf; the increasing trade and economic cooperation with Central Asian countries; and existence of industrial hinterlands close to big ports are just some examples for these.

2.5.1 Coastal Regime

According to the Constitution (article 43), the coastline of Turkey is legally public property owned by the state, and its use has to be such that it contributes to the public interest. So long as the coastline is open for public use, the construction of port facilities such as wharves, piers, breakwaters, etc. can only be constructed by permission from central government authorities (Oral et al. 2007).

Under the current coastal regime, the central government is responsible for ensuring that the administration, cleaning, deepening and widening of ports, for the placing of buoys and their maintenance in good shape, and all the other activities related to ports are performed properly (Law on Ports, article 1). The Government is also authorized for the establishment of a corporation for every port which possesses stocks for the arrangement of loading, and unloading, water and coal distribution activities by utilization a portion of its capital from its budget (Law on Ports, article 8). In this regard, Turkish State Railways (TSR), Turkish Maritime Organization (TMO) and some other industrial state owned entities were established in 1920s, being responsible for the establishment and operation of the ports given by the Government.

Because the coastline is legally public property and its use has to be such that it contributes to the public interest, the use of coastal facilities (including the privatization of port facilities) is possible only by the methods except the transfer of ownership of the properties (land).

2.5.2 National Port Governance System

The port governance structure in Turkey is very complicated in terms of administrative roles of different bodies. According to Oral et al. (2007), the main port-related governmental organizations can be summarized as follows: Prime Ministry State Planning Organization (SPO), Undersecretariat for Maritime Affairs (UMA), Ministry of Transport (MOT), General Directorate of Construction of Rail, Ports and Airports (CRPA, under MOT), Ministry of Public Finance (MOPF), Ministry of Public Works and Settlement (MPWS), Ministry of Industry (MOI), State Economic Enterprises such as Turkish State Railways (TSR) and Turkish Maritime Organization (TMO), Ministry of Health, Ministry of Agriculture, Ministry of Interior, Ministry of Environment, municipalities, customs, immigration police, etc.

The relationship between governmental organizations and the functions and responsibilities of the main port-related organizations are described below (Oral et al., 2007) in Figure 3:

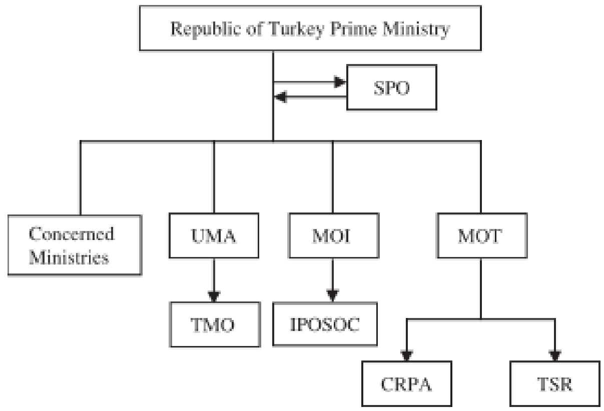

Figure 3: Port related governmental organizations in Turkey
Source: Oral et al. (2007)

SPO considers the total balance of investment in Turkey and judges the feasibility of specific projects. The MOT coordinates all the development of ports in Turkey and has responsibility for setting the port tariff of TSR ports. The MOI controls and coordinates the industrial ports of state-owned companies (IPOSOC). The CRPA (under MOT) undertakes all planning, research, construction and maintenance work on ports belonging to the public and affiliated sectors. It also approves the infrastructure and port development investments of private ports. UMA coordinates political, economic and legal aspects concerned with international maritime issues according to national policy. The UMA used to set the port tariff of TMO ports. Such public ports are not operated by TMO any longer since they have been privatized. It is the UMA that acts as the maritime authority in Turkey (focal point in international relations) and administers the maritime vessel traffic system. This relates to aspects such as the entry and exit of ships into and out of port and the regulation of shipping and navigation, etc. MPWS prepares territorial application plans and defines the land use principles for all industrial sectors, including the transportation sector. State Economic Enterprises, such as the TSR, TMO, and IPOSOCs, operate, develop and maintain owned ports. The TSR also undertakes miscellaneous transportation by providing connections between railways and ships and establishing and operating the required superstructure, such as warehouses, silos, fuel facilities, etc. Municipalities are concerned with city–port relations and environmental impacts and they provide some services to ports such as fresh-water, garbage collection, etc.

As mentioned above, there are many governmental bodies responsible directly or indirectly for port related activities. Due to the lack of a single authority responsible for regulating the ports, there is a coordination problem and conflicts of authority among these related bodies. There is a complex system of involvement in the investment, operation and administration process (Oral et al., 2007). This situation causes some confusion in the decision making process and coordination.

Turkey does not have a port authority system, fulfilling the regulation and landlord functions under a single body. The maritime rules and regulations at the coasts of Turkey are implemented by UMA. It is also the main authority in the fields of maritime issues at the national and international level with the main objective of determining and coordinating the national maritime policy and other studies related to the maritime issues. It has sixty eight Harbor Master Offices for the implementation of the marine related rules and regulations (Gunaydın, 2006). Though UMA is responsible for the regulation of the ports, it does not have full regulation authority including the construction and development of ports.

Regarding construction and development activities that can be considered a part of regulation system, Oral et al. (2007) summarize the construction and development procedures for ports. All private and public institutions or individuals who construct marine structures such as berths, docks, piers and breakwaters must get approval from the relevant government organizations, including the CRPA. First, the governor of the province reviews the investment plans including all the details and properties of the structures, as well as reports, maps and other related documents, on the background and local information of the area. Then, the MPWS examines the proposal in terms of the general and regional planning principles, and general settlement plan decisions. After obtaining approval from the MPWS, the CRPA examines the implementation projects from a technical point of view. The investors go ahead with construction with full responsibility and control still lying with the CRPA. Following the completion of construction, UMA gives the investors permission to operate the new facility. This shows that even some part of the regulatory functions is performed at central level.

Some regulation functions (e.g. tariff setting) have also been implemented by TSR and TMO that owned and managed the main ports in Turkey.

There is clearly a need for a single port authority responsible for the regulation of all ports and port related activities. The need for a port authority in order to simplify and collect all the regulatory functions under a single authority has been emphasized by the latest State Development Plan issued by SPO.

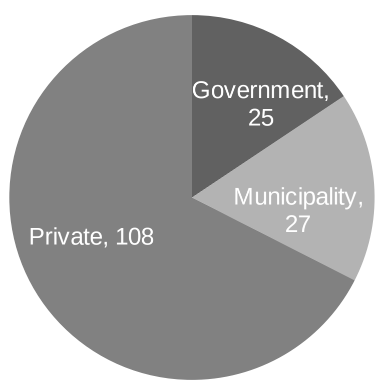

Figure 4: Ports in Turkey from an operational point of view
Source: Maritime Sector Report 2007

The ports of Turkey are classified into three groups according to an operational point of view: public ports, municipal ports, and private ports. According to Maritime Sector Report (2007), out of 160 ports including all cargo, passenger, yacht and fishery port facilities in Turkey, 108 ports are operated by private, 27 ports are operated by municipalities, and 25 ports are operated by the government (Figure 4). In this paper, we will discuss only the main cargo ports and their governance structures.

The main public ports are operated by TSR and the TMO. The TSR manages ports connected to the railway system. These major public ports are general-purpose ports under the control of the MOT, which approves the budgets and annual programmes and plans of both TSR and TMO. The ports operated by TMO are small scale and generally non-cargo ports. There are also some specialized affiliated ports owned and operated by large state-owned industrial companies and these ports usually serve the tramp and bulk market, and controlled by MOI.

TSR ports are managed from its headquarters in Ankara. The CRPA coordinates with the TSR headquarters in formulating port development plans. Each port also consults and advises headquarters in planning its port development. TSR ports procure superstructure (warehouses, cranes, and cargo handling equipment, etc.) and engage in operations in their own right. TSR ports provide marine services (pilotage, tugs, mooring, fresh-water supply and bunkering) in some TSR owned ports.

The construction of infrastructure at public ports is met from the national budget, while the maintenance of these structures is undertaken by the respective port management bodies at their own expense. Similarly, superstructure and cargo handling facilities are established and maintained by port management bodies. Gunaydın (2006) mentions that the present condition of the public ports involve several disadvantages like obsolete technology, low modernization and expansion investments, thus, investment requirements but state budget restrictions, lack of finance, inefficient and ineffective management, insufficient depth of the ports, poor rail and road connections for intermodal transportation.

Municipal ports are, in fact, public service ports owned and operated by local government. They can be considered as negligible as they do not play an important role in the overall marine transportation of Turkey because of their low share of cargo throughput.

Private ports have specialized terminal operations that usually serve the bulk and tramp market. Some are occupied with the liner market by serving containerized cargo. The private ports/terminals are in a rather competitive position compared with publicly operated ports. Generally, they prefer to specialize and operate more efficiently. The decision-making process in private ports is much quicker and more efficient at investing, especially in cargo handling equipment. The management style of the private port sector has minimized internal bureaucracy (Oral et al. 2007, Gunaydın 2006).

The Figure 5 and Figure 6 exhibit the container throughput of public and private ports since 2003. The share of private ports in container transportation has been rising while the public ports have almost stayed at the same level in absolute terms.

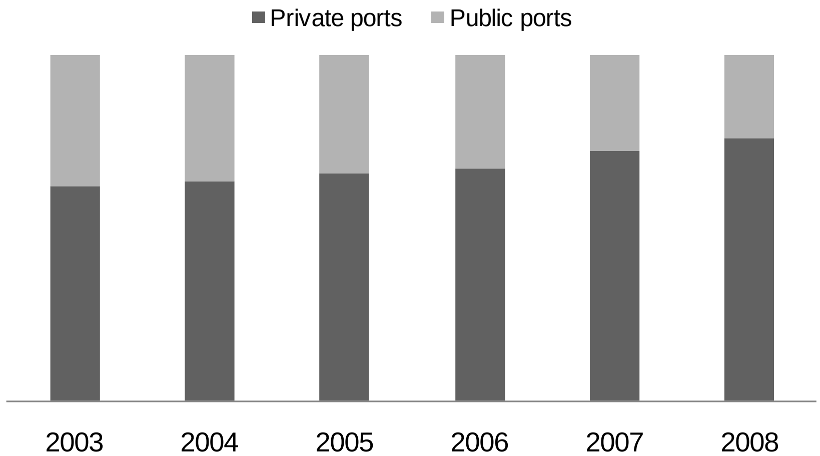

Figure 5: Container Throughputs (%) in Turkey
Source: TURKLIM (http://www.turklim.org)

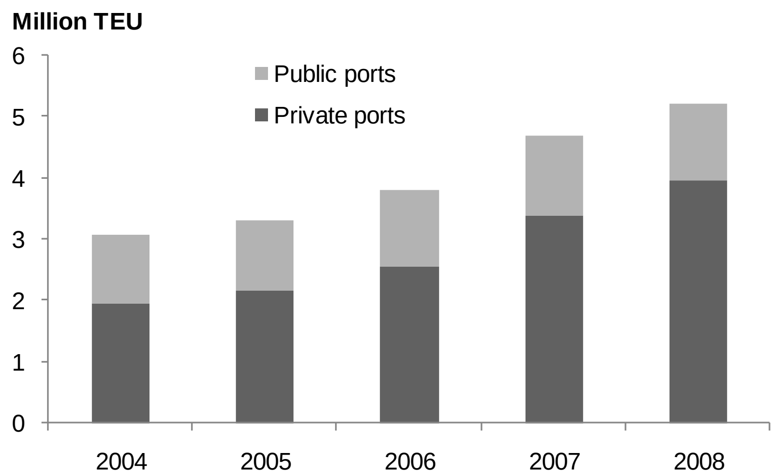

Figure 6: Container Throughputs (TEU) in Turkey
Source: TURKLIM (http://www.turklim.org)

Based on Baird's port function matrix mentioned in the introduction part of this chapter, the functional structure in Turkey is illustrated in Table 4:

Table 4: Port functional structure in Turkey
Source: Own classification.

Type	*Port functions*		
	Regulator	*Landlord*	*Operator*
Public ports	SPO, UMA, MOT, MPWS, TSR, Municipalities	MOPF (DG of National Estate), Privatization Board	TSR, TMO, or IPOSOC
Municipal ports	SPO, UMA, MOT, MPWS, Municipalities	Municipalities	Municipalities
Private ports	SPO, UMA, MOT, MPWS, Municipalities	MOPF (DG of National Estate)	Private Operator

As seen in Table 4, all major port governance types exist in Turkey. Considering that all the commercial public ports are included in the privatization programme, this situation may not last forever due to the transitional phase. Brooks and Cullinane (2007) mention that there are few countries (Turkey, Australia and UK) exhibiting the complete range of governance structures, with some ports pursuing solely economic objectives, others pursuing solely non-economic objectives and yet others pursuing a mix of economic and non-economic objectives. Within the 42 ports in the world studied by the authors, they find that there exists a full spectrum from fully public to fully private management of port activities, with 4 ports being the only ones operating under a fully public model, and only one port being fully private, and find very interesting that these 5 were all in Turkey, reflecting its period of transition.

Public ports

Turkey had only public ports until 1980s, under the government owned enterprises like TSR, TMO, and IPOSOCs. The main public ports in Turkey are operated by TSR and the TMO. The TSR manages ports connected to the railway system. These major public ports are general-purpose ports under the control of the MOT, which approves the budgets and annual programmes and plans of both TSR and TMO. The ports operated by TMO are small scale and generally non-cargo ports. There are also some specialized affiliated ports owned and operated by either large state-owned industrial companies and these ports usually serve the tramp and bulk market. These ports fall under the control of the MOI and are mostly limited in purpose to the particular needs of industrial concerns.

TMO, which had previously operated some medium and small scale ports like Trabzon, Antalya, Salıpazarı, Giresun, Hopa, Marmaris, Ordu, Rize, Sinop, Tekirdağ, Çeşme, Dikili, Güllük, Kuşadası, and Alanya, is also a state owned enterprise like TSR. The enterprise was included in privatization programme and affiliated to the Privatization Authority in 1994. Except Salıpazarı and Güllük ports, all the ports under TMO were privatized by means of transfer of operation rights for 30 years period of time.

TSR is responsible for operation of railway connected public ports in Turkey. These ports are Samsun, Haydarpaşa, Derince, Bandırma, Izmir, Mersin and Iskenderun ports. Two of these ports, Mersin and Iskenderun ports, were privatized in 2007. Except Haydarpaşa port, all the other ports under TSR are included in privatization programme. Haydarpaşa port is planned to be converted to a cruise passenger terminal.

Even though the rail connection between seaports and rail industry is regarded as an important critical determinant for container port infrastructure productivity (Turner, Windle and Dresner 2004), TSR ports are regarded as inefficient ports compared to the private peers in Turkey (Oral et al. 2007, Gunaydın 2006).

Both TSR and TMO has been organized as central government bodies in terms of investments, budget planning, decision making, implementation of large scale investments and tariff setting. Including the management of the ports, both are managed from their headquarters in Ankara. The centrally managed structure creates some weaknesses. Especially the final decisions involving the port management issues like investment planning and price setting, are taken by the headquarters in Ankara. This takes a long time and is far from being responsive to local needs and market conditions.

Due to its consolidated budget system including all the services provided (rail freight, rail passenger, station services, port services etc), TSR does not have a separate budget for the ports it is responsible for operation. It is one of the state enterprises which make substantial losses. Therefore, though not enough to cover all the losses, the earnings from port operations are channeled to other services. This impedes the development of the port facilities. As seen on Figure 7, losses are increasing each year, and therefore it gets subsidy from Treasury. Treasury makes regular transfers from national budget to TSR in order to finance its current costs and operating losses from activities other than ports. In this sense, TSR gets the largest subsidy from Treasury among the other state enterprises. On the other hand, the capital transfers from Treasury do not cover TSR's investment spending. Thus, TSR finances its investments by long term foreign bank loans.

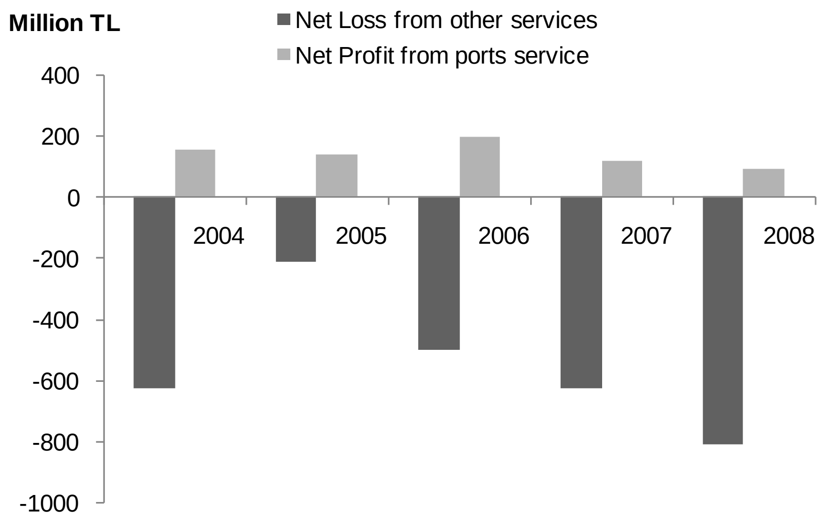

Figure 7: TSR Net Income from port services and Net Loss from other services
Source: TSR Annual Report 2008

Since the operational income of TSR from all the services it provides, has not sufficed the rail investments and development projects based on the Cabinet Decision in 2004, in order to cover the investment expenditure for fast train projects, the income from the privatization of the public ports has been transferred to TSR. Therefore, all the earnings of the public ports as in the hands of TSR or in the private sector (after privatization), have been used for the development of core services of the enterprise. This has been the most important handicap in terms public ports in Turkey.

As in all other state enterprises, TSR has also employment problems. Due to political intervention, the enterprise has gone into a position in which it does not need labor in terms of quantity but it needs qualified personnel. Employing personnel having various statutes such as civil servants, contracted workers, temporary workers and non union workers and determining their wages with different legislations and implementations make human resources management in TSR more difficult in terms of responsiveness like in any commercial business. Therefore, TSR does not have the flexibility on employment issues like hiring-firing personnel, wage policies and promotion as much as the private companies (Public Enterprises Report 2007).

The most important public ports in Turkey are:

Izmir port: It is located in the Aegean region and placed in the heart of urban area. It is the biggest container port operated by TSR. All the primary and secondary services are delivered by TSR. The port is planned to be privatized.

Haydarpaşa port: The port is located in the Anatolian side of Istanbul and placed in the heart of urban area. It is specialized mainly in container business, but due to competition in Istanbul region, its volumes are declining. All the primary and secondary services are delivered by TSR. The port is planned to be transformed into cruise passenger terminal in the future.

Mersin port: Until 2007, Mersin port was public service port located in the south region and operated by TSR. It is the most important container ports in southern Turkey. On February 2007, the port was privatized and since then it has been operated by PSA-AKFEN (A consortium between PSA International and Turkish Group Akfen).

Samsun port: The port is located in Black Sea region. It is multipurpose port, handling almost all types of general and dry cargo. The port also has a RO-RO berth for Ro-Ro vessels between Turkey, Russia and Ukraine.

Iskenderun port: The port is located in South region. It is a multipurpose port, handling almost all type of general and dry cargo. It was privatized in 2007.

Bandırma port: The port is located in the southern side of Marmara Sea. It is a multipurpose port, handling almost all type of general and dry cargo. All the primary and secondary services are delivered by TSR.

Private ports

After 1980s, especially in Marmara Sea and Izmit Gulf regions, many private enterprises have been allowed to establish ports, being subject to the same rules and regulations. Some of these ports are specialized in container terminals, some others in liquid bulk, dry bulk and general cargo, Ro-Ro, and others. The land is leased by MOPF (DG of National Estate) and the operations are approved by UMA.

The most important private ports are:

Ambarlı port: Ambarlı port is located in the Europe side of Istanbul, and far from the urban area. The port is a private port in which 7 private terminals are located. 3 of these terminals are container terminals out of which, Marport terminal is the biggest terminal in Ambarlı port. The other private container terminals are Kumport and Mardaş.

Antalya port: Until 1998, the port was operated by TMO, and then privatized through a concession contract for 30 years afterwards. It is a multipurpose port, handling almost all type of general and dry and liquid cargo.

Derince port: It is main general cargo port in Izmit Gulf in Marmara Sea. Until 2007, the port was operated by TSR. It was privatized in 2007.

Limaş: Located in Izmit Gulf in Marmara Sea, it is a multipurpose private port mainly specialized in liquid bulk, dry bulk and general cargo.

Gemport: Being the first private terminal in Turkey, Gemport is located in the southern Marmara region. It is specialized in container handling and commercial and private automobile handling.

Akport: Located in the northern Marmara Sea, the port is specialized in general cargo, dry and liquid bulk, container and Ro-Ro cargo.

Borusan: Located in the southern Marmara region, Borusan port is specialized in container handling and handling of general cargo and Ro-Ro cargo.

Evyapport: The port is located in Izmit Gulf, and specialized in container and liquid bulk cargo.

Yılport: Located in the northern side of Marmara Sea, the port is specialized in container, general cargo and liquid cargo handling.

2.6 Privatization Policy

2.6.1 Overview

After 1980s when the ruling government was in favor of liberalization in the economy and trade, a sustainable reduction of the power and role of the public entities in the economic and commercial activities has remained one of the main objectives of the economic programs supported by International Monetary Fund (IMF) and the World Bank. Therefore, in parallel to the global trend in privatization, government started programmes involving the privatization in the economy as a part of economic reforms with the primary objective of minimizing the involvement of the public sector in the industrial and commercial activities and developing the economy into a free market environment.

Gunaydın (2006) summarized the primary targets of privatization programmes in Turkey as follows:

(i) To minimize the state involvement in the economy for developing a free market economy and improve the competitive position of the private enterprises,
(ii) To improve the efficiency and the management of the enterprises and the economy,
(iii) To relieve the burden of the state enterprises on the national budget, and
(iv) To develop the capital markets and mobilize the private investments.

With the relief of the burden of the state enterprises and the generation of revenue for other state services, the privatization in Turkey has brought important funds for the government. Since 1985 when the privatization process actually started, until today, total revenue from the privatization implementations has been recorded as 36 billion US dollars.

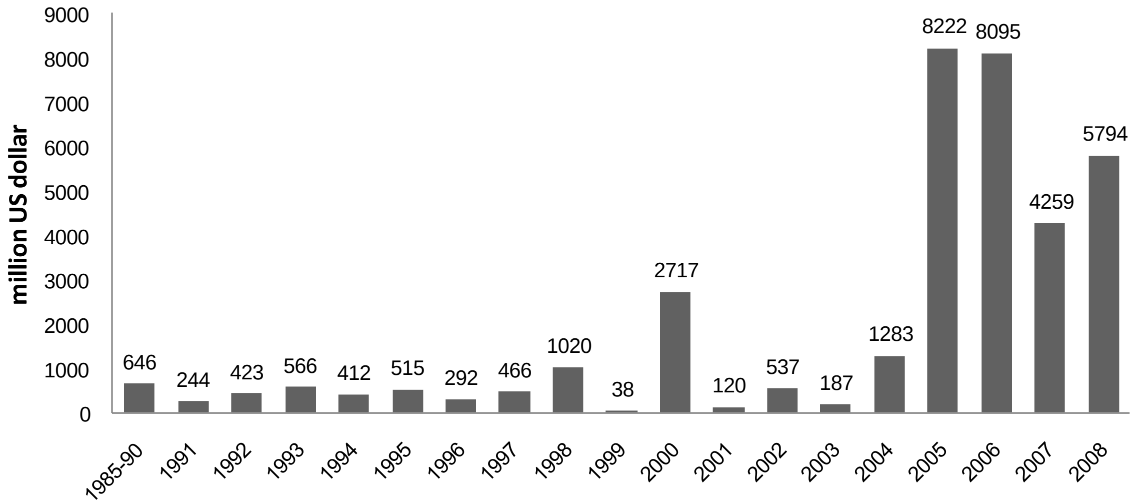

Figure 8: Privatization Implementation by Year in Turkey
Source: Investment Environment 2008 Report, International Investors Association of Turkey

Considering the privatization implementations for the last 15 years, it is observed that (Investment Environment 2008 Report by International Investors Association of Turkey):

- Government has completely withdrawn from the commercial sectors like cement, animal feed production, milk-dairy products, forest products, civil handling and catering services.
- More than 90 % of the public shares were privatized in tourism, iron and steel, textile, sea freight and meat processing sectors.
- Government has withdrawn from most of the seaports and airports and petroleum refinery and distribution sectors.
- Public shares in many companies were issued to the public through Initial Public Offerings at Stock Exchange, particularly in the beginning of this decade.

The Privatization Law, which regulates the principles and procedures regarding privatization in Turkey, indicates in its first article that the objective of privatization is to improve productivity in the economy and to reduce public expenditures.

As indicated legally, improving the efficiency is one of the main objectives of privatization in Turkey. This is an increasingly important claim discussed by many studies (Baird 2000; Cullinane and Song 2002, Cullinane, Ji and Wang 2005). Though the objective of this thesis is not directly related to the effects of privatization, the private sector involvement is also tested in this study with a narrower scope involving the container industry in Turkey by using a sample of terminals from the Eastern Mediterranean region.

Privatization process is carried out by mainly two bodies in Turkey, namely the Privatization High Council and the Privatization Authority. The Privatization High Council is the highest level decision-making authority in privatization. The Privatization

Authority is the executive body for the privatization process, reporting directly to the Prime Minister.

Besides, the Competition Authority is also actively involved in the privatization process. The Authority has to be notified in advance of the announcement of any tender, where the market share of the entity intended to be privatized exceeds 20 percent, or where the turnover of the same entity exceeds 20 trillion Turkish Liras and even though the aforementioned limits are not exceeded, where the entity to be privatized does have judicial or de facto special rights.

In addition to this, a company which takes over any entity (public or private) shall seek a permit from the Competition Authority before beginning its activities, where total market share of the acquiring party in the relevant market exceeds 25 percent, or acquiring parties' turnover exceeds 25 trillion Turkish Liras.

There are also some other governmental bodies involved indirectly in the privatization process. Ministry of Transport and Ministry of Public Finance are among the related bodies for privatization in terms of the privatization of ports. Oral et al. (2007) propose that there should be an integrated supreme body to coordinate all the ports according to a national port policy that is compatible with EU transport policy.

Regarding the privatization of coastal facilities, the issue of public interest stated in the Constitution, determines the main principle for privatization of ports. Because the coastline is legally public property owned by the government, and its use has to be such that it contributes to the public interest, the use of coastal facilities (including the privatization of port facilities) is possible only by the methods except the transfer of ownership of the properties (land). Therefore, the privatization of ports in Turkey is a partial privatization, which could be called as Private I type as Baird (1999) describes, where the operational right is transferred to the private sector. Similar methods like Build-Operate-Transfer (BOT) and leasing may also be utilized, while the ownership and regulation is kept by the government as set by the Constitution. In addition, according to Privatization Law, though both national and foreign entities may benefit from the privatization of ports, foreign investment share is not allowed to exceed 49 percent.

2.6.2 Privatization in Port Sector

Turkey had only public ports until the 1980s, under the government owned enterprises like TSR, TMO, and IPOSOCs were established. After the 1980s, the governments allowed the private enterprises to establish ports with completely private funds. Even though the economic programmes in favor of privatization introduced during the years, none of the public ports were privatized until 1995. In the last 5 years of time, the privatization efforts including the port sector have been intensified.

TMO, previously operated some medium and small scale ports like Trabzon, Antalya, Salıpazarı, Giresun, Hopa, Marmaris, Ordu, Rize, Sinop, Tekirdağ, Çeşme, Dikili, Güllük, Kuşadası, and Alanya was included in privatization programme in 1994 and affiliated to the Privatization Authority. Except Salıpazarı and Güllük ports, all the ports under TMO were privatized in the course of time by means of transfer of operation rights for a 30 year period of time.

As mentioned before, TSR is responsible for operation of railway connected public ports in Turkey. The ports with railroad connection are Samsun, Haydarpaşa, Derince, Bandırma, Izmir, Mersin and Iskenderun ports. Two of these ports, Mersin and Iskenderun ports, were privatized in 2007. Except Haydarpaşa port, all the other ports under TSR were scheduled to be privatized in privatization programme by the Decree of Privatization High Council in 2004. Haydarpaşa port is planned to be converted to a cruise passenger terminal.

The privatization strategy has been decided as transfer of operational rights, in which the ownership of the ports and the port assets and land remain public property. According to the program for the privatization of TSR ports, the operational rights will be transferred to the private sector for a period of 49 years for Izmir Port and 36 years for the other ports. TSR will be further responsible for the post-privatization performance monitoring of the private sector performance of the port operations.

TSR ports are scheduled for privatization due to the fact that the projects including necessary investments could not be realized for various reasons such as absence of bidders in tenders for projects regarding specific ports, delays in tenders, court decisions etc, that the ports became far from being functional in the face of increasing volume of trade due to deficiencies in the management of TSR.

Therefore, privatization has been seen as an opportunity to realize necessary investments. For instance, the privatization contract for Mersin port requires the operator to realize the compulsory investments within the first five years. As a result, the main objectives regarding privatization of ports are to realize the investments, bring more efficiency and provide better service. According to the termination clauses, the contract may be terminated in case the port operations are not performed wholly or significantly, or port services do not satisfy the service quality. To ensure efficiency of the port after compulsory investments are made, the average port time of ships should not fall below the average port time of ships in the top 10 Mediterranean ports. Considering the fact that the biggest ports in the Mediterranean are mainly hub ports and can accommodate vessels with more than 6000 TEU, length of time of service to ships in these ports will be definitely much more than the length of time in Mersin port due to much higher call size. In addition, it is very restrictive and uncommon to measure the efficiency of ports by just comparing the port time. Therefore, this clause probably will not be applicable.

The responsibility has been given mainly to TSR to supervise the compliance with these obligations, due to the lack of a regulatory port authority in Turkey. By this way, the risk that the new private operator may behave like a monopoly or oligopoly is intended to be minimized.

Chapter 3 Literature Review of Efficiency Studies

3.1 Introduction

This chapter provides a brief but non-exhaustive overview of the majority of the studies published and relevant with regard to the estimation of efficiency levels in the port sector and the possible causes of the inefficiencies. At the end of the chapter, the common findings and some controversial issues arose in the literature related to the overall framework of this study are presented.

The Chapter attempts to find answers to the following questions:

- What are the empirical studies on port efficiency?
- What are the results of the studies investigating the impact of private sector involvement in port sector on port efficiency?
- What are the results of the studies investigating the relationship between efficiency and the causes of (in)efficiency in port sector?

3.2 Literature on port efficiency

Even though there are many studies regarding the estimation of efficiency level at berth level, terminal level, or port level (either national, regional, or international level), there are specifically a few studies done previously in order to find out whether the private sector involvement in port or terminal business brings about higher efficiency.

In parallel to the objective of the study, which is based on the relationship between the private sector involvement in ports and the efficiency level in general, this chapter provides the literature regarding the measurement of efficiency of the port sector and the relationship between private sector involvement in port business and efficiency. In the end of the chapter, some important points for this thesis are summarized.

Numerous studies have been conducted regarding the efficiency evaluation of organizations including schools (e.g. Soteriou et al., 1998), airports (e.g. Martin and Roman, 2001), banks (e.g. Oral and Yolalan, 1990) etc.

The studies focusing on the measurement of the efficiency level in the port sector have also increased in the recent years. These studies utilized various mathematical approaches in order to estimate the efficiency level. However, in empirical research focusing on relative efficiency by comparing the peers within the sample, mainly two holistic approaches have been chosen, namely data envelopment analysis (DEA) and stochastic frontier analysis (SFA). Due to the importance of the estimation of relative efficiency, which this thesis aims to obtain, especially the researches applying these two approaches have been discussed. The detailed information about these methodologies is presented in the Chapter 4.

3.2.1 Literature applying DEA approach

A comprehensive list of studies applying specifically the DEA approach for efficiency analysis of the port sector has been presented below chronologically:

- Roll and Hayuth (1993) is regarded as the first trial to apply the DEA methodology in order to estimate the port efficiencies. The DEA approach was demonstrated by a hypothetical numerical example where the performance of twenty ports is compared. Since the authors did not use real data, this study is treated as a test for the applicability of the DEA methodology to the port sector.

- Poitras, Tongzon and Li (1996) applied DEA to provide an efficiency ranking for five Australian and eighteen other international container ports for the year 1991. They selected the number of TEU/berth and the number of containers as output measures, and average delays in commencing stevedoring, the difference between the berth time and gross working time, average quay crane productivity, number of gantry cranes as the input measures of the analysis. The authors concluded that primary contribution of their study was methodological, demonstrating that DEA provides a viable method of evaluating relative port efficiency.

- Martinez-Budria et al. (1999) applied DEA (assuming variable return to scale) models to twenty six Spanish ports during 1993-1997 periods, which they divided into three groups: high complexity ports, medium complexity ports and low complexity ports. They concluded that the ports of high complexity are associated with high efficiency, compared with the random mix of medium and low efficiency found in the other ports.

- Tongzon (2001) studied the efficiency of four Australian and twelve other international container ports for the year 1996. It was found by the author that the ports of Melbourne, Rotterdam, Yokohama and Osaka were the most inefficient ports in the sample, based on both constant and variable returns to scale assumptions, primarily caused by large slacks in the inputs of container berths, terminal area and labor. The study used two output and six input variables for port performance. The output variables he used were cargo throughput and ship working rate, and input variables were the number of berths, cranes and tugs, the number of stevedoring labor (however, due to a lack of information on this particular variable, a proxy variable was used represented by the number of port authority employees for the respective ports), terminal area, amount of amount of delay time at berth. The results indicated that port size or function alone is not the primary determinant of port efficiency.

- Itoh (2002) conducted a DEA window analysis using panel data for the period between 1990 and 1999 relating to the eight international container ports in Japan. The outputs were handling volumes for export and import, and the inputs were number of container berths, number of cranes, and area of container terminal, and also labor. Tokyo was found to be consistently efficient in terms of its infrastructure and labor productivity over the whole period, while Nagoya performed well during the early part of the period covered by the analysis. At the other extreme, efficiency scores for Yokohama, Kobe and Osaka were found to be low throughout the duration of the period under study.

- Bonilla et al. (2002) analyzed the efficiency of the Spanish port system, investigating the relationship between the available port equipment and the commodities traffics (liquid bulks, solid bulks and general commodities). Their sample comprised twenty three ports with annual data for 1995-1998 periods. The study used the port equipment as the input, and the commodities traffic (including the containers) as the output for the DEA methodology. The most and least efficient Spanish ports were identified and, using a DEA model with tolerances, the authors investigated the reasons why some ports, due to their traffics, were so sensitive to the variations in traffics.

- Barros (2003a) applied DEA to five Portuguese ports in 1999 and 2000. The author selected various inputs and outputs. The selected outputs were ships, movement of freight, gross tonnage, market share, break-bulk cargo, containerized cargo, Ro-Ro traffic, dry bulk, liquid bulk, net income, and the selected inputs of the study were number of employees, book value of assets. The author used the prices of labor and capital in estimating the allocative efficiencies. The study analyzed the technical and allocative efficiencies of Portuguese port authorities in order to investigate if the state's policy was achieving its aims. The author found that the results were, at best, mixed, leading to conclude that the incentive regulation carried out by the government was not achieving its aims. Therefore, he proposed a policy revision to enforce efficiency, involving the establishment of an organizational governance environment with accountability, transparency and efficiency incentives that explicitly oblige the seaports to achieve efficiency in their operational activities.

- Barros (2003b) applied DEA again to the Portuguese port industry for the for 1990 to 2000 period to derive estimates of efficiency that can then be utilized to determine the source of any inefficiency that may be identified. One of the results of the analysis was that while Portuguese ports attained high levels of technical efficiency over the period covered by the analysis, the sector generally did not keep pace with technological change. Through the application of Tobit regression analysis (dependent variable is the efficiency scores obtained by DEA models), it was also found that efficiency scores are positively related with container handling, meaning that container ports are more efficient than their multi-cargo counterparts, that efficiency is positively related to scale (throughput), market share and, finally, that efficiency scores are negatively related with public management of seaports.

- Barros and Athanassiou (2004) conducted a DEA in order to estimate the relative efficiency of a sample of Portuguese and Greek seaports. The aim of this study was seek out the best practices that will lead to improved performance in the context of European seaport policy. They measured output by 4 indicators: ships, movement of freight, total cargo handled (dry and liquid cargo, unloaded and loaded) and containers (loaded and unloaded), measured inputs by two indicators:

labor, measured by the number of workers and capital, measured by the book value of assets. The general conclusion of the study was that the majority of the seaports in the sample were efficient with the exception of Thessaloniki port. The result suggested that scale economies should be the principal target for adjustment in this sector. The paper suggested that the privatization will allow improving the productivity of the ports covered in the study.

- Cullinane et al. (2004) applied DEA window analysis approach based on cross-sectional and panel data analysis utilizing panel data, to a sample of the world's major twenty five container ports from 1992 to 1999, with an emphasis that cross-sectional data provide inferior estimates of efficiency than panel data as single measured value of efficiency as each port will not capture the variations in efficiency over time. The authors argued that by using panel data, the development of the efficiency of each container port in a sample can be tracked over time. They selected container throughput (TEU) as the output variable, and quay length, terminal area, quayside gantries, yard gantries, straddle carriers as the input variables. The paper emphasized the inadequacy of the existing programming methods for estimating efficiency especially in capturing the long-term increased efficiency and competitiveness arising from significant investments.

- Park and De (2004) introduced an alternative approach to measuring seaport efficiency, with the use of eleven Korean port traffic data for 1999. This study considered a four-stage DEA, to overcome the limitations of basic DEA models. The authors divided the overall efficiency into several stages by transforming the inputs and outputs in each stage (namely productivity, profitability, marketability, and overall efficiency). Therefore, their output variables became input variables in the next stage. They used cargo throughput, number of ship calls, revenue, and customer satisfaction, berthing capacity and cargo handling capacity as the variables of their DEA models. Except the berthing capacity and cargo handling capacity variables, the output variables became input variable in the next stage.

- Turner, Windle, and Dresner (2004) applied DEA to the measurement of seaport infrastructure productivity growth in North American over the period 1984-1997. Tobit regression was then presented as a means of examining the determinants of infrastructure productivity in seaports. The study supported the presence of economies of scale at the container port and terminal level in North America. They also found that the longstanding relationship between seaports and the rail industry appears to remain a critical determinant of container port infrastructure productivity.

- Cullinane, Ji and Wang (2005) investigated the relationship between privatization and relative efficiency within the container port industry based on the panel data from the top thirty container ports for eight years period (from 1992 to 1999). They applied the DEA methodology in their study in a variety of panel data configurations. The output variable was throughput (TEU) while the inputs were terminal length, terminal area, quayside gantry, yard gantry, straddle carrier. The analysis concluded that there is no evidence to support the hypothesis that greater private sector involvement brings about improved efficiency in the container port sector.

- Cullinane, Song and Wang (2005) aimed to evaluate the efficiency of fifty seven of the world's most important container ports and terminals using the two alternative techniques of DEA and the Free Disposal Hull (FDH) model. They selected container throughput (TEU) as the output variable, and quay length, terminal area, quayside gantries, yard gantries, straddle carriers as the input variables. The study revealed that different programming methodologies lead to different results and that appropriate definition of input and output factors is a crucial element in meaningful applications of the methodologies applied in the study. It was also concluded in the study that the panel data have some advantages over cross sectional data, especially regarding the validity of the efficiency estimates obtained in the programming techniques applied.

- Cullinane et al. (2006) applied both DEA and SFA to the same set of container port data for the world's largest container ports and compare the results obtained. A high degree of correlation was found between the efficiency estimates derived from all the models applied, suggesting that results were relatively robust to the DEA models applied or the distributional assumptions under SFA. The results showed that high levels of technical efficiency were associated with scale, greater private-sector participation and with transshipment, as opposed to gateway ports. In analyzing the implications of the results for management and policymakers, this study concluded that a number of shortcomings of applying a cross-sectional approach to an industry characterized by significant, lumpy and risky investments are identified and the potential benefits of a dynamic analysis, based on panel data, are listed.

- Cullinane and Wang (2006) focused on measuring the efficiency of container terminals in Europe using the DEA approach. They estimated relative efficiency for a sample of Europe's sixty nine container terminals across twenty four countries with annual throughput of over 10,000 TEUs, for the year 2002. The output variable was throughput (TEU) while the inputs were terminal length, terminal area, and number of equipment. The main finding was that there was significant inefficiency in the European container terminals under study, with the average efficiency equal to 0.48 (assuming constant returns to scale) and 0.42 (assuming variable returns to scale). Most of the container terminals under study exhibited increasing returns to scale, with large container terminals more likely to be associated with higher efficiency scores.

- Wang and Cullinane (2006) investigated the efficiency of container terminals within the context of global supply chain management. The efficiency and scale properties of one hundred four of Europe's container terminals with annual throughput of over 10,000 TEUs in 2003, distributed across twenty nine European countries, were derived using DEA approach. They selected container throughput as the output of the model, and terminal length, terminal area, equipment cost as the input variables. The main conclusions were that most of the terminals under study were significantly inefficient and that large-scale production was closely correlated with higher efficiency. It was also found that the container terminals in the British Isles and Western Europe had the highest efficiency, compared to their peers with the lowest efficiency in Scandinavian and Eastern European countries.

- Lin and Tseng (2007) applied various models of DEA to acquire a variety of complementary information about the operational efficiency of major container ports in the Asia-Pacific region and to identify trends in port efficiency. They used two output measures (number of vessel arrivals at port, loading/unloading volumes of containers) and 4 input measures (area of container base, number of gantry cranes, length of container terminals, and number of deep-water piers). They found various inefficiencies at some ports under the study.

- Cullinane and Wang (2007) analyzed the relevance of DEA methodology to the estimation of productive efficiency in the container port industry by using two samples. The first sample was comprised of fifty seven container terminal with cross sectional data in 2001, and second sample was comprised of twenty five container ports with panel data from 1992 to 1999. They selected container throughput (TEU) as the output variable, and quay length, terminal area, quayside gantries, yard gantries, straddle carriers as the input variables. The results indicate that substantial waste existed in container port production. It was also found that the optimum efficiency levels indicated by DEA results might not be achievable in reality, because each individual port has its own specific and unique context.

- Al-Eraqi et al. (2008) evaluated the efficiency of twenty two seaports in the Middle East and East African region. Two separate analyses were performed based on data collected for six years (2000–2005), standard DEA method was used in the first analysis and DEA window analysis was used in second analysis. By using both methods, the authors gathered better insight into the efficiency situation in the regions; and highlighted the advantages and disadvantages of the methods. The study concluded that the small ports in the sample were mostly efficient while big ports were inefficient.

- Herrera and Pang (2008) estimated efficiency of container terminals across the world based on data from eighty six ports across the world by using two non-parametric methods, namely the Free Disposable Hull (FDH) and DEA techniques. They used the cargo throughput (TEU) as the output, and the terminal area and three types of equipment (the number of ship-to-shore gantries, the number of quay, yard and mobile gantries, and the number of tractors and trailers) as the input measures of the models. The efficiency scores computed by the author revealed that the margin for cost reduction was significant. The most inefficient ports used inputs in excess of 20 to 40 percent of the level used in the most efficient ports. It was also found that infrastructure costs could be reduced by 12 percent by moving from the inefficient extreme of the distribution to the efficient one, since they represent about 40 percent of total maritime transport costs.

- Barros and Managi (2008) analyzed efficiency drivers of a sample of thirty four Japanese seaports for 2003-2005 periods by means of the two-stage procedure. The technical efficiency of seaports was estimated using several models of DEA in the first stage of the analysis. In the second stage, bootstrapping procedure was applied for the DEA scores with a truncated bootstrapped regression to identify the drivers for higher efficiency. The seaports which adopted strategic procedures, such as hub strategy, were found to be on average more efficient than those which did not adopt this strategy.

3.2.2 Literature applying SFA approach

An exhaustive list of applications of SFA to the efficiency analysis of port industry has been presented below chronologically;

- In order to test the relative efficiency of public ports compared with private enterprises, Liu (1995) applied SFA to a set of panel data relating twenty eight important British ports over the period between 1983 and 1990. The research failed to identify ownership as a significant factor of production and the evidence did not establish a clear cut pattern of efficiency in favor of one or other type of ownership. In other words, the results failed to imply any clear cut efficiency advantage for private enterprises.

- Notteboom et al. (2000) applied a Bayesian approach based on Monte-Carlo approximation to the estimation of a stochastic frontier model aimed at assessing the productive efficiency of a sample of thirty six European container terminals supplemented with four Asian container ports. The data analyzed related to the single year of 1994. The authors concluded that north European container terminals attained a slightly higher degree of efficiency than southern terminals. No clear relationship was found between the type of ownership, operations of a terminal and the efficiency level. Terminals located in hub ports on average were found more efficient than those in feeder ports.

- Coto-Millan, Banos-Pino and Rodriguez-Alvarez (2000) applied a SFA model to estimate the economic efficiency of twenty seven Spanish ports. Panel data for the period 1985–89 were collected and analyzed using the Cobb–Douglas and Translog versions of the model. The authors found that the type of organization has an important effect on economic efficiency, but ports with autonomy are less efficient than the rest. Analyzing the efficiency indices obtained, they found that the relatively larger ports are more economically inefficient. They also found that the type of organization has a significant effect on economic efficiency, but ports with autonomy are less efficient than the rest.

- Estache, Gonzales and Trujillo (2002) showed how measures of relative efficiency performance could promote yardstick competition between port infrastructure operators, based on a study of the efficiency effects of the Mexican 1993 Port Reform by using panel data (1996-99) of forty four observations from eleven independent Port Administrations. They applied a stochastic production frontier to show that Mexico's ports achieved 2.8-3.3 percent average annual efficiency gains since the reform. The efficiency scores showed that the reform of decentralization and privatization taken at Mexican ports produced significant short-term improvements in the average performance of the port industry in Mexico.

- Cullinane, Song and Gray (2002) employed both the cross-sectional and panel data versions of the stochastic frontier model to assess the relative efficiency of selected fifteen Asian container ports or terminals. From the results of the analysis, it was concluded that the size of a port or terminal was closely correlated with its efficiency and that some support existed for the claim that the transformation of ownership from public to private sector improves economic efficiency.

- Cullinane and Song (2003) assessed the success achieved by Korea's port privatization policies in increasing the productive efficiency of its container terminals using cross sectional and panel data models of SFA. It was found that the degree of private sector involvement in sample container terminals was positively related to the efficiency of the selected terminals.

- Tongzon and Heng (2005) applied a stochastic frontier model to twenty five container ports/terminals to show whether port privatization is a necessary strategy for ports to gain a competitive advantage. This study also investigated the determinants of port competitiveness. Both the principal component analysis (PCA) and the linear regression model were used to examine the effects of identified key factors on port competitiveness. The results of this study showed that private sector participation in the port sector can improve efficiency to some extent, which would then improve port competitiveness.

- Cullinane and Song (2006) estimated the relative efficiency of a sample of seventy four European container ports for 2002 using the cross-sectional version of the SFA with an assumption of the log-linear Cobb-Douglas function in production. They concluded that the size of a port or terminal is closely correlated with its efficiency. Ports in the United Kingdom were found to have the most efficient infrastructure, while Scandinavian and Eastern European container terminals produced the lowest relative efficiency. The authors noted that geographical location and small scale may be the reasons for this result. Together with some other terminals, Haydarpaşa container port (one of public ports) in Turkey was found consistently to be among the most inefficient ports in the sample.

- Trujillo and Tovar (2007) chose SFA method in order to estimate the efficiency of EU ports (a sample of twenty two European ports for the year 2002). In order to capture the multi-output processes, they selected the distance function to estimate the relative efficiency of EU ports. Their output variables were the freight and passenger traffic, and input variables were labor, surface of land, and containerization rate. The average port efficiency in 2002 was estimated to be around 60 percent, denoting that ports could have handled 40 percent more traffic with the same resources.

3.2.3 *Literature applying other approaches*

The studies using other mathematical methods (mainly regression analysis) for efficiency analysis of the port sector have been presented below chronologically:

- Tongzon (1995) attempted to establish a model of port performance and efficiency with a sample of 23 container ports across the world in 1991. The author aimed to identify and analysis the various factors which influence the performance and efficiency of a port. It was the first attempt to establish a mathematical model seeking out the indicators of port performance. The model constructed by the study also quantified the contribution of terminal efficiency to the overall determination of port performance. It provided empirical support for the notion that terminal efficiency was a vital component of any waterfront reform aimed at improving port performance and efficiency.

- Instead of estimating the efficiency of port sector directly, Clark, Dollar, and Micco (2002) investigated the determinants of the costs of shipping to the United States using a large database (more than 300,000 observations a year) on shipments of products from different ports around the world. They concluded that port efficiency can affect transportation costs and that an inefficient port can increase the distance to a shipper's export market by 60 percent.

- Sanchez et al. (2003) examined the determinants of transport costs, with a sample of nineteen ports for the year 1999. In order to include different port efficiency measures from the survey, they constructed a regression model based on principal component analysis. The result obtained by the authors was especially important since one of the port efficiency measures obtained through the model had an estimated elasticity value equivalent to that of distance. One of the most important conclusions of the study were that port efficiency is an important determinant of a country's competitiveness.

- Londono Kent and Kent (2003) analyzed the port costs and inefficiencies by comparing an efficient port (Port of Cartegena in Colombia) with an inefficient port (Puerto Santo Tomas de Castilla in Guatemala) with respect to vessel berth, cargo dwell times and tariffs, arriving at a cost of inefficiency. The inefficient port is estimated to impose 42 US dollars more per TEU, 28 percent cost penalty.

- Wilson, Mann, and Otsuki (2003) discussed the importance of port efficiency relative to other factors that enhance or hinder trade, such as customs, the regulatory environment, and e-business, in a study of Asia Pacific Economic Cooperation (APEC) countries. By using a gravity model, the authors estimated the relationship between these mentioned factors and trade flows. The study found that improved port efficiency has a positive effect on trade.

- Gonzales and Trujillo (2005) attempted to quantify the development of technical efficiency in port infrastructure over time in the major port authorities in Spain. The paper also analyzed the impact of the port reform in the 1990's on the efficiency of the Spanish container ports. They estimated a distance function in a multi-output port context with a database covering the 1990-2002 periods. The results showed that there was a considerable evolution of the efficiency level within those ports over time as a result of these reforms.

- Cochrane (2008) discussed the effects of exogenous market differences on the potential throughput capacity of container terminals having similar levels of efficiency. The author selected the factors such as the proportion of containers of differing size in the market, vessel size, the size of transshipment and landed container markets etc. The study concluded that the aggregate effect of the selected factors on container throughput can be very significant and that aggregate analyses of container terminal efficiency should disaggregate the output measure into separate components.

3.3 Summary of Literature Findings

The most important points for this thesis, arising out of the studies mentioned in this chapter, have been summarized as follows:

- Even though there are some exceptions using different mathematical models, measurement of the efficiency in port sector has been analyzed in general by two approaches, DEA and SFA.

- Even though there are some studies rejecting the hypothesis that greater private involvement in the port sector leads to higher efficiency (Liu 1995, Cullinane, Ji and Wang 2005), in majority of the studies, high levels of technical efficiency were generally associated with greater private-sector participation.

- Except a few studies rejecting that port size alone is one of the primary determinant of port efficiency (Notteboom et al. 2000, Coto-Millan, Banos-Pino and Rodriguez-Alvarez 2000, Tongzon 2001, Al-Eraqi et al. 2008), scale effect has been proved to be positively correlated to the efficiency level.

- In some studies it has been empirically proven that high levels of technical efficiency were associated with transshipment as opposed to gateway ports (Notteboom et al. 2000, Cullinane et al. 2006, Barros and Managi 2008).

- There is no clear evidence presented in the literature that specialization in ports (container port, multi cargo port etc) brings about more efficiency.

- Except for some researches investigating only single country data, the efficiency studies mainly focused on more than one country.

- Data availability is stated as the most important problem of current DEA studies regarding port efficiency. Almost no identical input variable has been selected by different authors to include in their DEA models.

- Almost all studies applying DEA methodology used physical input or output measures. There is hardly any DEA study which includes the price or cost data in order to measure the allocative efficiency rather than technical efficiency.

- Cargo throughput has been selected as the output measure of the models in almost all studies. On the other hand, various input measures were utilized, but in general, the input measures selected have been the physical indicators (quay length, terminal area, etc) of the terminal.

Chapter 4 Research Methodology

4.1 Introduction

This chapter provides brief information about the methodology followed in the dissertation in order to find empirical answers to the research questions. Therefore, firstly, the methods used to measure efficiency, and in this context, the DEA methodology are elaborated. Then the research structure is provided, mentioning the Tobit regression model used to establish the determinants of terminal efficiency. Finally, the data collection approach and the data collected are discussed.

The main questions the chapter is trying to answer are:

- What methods are used basically to measure efficiency in port sector?
- How the theoretical framework of the DEA methodology has been developed?
- What are the variants of DEA methods, and their relevant assumptions?
- What are the strengths and weaknesses of DEA?
- What are the inputs and output of the dissertation and to what extent they are relevant to the efficiency estimations in container terminals?

4.2 Methods used to measure efficiency

Evaluation of efficiency in an organization may be performed in various forms. The efficiency measurement may be based on a simple ratio form like cost per unit, output per employee or output per hour, or it may be based on a form where all or at least more than one factor are taken into account. The former are referred to as *single factor* or *partial productivity measure* (Cooper 2006). The latter is called *total factor productivity* measures because an output-to-input ratio value which takes account of all outputs and all inputs are intended to be obtained.

Even though the efficiency evaluations for port sector have been generally investigated using multi factor measures, some studies regarding single factor measures were made before in order to assess the port productivity indicators (UNCTAD 1987, World Bank 1993). The studies focusing on port productivity indicators help especially when the local optimization in a port or terminal is examined in water side, gate side, or in the yard.

In order to measure the port efficiency by using total factor productivity, or at least using multiple factors affecting the performance of a port, various techniques have been developed. These methods can be categorized either parametric or non-parametric, and stochastic or deterministic. The parametric approach takes a precise functional structure for the relationship between the inputs and the outputs, and the inefficiencies are measured by the deviation of the values in dataset from the frontier. The non-parametric approach estimates the frontier directly from the data without requiring any functional structure. The parametric approach is based on statistical or econometric methods, while the non-parametric approach uses mathematical linear programming techniques. The deterministic approach assumes that all deviations from the frontier are the indicators of inefficiency, while the stochastic approach evaluates those mentioned deviations a combination of inefficiency and random shocks, which is generally outside the control of the decision maker (Herrera and Pang 2008).

In analyzing the port performance, both parametric and non-parametric approaches have been utilized in the literature. In this context, Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA) are the two methods most widely utilized in measuring the port performance. DEA is non-parametric approach for evaluating the performance of a set of peer units which convert multiple inputs into multiple outputs without assuming a functional relationship between inputs and outputs, and a statistical distribution of the error terms. The units mentioned here are referred to as decision making units (DMU) in the literature. SFA on the other hand, is a parametric and stochastic approach with the assumptions on the production technology by choosing a functional form (e.g. Cobb–Douglas, translog, etc.). The SFA approach also allows for random shocks and measurement error.

In this study, the DEA approach will be utilized in order to measure the efficiency of a sample of container terminals in the Eastern Mediterranean region. Compared to the other parametric methods with a priori assumption about the production functions of ports or terminals, DEA is much more flexible in determination of the relationship between factors of production and the output (s).

4.3 Data Envelopment Analysis (DEA)

4.3.1 Theoretical Framework

DEA is one of the most extensively used methodologies in the literature with more than 4000 research articles published in journals or book chapters. Banking and financial units, education, health care, hospital, and judicial bodies were found to be the most popular application areas (Emrouznejad, Parker and Tavares 2008).

As mentioned before, DEA is defined as a nonparametric method of measuring the efficiency of a set of peer DMUs with multiple inputs and outputs. It measures the efficiencies without assuming a functional relationship between inputs and outputs, and a statistical distribution of the error terms.

What makes DEA so peculiar is the characteristic that it is directed to frontiers rather than central tendencies (Cooper, Seiford and Zhu 2004). Contrary to parametric models focusing on averages of parameters, DEA aims to calculate a discrete piecewise frontier determined by Pareto efficient units. An illustration of the difference between regression line and efficient line is exhibited in Figure 9, covering single input and single output for simplification purposes. The efficient frontier is the line with the highest slope from the origin, and in this case the line going through point X. The regression line, on the other hand, under the least squares principle goes through the middle of these data points. The frontier line measures the efficiency of units by deviations from the units, placed on the line and therefore regarded as fully efficient. Cooper, Seiford, and Tone (2006) noted that DEA identifies the efficient units to serve as benchmarks to use in seeking improvements, while the statistical approaches averages the efficient and inefficient units along with the other observations as a basis for suggesting where improvements might be sought.

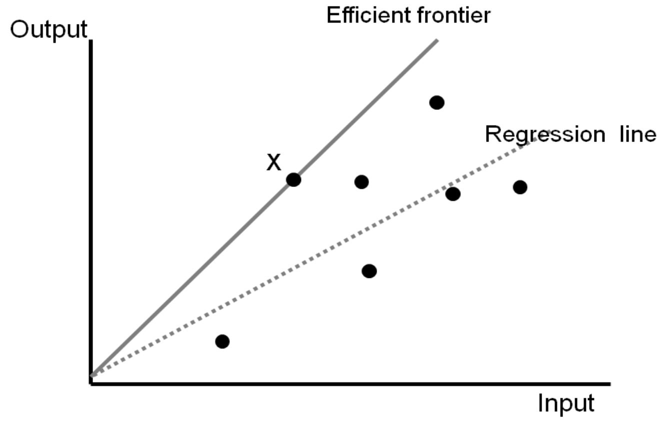

Figure 9: Regression Line vs. Efficient frontier
Source: Cooper, Seiford, and Tone (2006)

Another characteristic of DEA methodology is the fact that it measures efficiency without making any assumption about the weights reflecting the importance of the inputs or outputs. It determines the optimal weights of inputs and outputs for each DMU based on the sample.

Efficiency mentioned here and in the rest of the study should be distinguished from the other efficiency definitions. The kind of efficiency referred to here is technical efficiency since only the actual input output relationship in physical parameters were taken into account. It simply refers to the use of resources (inputs) in the technologically most efficient manner. If the importance or cost/price of the inputs or outputs is also considered, then it is called economic efficiency.

Cochrane (2008) lists the most important requirements or pre-conditions for DEA methodology. These requirements are positivity (no negative outputs), isotonicity (all increases in individual inputs lead to positive increases in outputs) and homogeneity (all the DMUs have the same inputs and outputs).

As the term speaks itself, positivity requires that the outputs should be all positive. In terms of technical efficiency, container terminals always produce positive output. As in majority of the studies, cargo throughput is selected as the output variable in this study.

Isotonicity means that all increases in individual inputs should lead to increases in output(s). As mentioned by Cochrane (2008), the requirement of isotonicity for the application of the DEA may not be always valid in container terminals because the handling process at each stage in the terminal is dependent on the other stages for the completion of the service. Therefore, increasing the number of quay cranes may not increase the throughput if trucks, straddle carriers or yard gantries are not enough to feed these cranes. Similarly, if the quay length in full capacity is not increased in parallel to the increase in the terminal capacity, the throughput may not be increased.

Homogeneity requirement means that all the DMUs have the same inputs and outputs. Even though some container terminals handle some other cargo types, like general cargo, the majority of the container terminals are specialized only in containerized cargo. Therefore, for container terminals, the homogeneity requirement is met.

There are various models of DEA. The initial model proposed by Charnes, Cooper and Rhodes (1978) is called in the literature as CCR model. Various extensions of this model have been proposed later, among which, the BCC model proposed by Banker, Charnes and Cooper (1984) is the one most widely referred. The efficiency scores obtained through these models are referred frequently to as CCR and BCC efficiency, respectively. The difference between the two models is the assumption about the existence of scale economies.

The efficient frontier in Figure 10 assumes a constant return to scale. This approach forms the basis of CCR model. BCC model on the other hand assumes a variable returns to scale, and has its production frontiers spanned by the convex hull of the existing DMUs. The frontier lines under the constant and variable returns to scale assumptions are given in Figure 10.

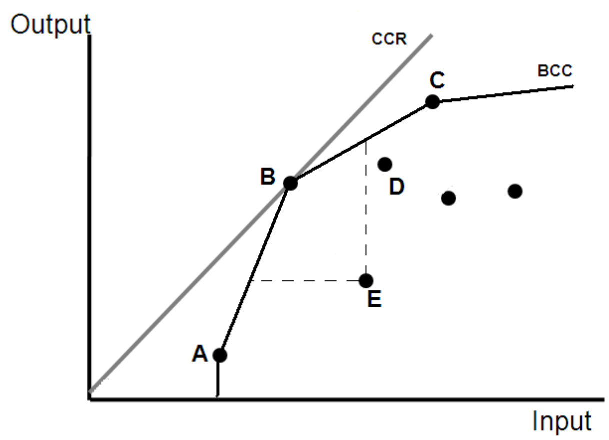

Figure 10: Production frontiers of CCR and BCC models
Source: Own elaboration based on the explanations by Cooper, Seiford, and Tone (2006).

Due to the concave characteristics of the BCC frontier, increasing returns-to-scale prevails in the first segment followed by decreasing returns-to-scale in the second segment and constant returns-to-scale occurring at the point B where the transition from the first to the second segment is made.

The CCR efficiency score is called global technical efficiency since it takes no account of scale effect. On the other hand, the BCC efficiency score is called local pure technical efficiency. If a DMU is fully efficient in both the CCR and BCC models, it is said to be operating in the most productive scale size (unit B in Figure 10). If a DMU has full BCC efficiency but a low CCR score (like the unit C in Figure 10), then it is operating locally efficiently but not globally efficiently due to the scale size of the unit. On the other hand, the unit D is neither technically efficient nor scale efficient. Thus, the scale efficiency of a DMU is measured by the ratio of the two scores (Cooper, Seiford and Tone 2006).

Since CCR model provides information purely on technical and scale efficiency taken together while BCC model identifies technical efficiency alone, BCC models produce more efficient DMUs than CCR models. This is clearly seen on the efficiency scores obtained in the following chapter.

DEA models can also be distinguished according to orientation towards input or output. Efficiency measurement and the selection of benchmarks for DMUs may be either input or output oriented. In Figure 10, the input and output orientation of BCC model is illustrated in terms of inefficient unit E. For the unit E, A and B serve as the benchmark peers when measuring input efficiency (input orientation), and B and C are peers when measuring output efficiency (output orientation). In the Additive model of DEA, an extension of the BCC model, the projection is done towards the closest efficient unit (unit B), and therefore orientation is not an issue. Cullinane, Ji and Wang (2005) state that input orientation is closely related to operational and managerial issues, while the output orientation is more related to port planning and strategies. The authors suggest the output-oriented models for container terminals if the main interest of a research is to inform the policy-decisions at national, regional or local levels. From a pragmatic point of view, Cullinane et al. (2004) suggest the choice of an output-oriented approach as it greatly facilitates discussions for the case where there is a single output. Another approach in terms of input or output orientation has been raised by Barros and Athanassiou (2004). The authors note that the choice of input or output-oriented model is based on the market conditions of the DMU. As a general rule of thumb, in competitive markets, the DMUs are output-oriented, since the inputs are assumed to be under the control of the DMU, which aims to maximize its output, subject to market demand, outside the control of the DMU. In monopolistic markets, on the other hand, the DMUs are generally input-oriented, because output is endogenous, while input is exogenous and the cost function is the natural choice.

Inspired by the view in the study made by Cullinane et al. (2004), output orientation is chosen for this study from both a pragmatic point of view, and that the results and the conclusions of this study has some implications at policy level, rather than micro level efficiency research.

The formal mathematical specification of the various DEA models can be found in Cooper, Seiford and Tone (2000), Cooper, Seiford and Zhu (2004) and Cooper, Seiford and Tone 2006.

4.3.2 Strengths and Weaknesses

The strengths of DEA, mentioned several times in this chapter, have been summarized here. First, DEA provides the possibility to measure efficiency with multiple input and multiple outputs. In this regards, the method fits best to total factor productivity approach. Second, it has the advantage of making no assumptions regarding the functional form of the efficient frontier and distribution of errors. The efficient frontier extracted from DEA is based on the best observed units rather than measures of central tendency. Finally, it is not necessary to know the type of production function in advance.

Some of these strengths are also considered weaknesses of the methodology. Since DEA is a deterministic approach, it takes no account of possible influences of measurement error and other noise in the data. The deficiency regarding the measurement for statistical noise in the data set is widely considered in the literature as the most serious drawback of DEA (Cullinane and Wang 2007). Therefore, DEA methodology is regarded as quite susceptible to bias from outliers (Bronigen and Wilson 2006). What's more is that the outliers appear as the units forming the efficient frontier.

The fact that efficiency measurement and the efficient frontier is based on best observed units is also criticized as the scores obtained are not absolute efficiency values, but change depending on the data set. DEA implies a relative efficiency for a DMU, compared to all other DMU's in the sample.

The requirements of DEA are also regarded as the drawbacks of the methodology. Due to homogeneity requirement, all the DMUs should have the same inputs and outputs. In some organizations, this is a strong requirement that should be consistently measured across the sample and time periods. In the port sector, this is the most difficult requirement as in many cases, in order to have a large enough sample size; the sample includes third country ports. The question mark regarding the availability of the homogeneity in the port sector is emphasized by Barros and Athanassiou (2004), noting that the seaports with different dimensions, traffic characteristics and locations, which may face different restrictions, are hardly comparable.

The other requirement of DEA, isotonicity (the output must not decrease while the input increases) is not always possible to meet (Lin and Tseng 2007). In the port sector, for instance, the number of ship calls is considered as one of the widely accepted output. However, the bigger the container terminal, the bigger the call size, therefore the less ship calls.

Another drawback is the data requirements. As a rule of thumb, in order to obtain the best results, the number of DMUs is advised to be at least twice the total number of input and output variables. Therefore, most DEA studies are quite limited in the scope of inputs and output analyzed. Furthermore, if the literature is roughly examined, it can be easily seen that almost no identical input and output variables have been chosen by the authors in their DEA models. This is an indicator of the problem about data availability.

DEA has also the deficiency of identifying the causes of the (in)efficiency. DEA identifies the slacks for the inefficient DMUs and gives to each DMU a reference set of peer which allows for specific recommendations to improve efficiency (Barros and Athanassiou 2004). The main research question of this study requires the establishment of a relationship between the possible factors or causes of inefficiency and the efficiency scores, therefore, in order to overcome the deficiency of DEA in this regard, a causal relationship between efficiency and 3 factors (private sector involvement, scale and transshipment (hub or gateway)) is formulated and an econometric methodology, Tobit regression, is presented in the following chapter as a means of examining the determinants of efficiency in container terminals.

Last but not least, DEA measures the technical efficiency of the DMUs since the focus lies with assessing the extent to which physical resources and facilities. Therefore, if the sample covers more than one country, it is quite possible that any container port in the sample may be estimated as being technically inefficient while simultaneously achieving allocative efficiency. For this specific situation, Cullinane and Wang 2007 exemplify the case when, in a labor intensive country, a port utilizes a large volume of labor simply because it is less costly than capital.

4.4 Research Approach

In this study, DEA is the principal methodology, the results of which will be the basis for the analysis of the research questions regarding the existence of any relationship between efficiency in container terminal operations and private sector involvement in Turkey and in the region (Eastern Mediterranean), scale effect, transshipment status (hub, or gateway), nautical distance from the trunk route, and the efficiency and effectiveness of customs and other border procedures.

The research structure is illustrated in Figure 11. Firstly, the sample of container ports has been selected. In this stage, the sample size is determined arbitrarily, and some representative container terminals from the region have been included. The input and output variables have been chosen for DEA methodology based on the availability and accessibility of data.

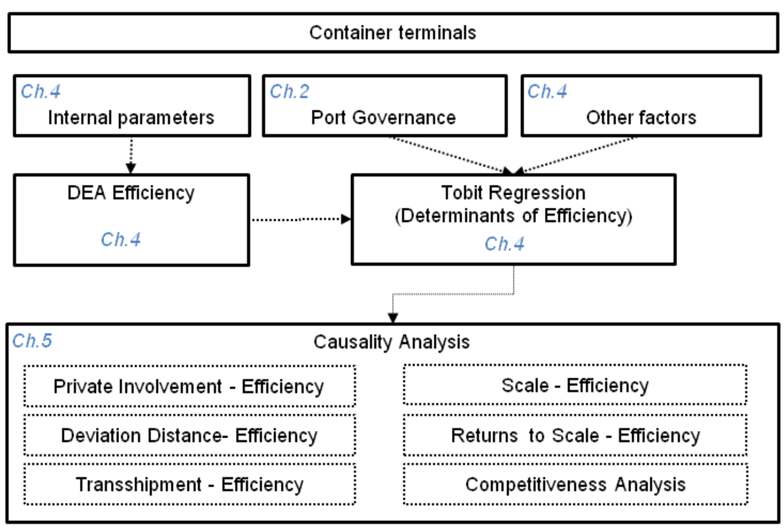

Figure 11: Research Structure
Source: Own preparation.

Second, the DEA methods (both CCR and BCC models) are executed, and the results of the efficiency evaluation, together with 5 factors (private sector involvement, scale, transshipment function (hub or gateway), nautical deviation distance and efficiency and effectiveness of customs and other border procedures) are built into a Tobit regression model in order to investigate the determinants of the efficiency and the relationship between the mentioned factors and efficiency. Port governance in Turkey is elaborated and the detailed information is presented about private and public sector involvement in Chapter 2.

The Tobit regression model is preferred in this dissertation to find out the relationship between the factors (as determinants of efficiency) and efficiency scores. The Tobit model fits best with the cases when the dependent variable in a regression model is a proportion or a percentage (like the DEA efficiency scores).The problem with ordinary linear regression is that the model can predict values that aren't possible (values below 0 or above 1). The Tobit model is applied to data which is censored or constrained in some way, so that it is actually a truncated normal distribution (i.e. constrained at one end). DEA efficiency scores are constrained at both ends (0 and 1). Therefore, the efficiency scores are transformed into truncated data (constrained in one side), from 0 up to infinity. This transformation is simply obtained by:

$$Y = \left(\frac{1}{E}\right) - 1 \tag{1}$$

where *E* is the DEA estimate and *Y* the newly transformed variable which possesses the characteristics that all observations are greater than or equal to zero (i.e. censored or truncated at zero), there is a cluster of observations equal to zero because efficient observations will now take a value of zero and inefficient observations have an unconstrained value which is greater than zero (up to infinity for DEA estimates of zero). This new variable meets the criteria for applying the Tobit model.

The results of the Tobit regression analysis are then discussed and graphed separately in terms of bilateral relationship between the factors (private sector involvement, scale, transshipment function (hub or gateway), and nautical deviation distance) and efficiency. In addition, in this part, intra-competition, intra-Marmara completion, and inter competition are analyzed graphically.

4.5 Data Collection

In order to make analysis through DEA methodology, both the input and output variables and the sample or DMUs, should be determined properly.

First, the minimum sample size should be determined. As a rule of thumb, the sample size is advised to be at least twice the sum of the inputs and outputs. Some studies advise even more conservative approach. Cochrane (2008) mentions a minimum size data set of at least three and preferably four times the total number of input and output parameters. Cooper, Seiford and Tone (2000, 2006) make a formal recommendation regarding minimum sample size. They advise that sample size be determined as follows:

$$N \geq \max\ [m \times s, 3(m+s)] \tag{2}$$

where N is the minimum sample size of DMUs, m the number of inputs and s the number of outputs.

Due to the fact that the measures of technical efficiency are determined relatively, the use of as large a sample size as possible allows some more meaningful generalization of the sample results to the population and also enhances the accuracy of the estimates derived for individual DMUs (Cullinane and Wang 2007).

In accordance with the objective of this study, except for a few ports handling containers in very small shares together with other cargo (dry, liquid, general etc), all the container terminals in Turkey are included in the sample of the research. Since the number of container terminals in Turkey is not enough to enable meaningful DEA results, and also to prevent the likelihood that majority of the sample will be assessed as fully efficient due to limited number of observations, seven container terminals from countries in the Eastern Mediterranean region are also included into the sample. Therefore, the sample size for a specific year is 16 (except 2006, where one small scale container terminal (Evyapport) was excluded due to unavailability of data), and the number of observations is 47. Considering that 5 input and 1 output variable have been selected, sample size and the number of observations comply to a great extent with the recommendations regarding the minimum sample size.

The inclusion of other container terminals from the countries in the region will be beneficial to compare the efficiency of the container terminals in Turkey with their peers in the region in terms of private sector involvement, scale, competitiveness and role or function of the terminals (hub or gateway). The container terminals covered in this study are listed in Table 5 and plotted on the map in Figure 12.

Table 5: Container Terminals in the Sample

Turkey	*Greece*	*Egypt*	*Israel*	*Romania*	*Russia*
Izmir	Thessaloniki	Port Said SCCT	Haifa	Constanta CSCT	Novorossiysk
Haydarpaşa	Piraeus	Damietta DCHC			
Mersin					
Marport					
Kumport					
Gemport					
Mardaş					
Borusan					
Evyapport					

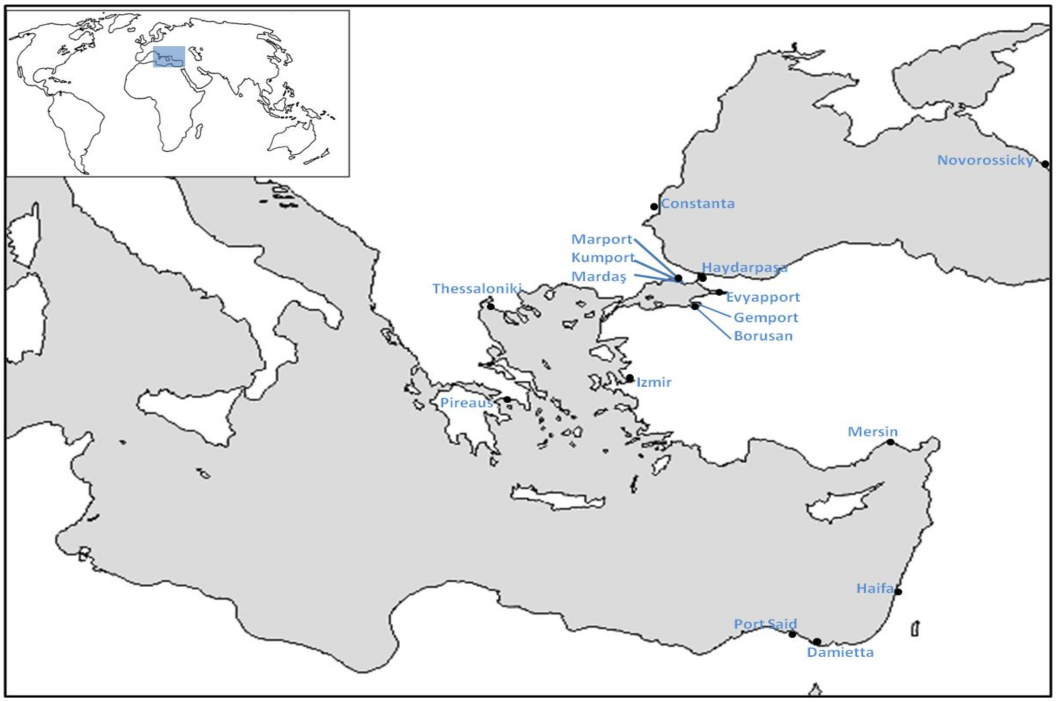

Figure 12: Container Terminals in the Sample
Source: Own preparation.

In order to minimize the impact of port specific cases (expansion, handover, labor strike, etc) in a year on efficiency, the units under study should be observed over more than a single point of time. Therefore, data have been collected for 2006-2008 period.

After deciding on the sample size and the DMUs, the input and output variables should be determined. Cullinane and Wang (2006) suggest that input and output variables should reflect the actual objectives and process of container port production as accurately as possible. Here, due to the restrictions of the methodology (as the output oriented DEA models have been chosen), it is assumed that container terminals have an objective of maximization of their outputs. This does not comply with the objective of especially private container terminals, which as a general rule aim to maximize profit for shareholders. However, as a capital intensive industry, the profits of container terminals arise mainly from handling large volumes to cover the high fixed cost of investment (Cullinane and Wang 2006); therefore, the objective of profit maximization is in fact parallel to the assumed objective of output maximization.

Like in majority of the studies investigating the efficiency of port sector, cargo throughput has been selected in this study as the output variable of the DEA methodology. Cargo throughput covers almost all services provided by the terminal operators and is most widely accepted performance indicator for comparison of container ports.

When the container throughput is considered an output variable, the transshipment activities arises as a potential problem in the calculation of total container traffic. According to Wang and Cullinane (2006), this is not a big issue as in the majority of cases, the amount of work associated with the handling of a transshipment container within a terminal does, in fact, equate very closely to that associated with an import or export container.

The impact of transshipment (hub or gateway) on the terminal efficiency scores, and the relationship between the efficiency and transshipment ratios will be investigated comprehensively in the following Chapter.

As far as input variables are concerned, physical measures of port infrastructure are considered the most widely used input measures for DEA methods. Contrary to the cargo throughput data, which is available and easily accessible, it is not always possible to obtain all the terminal production inputs in terms of labor and capital. In this study, only the physical measures of port production are included as the input variables of the study, as the labor data is kept as a commercially confidential data and not provided by all the terminals in the sample. However, it should be noted that some of the input variables, like yard equipment, reflect the size of labor work in the terminal.

The input variables of the methodology in this study cover almost all the physical characteristics of a container terminal. The selected inputs are quay length in terms of meters, terminal area in terms of square meters, the number of quay cranes (including both ship to shore and mobile quay cranes used mainly by small container terminals), the number of yard equipment, and draught in terms of meter.

Quay length has been chosen in order to integrate a measure for local productivity at berth. Terminal area is a good indicator for yard capacity. The number of quay cranes is considered an indicator for the utilization of the quay, and crane productivity. The number of yard equipment indicates the volume of handling, labor force and automation level in the terminals. Finally, draught, together with quay length, is considered in this study an indicator for the capacity for maritime access to the terminals. The summary statistics for the input and output variables are provided in Table 6.

Table 6: Summary Statistics for Sample
Source: Own calculations.

	Throughput (TEU)	*Quay Length (m)*	*Terminal Area (m^2)*	*Quay Cranes (#)*	*Yard Equipment (#)*	*Draught (m)*
Mean	771,775.91	1,076.32	371,561.30	8.91	102.62	13.45
Standard Error	96,625.00	82.38	37,264.48	0.76	8.13	0.27
Median	649,000	1,020	310,000	8	89	13
Mode	#N/A	1,200	400,000	12	53	14
Standard Deviation	662,427.62	564.75	255,472.43	5.21	55.71	1.84
Kurtosis	3.68	3.41	0.05	-0.51	-0.59	1.02
Skewness	1.67	1.66	0.96	0.59	0.50	0.53
Range	3,141,970	2,574	868,753	18	205	8
Minimum	60,030	200	33,247	2	18	10
Maximum	3,202,000	2,774	902,000	20	223	18
Count	47	47	47	47	47	47

The data set meets the previously mentioned requirements of DEA methodology. The positivity requirement is met as the container terminals always produce positive cargo throughput. The homogeneity requirement is also met to a great extent since all the container terminals including those in the sample have the same inputs and outputs due to specialization on the handling on containerized cargo.

Regarding isotonicity, the requirement may not be always valid in container terminals because the handling process at each stage in the terminal is dependent on the other stages for the completion of the service. To confirm that the chosen input and output variables could estimate the efficiency of the terminals properly, a correlation analysis was executed to investigate the isotonicity requirement.

Table 7: Correlation between input and output variables
Source: Own calculations.

		Inputs				
		Quay length (m)	*Terminal Area (m^2)*	*Quay Cranes (#)*	*Yard Equipment (#)*	*Draught (m)*
Output	*Container Throughput (TEU)*	0.4199964	0.5924915	0.3916529	0.6515747	0.4156335

The result of the correlation analysis is provided in Table 7. The correlation coefficients of 5 input variables against the output variable are all positive, demonstrating that they are all positively correlated and thus meet the isotonicity criterion.

Apart from input and output variables, in order to investigate the possible factors influencing the efficiency level in container terminals, additional data have been collected regarding private sector involvement (public or private) in terminal operations, transshipment ratios to be used for determining the function of the terminal (hub or gateway), nautical deviation distance from East West trunk route, and the efficiency and effectiveness of customs and border procedures.

For some container terminals, the nautical distance has been calculated based on the bird's eye view distance in miles. The data about the efficiency and effectiveness of customs and border procedures per country in the sample have been filtered from the sub indices of Logistics Performance Index (LPI) of the World Bank. LPI and its indicators provide cross-country assessment of the logistics gap among countries. In this study, the customs indicator has been selected due to its relevance to port operations and container dwell time in terminals. However, this indicator uses 5 point scale; therefore, the scores have been transformed to percentages over 5.

The data about transshipment ratios to be used for determining the function of the terminals (hub or gateway) have been collected through internet sources and wherever the data is not available for all years, the same transshipment ratios are assumed to be valid in the other years.

Chapter 5 Results and Analysis

5.1 Introduction

In this chapter, the results of efficiency estimation through the DEA CCR and DEA BCC models from a sample of 16 container terminals over 3 years (47 observations) will be analyzed from different views. First, all the efficiency scores will be evaluated statistically. In this regard, the efficiency scores will be discussed based on the model, country, and years of observation. Second, the factors which may influence the efficiency scores will be deliberated. A Tobit regression model will be produced in this respect, integrating the efficiency scores obtained in the DEA models as the dependent variable of the model. The private involvement, scale (throughput), hub or gateway function, nautical distance from trunk route, and efficiency and effectiveness of customs and other border procedures at country level derived from LPI of the World Bank will be set as the potential factors influencing the technical efficiency scores in the Tobit regression model. Third, the relationships between efficiency and the potential factors will be discussed separately in detail both at the national and regional level. Finally, the competitiveness analysis will be performed in intra-port, intra-Marmara, and inter-port level. In this regard, the efficiency level, scale (size), nautical distance from the East–West route, and transshipment ratios will be evaluated at national and regional perspectives.

The main questions the chapter is trying to answer are:

- Does the greater private sector involvement in container terminal operations have a positive impact on terminal efficiency in Turkey?
- Does the size or scale of the terminal have a positive impact on port efficiency?
- Are high levels of technical efficiency associated with transshipment (hub status) as opposed to gateway ports or terminals?
- Do the container terminals being far from the trunk route offer higher efficiency to compensate extra voyage time?
- Does the efficiency and effectiveness of customs and border procedures have any impact on terminal efficiency (in the Eastern Mediterranean region)?

5.2 Overview of the Results

In order to produce the efficiency levels for each container terminal in the sample, both CCR and BCC models have been utilized. The full results are available in Table 8.

Table 8: Efficiency Scores of the Container Terminals in the Sample.
Source: Own elaboration.

	2006		2007		2008	
	CCR Efficiency	*BCC Efficiency*	*CCR Efficiency*	*BCC Efficiency*	*CCR Efficiency*	*BCC Efficiency*
Izmir	0.460	0.612	0.392	0.522	0.319	0.430
Haydarpaşa	0.542	1.000	0.435	0.778	0.322	0.702
Mersin	0.444	0.467	0.445	0.503	0.390	0.391
Marport	1.000	1.000	0.763	0.802	0.747	0.794
Kumport	0.484	0.625	0.504	0.649	0.330	0.405
Gemport	0.543	1.000	0.547	1.000	0.445	1.000
Mardaş	0.313	0.475	0.359	0.592	0.386	0.467
Evyapport	-	-	0.217	1.000	0.250	1.000
Borusan	0.832	1.000	0.828	1.000	0.841	1.000
Constanta CSCT	0.922	1.000	0.842	0.851	0.662	0.668
Haifa	0.784	0.854	0.703	0.728	0.692	0.716
Thessaloniki	0.476	1.000	0.508	1.000	0.224	1.000
Piraeus	0.732	0.757	0.577	0.585	0.140	0.142
Novorossiysk	0.151	1.000	0.205	1.000	0.341	1.000
Damietta DCHC	1.000	1.000	0.887	0.899	0.579	0.637
Port Said SCCT	1.000	1.000	1.000	1.000	1.000	1.000

As a result of the two DEA models, significantly different efficiency scores have been obtained at each model. The summary statistics of the efficiency scores based on the models used is given in the Table 9. The mean efficiency score in CCR model is (0.565), while the mean efficiency score obtained in BCC model is (0.788). Since CCR model with an assumption of constant returns to scale provides information simply on technical and scale efficiency taken together, while BCC model with the assumption of variable returns to scale identifies only technical efficiency, it is a common result to have higher mean efficiency in BC models.

Table 9: Summary Statistics for Efficiency Scores
Source: Own calculations.

	DEA-CCR	*DEA-BCC*
Mean	0.565	0.788
Standard Error	0.037	0.034
Median	0.508	0.851
Mode	1.000	1.000
Standard Deviation	0.255	0.232
Kurtosis	-1.032	-0.410
Skewness	0.260	-0.740
Minimum	0.140	0.142
Maximum	1.000	1.000
Count	47	47

Considering the peculiar characteristics of the two models, what appears to be important is the ranking of the efficiency scores at each model. Contrary to the researches concluding that the efficiency scores obtained from the two models are highly correlated (Wang and Cullinane, 2006, Cullinane and Wang, 2007), the correlation between the efficiency scores out of CCR and BCC models is found to be quite weak. The correlation has been found to be less than 50 percent (0.413). It is considered that due to limited sample size, BCC model produced many full efficient scores, equivalent CCR scores of which are far from full efficiency.

The efficiency scores from CCR and BCC models have also produced significantly different distributions. As seen in the Figure 13 and Figure 14, the distribution in BCC model is skewed towards higher efficiency, while the distribution of CCR model seems like a bimodal distribution (0.4 and 1.0). However, this difference should be evaluated cautiously taking into account the sample size of the distribution, as the number of observations in the researches finding a high correlation between the two models is a lot more than that in this study.

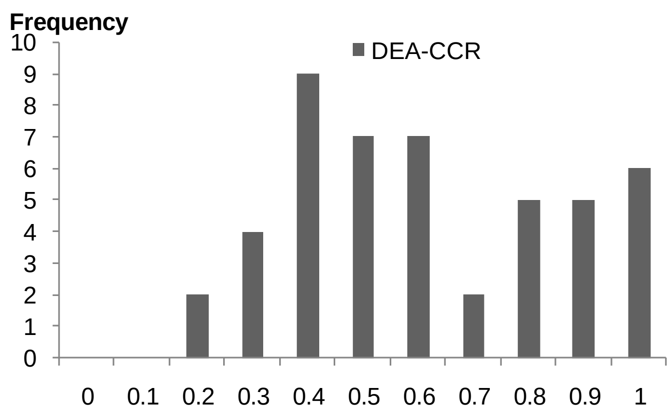

Figure 13: Histogram of Efficiency Scores obtained by DEA-CCR model
Source: Own calculations.

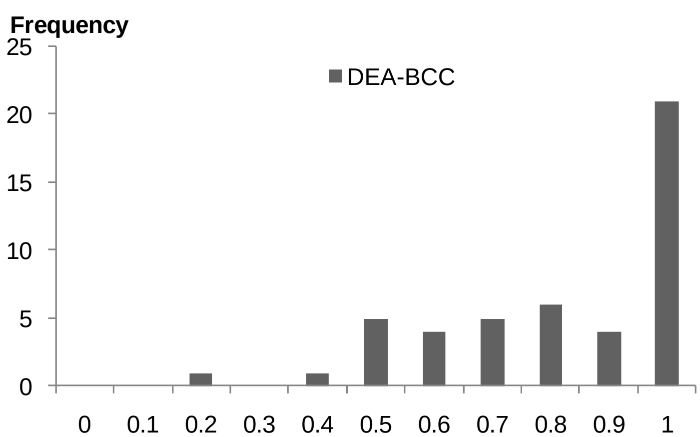

Figure 14: Histogram of Efficiency Scores obtained by DEA-BCC model
Source: Own calculations.

The average efficiency scores of (0.565) and (0.788) from CCR and BCC models mean that with the same inputs, the Eastern Mediterranean container terminals in the sample produced on average 77 percent, and 27 percent less outputs (container throughput) than potentially possible level, respectively. This indicates that there exists a significant inefficiency in container terminal operations in the Eastern Mediterranean region.

In terms of country specific terminal efficiencies, the average efficiency level of container terminals located in different countries is found to be different from each other significantly. As seen in Figure 15, average efficiency of Turkish container terminals is found to be (0.495) and (0.749) as a result of CCR and BCC models respectively. In this regard, the container terminals in Turkey, either public or private, have relatively less efficiency than the average efficiency levels produced by CCR and BCC models. The most similar country to Turkey is found to be Greece in this regard, while the most efficient country on average is found to be Egypt. However, the fact that though container terminals from Russia, Romania and Israel, are the most important container ports in those countries, the sample includes only one representative terminal from these countries, should be taken into account while comparing the efficiency levels in each country. The terminals not included in this study may influence either positively or negatively the efficiency estimates in the sample. After all, the average efficiency is calculated simply based on the sample size, instead of the size of each container terminal.

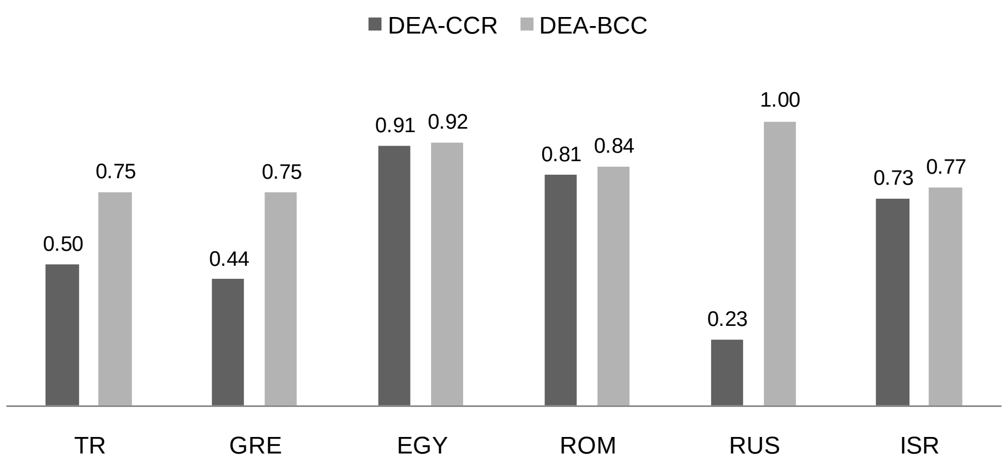

Figure 15: Average efficiency scores for each country in the sample
Source: Own calculations.

In terms of efficiencies over time, interestingly, average efficiencies calculated per year have a slightly decreasing trend as indicated in Figure 16. While the mean efficiency of the sample obtained from CCR model for the year 2006 is (0.646), it reduces to (0.576) and (0.479) in 2007 and 2008 respectively. The decrease in efficiency level in 2008 may be attributed to the decline in container throughputs in some ports, especially in Greece, where a labor strike locked the operations for a period of time in 2008. One possible explanation for the reduction in efficiency in 2007 is the exclusion of one of inefficient container terminals due to the unavailability of data in 2006.

The change in average efficiencies in each year of observation indicates that increasing the number of observations by using a panel data set for three years is an appropriate way to reduce the impact of exceptional incidences in some container terminals at a specific year.

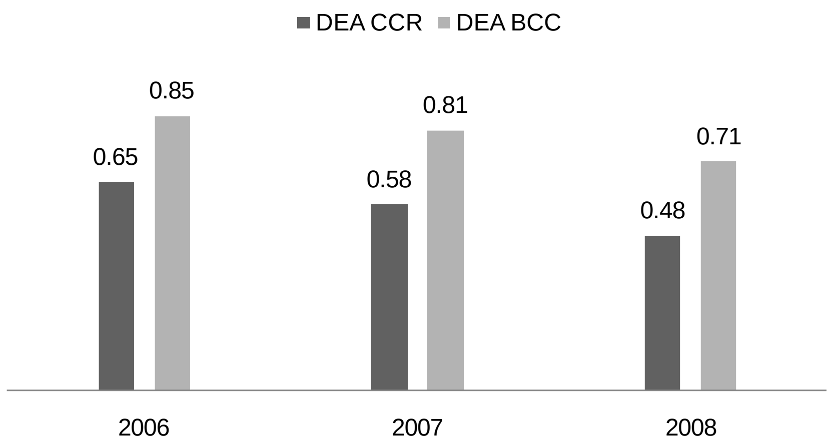

Figure 16: Average efficiency scores for each country in the sample
Source: Own calculations.

In the next part, the extent of influence of potential factors on the efficiency level at container terminals are sought by using the Tobit regression model. The efficiency scores obtained by the DEA models will be used as the dependent variable of the analysis.

5.3 Determinant of Port Efficiency

Even though DEA methodology identifies the slacks for the inefficient container terminals and gives to each terminal a reference set which allows for specific recommendations to improve efficiency, it does not identify the causes of the inefficiency or efficiency.

The basic hypothesis of this study is that private sector involvement in container terminals in Turkey will bring more efficiency and therefore, one of the determinants of the efficiency level in container terminal industry. In the next part, the relationship between efficiency and private involvement will be examined in detail both at national and regional level. However, before looking at the specific relationships, the concurrent analysis of the potential factors influencing the efficiency level may support the argument.

Apart from the private sector involvement in terminal business, there could be numerous factors influencing the efficiency of a container terminal, including scale and market share of the terminal, transshipment ratio, nautical deviation distance from man route, customs and border procedure, level of economic growth in the terminal region, extent of port competition, the geographical location, hinterland connections, labor costs, the automation level etc. The possible reasons behind inefficiency in the terminal operations can be so extensive, difficult to quantify and interdependent that an investigation in this manner might turn out to be extremely challenging. However, the most important and relevant factors in the framework of this study are the private involvement, scale (throughput), hub or gateway status, nautical deviation distance and the efficiency and effectiveness of customs and border procedure at country level.

A causal relationship between efficiency and these 5 factors (private sector involvement, scale, hub or gateway function, nautical distance and customs) is formulated and an econometric methodology, the Tobit regression, is presented below as a means of examining the determinants of efficiency in container terminals. In this analysis, only the CCR efficiency scores will be used as the input of the regression model.

As mentioned in Chapter 4, the Tobit model is applied to data that is censored or constrained in some way, so that it is actually a truncated normal distribution (i.e. constrained at one end). DEA efficiency scores are constrained at both ends (0 and 1). Therefore, the efficiency scores are transformed into truncated data (constrained in one side), from 0 up to infinity. This transformation is obtained by:

$$Y_{ij} = \left(\frac{1}{DEA\ Efficiency_{ij}}\right) - 1 \qquad (3)$$

where i corresponds to container terminal, and j is the year of observation, *DEA efficiency*$_{ij}$ is the DEA estimate of terminal i in year j and Y_{ij} is the newly transformed variable for terminal i in year j. This new variable meets the criteria for applying the Tobit model.

The Tobit regression model to be used in order to determine the extent of the relationship between efficiency level and the 5 factors is as follows:

$$\begin{aligned} Y_{ij} = \beta_0 + \ \beta_{\mathbf{1}} * PRINV_{ij} + \ \beta_2 * SCALE_{ij} + \ \beta_3 * HUB_{ij} \\ + \ \beta_4 * DIST_{ij} + \ \beta_5 * CUS_{ij} + \varepsilon \end{aligned} \qquad (4)$$

where:

$PRINV_{ij}$: a dummy variable (if the terminal is operated by private sector, equals to (1), otherwise equal to (0)),

$SCALE_{ij}$: the container throughput (TEU) of the terminal i in year j (note that average throughputs are used to calculate the market share of a terminal),

HUB_{ij} : a dummy variable (if the terminal is a hub port, equals to (1), otherwise equal to (0)).

$DIST_{ij}$: the nautical deviation distance of the terminal i in year j.

CUS_{ij} : the efficiency and effectiveness of customs and other border procedures in terms of percentages (retrieved from Logistic Performance Index of the World Bank)

The summary output of the Tobit regression analysis is given in Table 10. Since the probability of obtaining the chi-square statistic (30.42) or more if there is in fact no effect of the predictor variables to accept a type I error, at 0.05 confidence level, as depicted by p value is almost zero (0.0000), it can be concluded that at least one of the regression coefficients in the model is not equal to zero.

The result of the Tobit regression regarding the direction of relationship between the factors and the transformed efficiency values is in parallel to what is previously expected. Because of the transformation made based on the equation (1), full efficiency score (1.000) becomes (0.000) and the inefficiency scores changes from a value more than zero up to infinity (theoretically). Therefore, the coefficients are expected to exhibit this negative relationship.

Table 10: Summary Output for Tobit Regression Analysis
Source: Own calculations.

				Number of obs	=	47
				LR chi2(5)	=	30.42
				Prob > chi2	=	0.0000
Log likelihood = -66.424403				Pseudo R2	=	0.1863
Y	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
PRINV	-0.979599	0.413672	-2.37	0.023	-1.814424	-0.144775
SCALE	-1.31e-06	5.95e-07	-2.20	0.033	-2.51e-06	-1.09e-07
HUB	-0.420981	0.679898	-0.62	0.539	-1.793071	0.951109
DIST	0.000993	0.000822	1.21	0.233	-0.000665	0.002652
CUS	0.150386	2.391018	0.06	0.950	-4.674883	4.975655
_cons	2.10227	1.909761	1.10	0.277	-1.751784	5.956324
/sigma	1.122628	0.122657			0.875097	1.37016
Obs. summary:	5 left-censored observations at Y<=0					
	42 uncensored observations					
	0 right-censored observations					

The parameter PRINV associated with the private sector involvement in container terminals is found to be statistically significant with a p value of (0.023). This, therefore, supports the hypothesis that private sector involvement in the operation of container terminals is associated with higher efficiency. This relationship will be discussed in detail in this Chapter both from national and regional perspectives.

Scale effect (throughput values are regarded as a measure for scale) indicated as SCALE estimate in the model is similarly found to be statistically significant (p value <0.033). Therefore, it is found that the efficiency scores are positively related with scale (throughput), implying that large-scale production tends to be associated with higher efficiency.

Contrary to PRINV and SCALE variables, the parameters associated with the hub or gateway status of the terminals (HUB), the nautical deviation distance from the East West route (DIST), and the efficiency and effectiveness of customs and other border procedures (CUS) are found insignificant.

Considering the fact that none of the customs and border authorities shows outstanding performance in the region based on the LPI survey of the World Bank, the non-existence of statistically any significant relationship between terminal efficiency and customs procedures is not surprising.

It is also not surprising to find that there is no significant relationship between hub or gateway status of the terminals and efficiency levels. Even though a transshipment container is counted twice in annual container traffic volume of a terminal while occupying a single slot in the yard, this is not a big issue as in the majority of cases, the amount of work associated with the handling of a transshipment container within a terminal does in fact equate very closely to that associated with an import or export container (Wang and Cullinane 2006).

However, it is interesting to see the lack of significant influence of the deviation distance on efficiency. The container terminals being far from the trunk route theoretically are expected to offer either much more efficient and fast service to the shipping lines so that the time lost during the journey to these terminals are compensated with the time saved in the efficient and relatively fast handling in the terminal, or cheaper service so that total transport costs of the shipping lines are reduced The result indicate that the latter is more appropriate to explain the lack of relationship between efficiency and distance.

As a result, private sector involvement and scale in container terminals appear to remain critical determinant of terminal efficiency.

In the next part, the relationships between efficiency and the potential factors will be discussed separately in detail both at national and regional level.

5.4 Causality Analysis

5.4.1 Efficiency vs. Private sector involvement

The basic hypothesis of this study is discussed in detail in this part. As mentioned before in Chapter 2, in majority of the researches done in the field of efficiency in port sector, high levels of technical efficiency were generally associated with greater private sector participation, even though there are some studies rejecting the hypothesis that greater private involvement in the port sector leads to improved efficiency (Liu 1995, Cullinane, Ji and Wang 2005).

A concurrent analysis of the potential factors affecting the efficiency level through a Tobit regression model in the previous part reveals that private sector involvement is one of the determinants of port efficiency.

In this part, first the efficiency estimates of all container terminals in the sample will be discussed, and then it will be investigated in national level.

Regional perspective

Average technical efficiency estimates of public and private container terminals in the sample, obtained from CCR and BCC models are given in Figure 17. It is clearly seen that at both models of DEA methodology, terminals operated by the private sector has greater efficiency on average. Based on CCR model, private container terminals in the Eastern Mediterranean region have an average efficiency score of (0.626) and public container terminals in the region have an average efficiency score of (0.496). Therefore, under the assumption of constant returns to scale (CCR model), private terminals are almost 21 percent on average more efficient than public container terminals in the region. The efficiency estimates from the BCC model brings similar result, but the difference is not as big as that obtained in the CCR model. Based on the BCC model, private container terminals in the region have an average efficiency score of (0.809) and public container terminals in the region have an average efficiency score of (0.765). Therefore, under the assumption of variable return to scale, private terminals are almost 5 percent more efficient than public container terminals in the region.

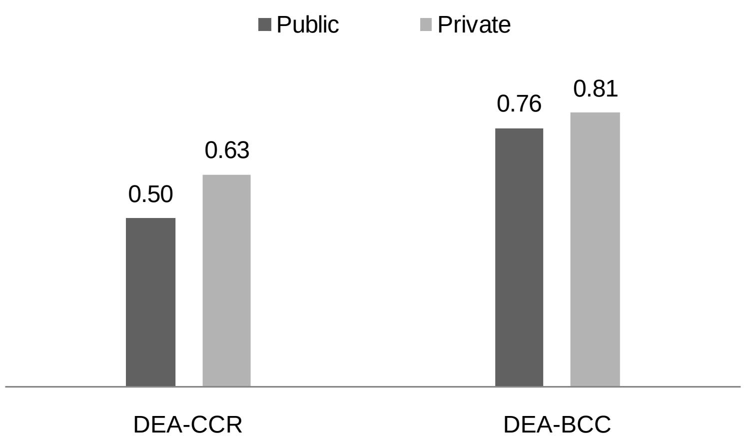

Figure 17: Average Technical Efficiency in the Eastern Mediterranean Region
Source: Own elaboration.

The port governance structure of the container terminals in the sample and the average efficiencies are given in Table 11. It is observed that Marport container terminal in

Turkey, Constanta container terminal in Romania and Port Said container terminal in Egypt are main determinants of the higher efficiency on average in private container terminals. On the other hand, with relatively lower efficiency scores, Izmir and Haydarpaşa terminals in Turkey and Piraeus and Thessaloniki terminals in Greece caused to a great extent that public container terminals are relatively less efficient.

It should be noted that some of the private container terminals in the sample are less efficient on average than some public ports, and vice versa. With average efficiency scores of (0.353) and (0.234) respectively, Mardaş and Evyapport container terminals in Turkey and with the average efficiency score of (0.232), Novorossiysk container terminal in Russia may be given as examples for outliers. For public ports, Haifa container terminal in Israel and Damietta container terminal in Egypt are the examples of terminals with higher efficiency scores on average than the private terminals. However, it is worth mentioning that these two terminals are operated by corporatized companies owned by the government, and the higher efficiency is obtained perhaps due to the operation of the terminals under private commercial rules.

Table 11: Port Governance and Average Efficiencies in the Sample
Source: Own research and elaboration.

Container Terminal	*Country*	*Governance*	*CCR Efficiency*	*BCC Efficiency*
Izmir	Turkey	Public	0.390	0.521
Haydarpaşa	Turkey	Public	0.433	0.827
Mersin	Turkey	Private*	0.426	0.454
Marport	Turkey	Private	0.837	0.865
Kumport	Turkey	Private	0.439	0.560
Gemport	Turkey	Private	0.512	1.000
Mardaş	Turkey	Private	0.353	0.511
Borusan	Turkey	Private	0.834	1.000
Evyapport	Turkey	Private	0.234	1.000
Constanta CSCT	Romania	Private	0.809	0.840
Haifa	Israel	Public	0.726	0.766
Thessaloniki	Greece	Public	0.403	1.000
Piraeus	Greece	Public	0.483	0.495
Novorossiysk	Russia	Private	0.232	1.000
Port Said SCCT	Egypt	Private	1.000	1.000
Damietta DCHC	Egypt	Public	0.822	0.845

* *Mersin port was a public port until 2007. It was privatized in April 2007.*

National perspective

Average technical efficiency estimates of public and private container terminals in Turkey, obtained from CCR and BCC models are given in Figure 18. Similar to the results at the regional level, it is clearly seen that at both models, terminals operated by the private sector has greater efficiency on average. Based on the CCR model, private container terminals in Turkey have an average efficiency score of (0.538) and public container terminals in the region have an average efficiency score of (0.416). Therefore, under the assumption of constant returns to scale, private terminals are almost 22 percent more efficient than public container terminals in Turkey. The efficiency estimates from the BCC model produce a similar result. Based on the BCC model, private container terminals in Turkey have an average efficiency score of (0.774) and public container terminals in the region have an average efficiency score of (0.644). Therefore, under the assumption of variable return to scale, private terminals are almost 17 percent more efficient than public container terminals in Turkey.

Comparing the average efficiency level in Turkey with the average in the Eastern Mediterranean region, it is found that both public and private container terminals have relatively less average efficiency. In CCR efficiencies, private container terminals in Turkey have an efficiency score of (0.538) and their peers in the region have an average efficiency of (0.626). Hence, under the constant returns to scale assumption, the private container terminals in the region are about 14 percent more efficient than those in Turkey. Similarly in BCC efficiencies, private container terminals in Turkey have an average efficiency of (0.774) and their peers in the region have an efficiency score of (0.809). Hence, under the assumption of variable returns to scale, it is found that the private container terminals in the region are approximately 5 percent more efficient than those in Turkey. For public container terminals, the difference is approximately 15 percent and 16 percent at CCR and BCC efficiencies respectively. Though it is too assertive an argument, Oral et al. (2007) claim that Turkish ports hardly compete with the regional ports as they have insufficient capacity in terms of infrastructure, superstructure, equipment, etc. for transshipment cargoes. The authors also add that the major ports in Turkey used to be operated within a monopolistic regime (until the privatization of some of them). From the efficiency results in this study, it seems that even though the competition level increased in the course of time in parallel to the entrance of the private sector ports to the market, at least some of these ports still lack the characteristics to keep pace with the ports in the region.

Like at the regional level, it is also observed that Marport container terminal, together with Borusan terminal, both located at Marmara Sea, are the main determinants of the higher efficiency in private container terminals in Turkey. If the average efficiencies were calculated on the basis of weights or market share, the relative efficiency of private container terminals would be much higher both at national and regional level, as those terminals with the highest efficiencies are in general the biggest container terminals as well.

Regarding the higher efficiency in private ports, Oral et al. (2007) associate this with specialization (in this case, container business) and the management style of the private port sector. The authors states that the management style in private sector ports has minimized internal bureaucracy.

On the other hand, with relatively lower efficiency scores, Izmir and Haydarpaşa terminals in Turkey caused to a great extent that public container terminals are relatively less efficient in Turkey. It should be noted that Mersin container terminal was counted as public terminal in 2006, and therefore, it has also some contribution to the average inefficiencies in the public terminals segment.

It should also be noted that some of the private container terminals in the sample are less efficient on average than some public terminals, and vice versa. With average efficiency scores of (0.353) and (0.234) respectively, Mardaş and Evyapport container terminals in Turkey may be given as examples. For public container terminals, there is no exception with higher efficiency than the average in Turkey or in the region.

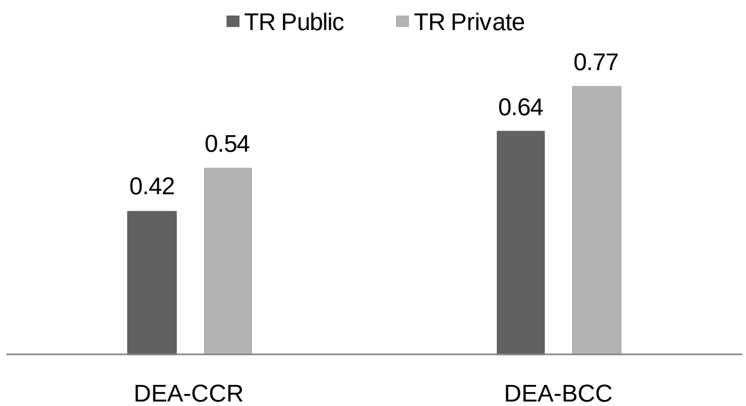

Figure 18: Average Technical Efficiency in Turkey
Source: Own elaboration.

Being recently privatized in 2007, Mersin container terminal deserves a particular attention in this respect. Even though, the approach of this paper is holistic based instead of focusing on a particular port in order to reach some general conclusions, the trend of efficiency in Mersin ports seems slightly a bit contrary to the hypothesis that greater public sector involvement is associated with higher efficiency. As seen in Figure 19, the CCR efficiency scores of Mersin container terminal are (0.444), (0.445), and (0.390) for the years 2006, 2007, and 2008, respectively. Similarly, the BCC efficiency scores of the terminal are (0.467), (0.503), and (0.391) for the years 2006, 2007, and 2008, respectively. However, together with the general trend in the region, port specific information and characteristics should be borne in mind in this case.

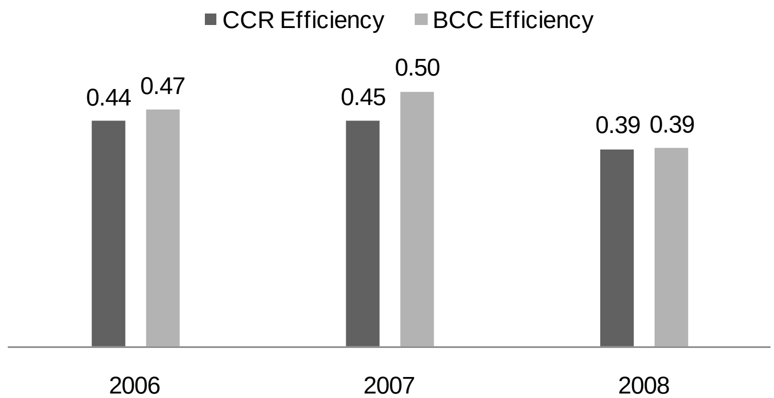

Figure 19: Efficiency Scores in Mersin container terminal
Source: Own elaboration.

In the last quarter of 2008, due to the global financial crisis, the trade and container traffic declined tremendously, and some of the container terminals in the sample handled less throughput than 2007 levels. Even though Mersin port increased its yearly throughput amount in 2008, majority of the container terminals in Turkey got throughput values less than 2007.

In addition, due to the lack of a single port authority in the ports in Turkey, in order prevent the monopolistic or oligopolistic behavior after privatization; the privatization contract for Mersin port requires the operator to realize the compulsory investments within the first five years. In this regard, the port operator PSA-AKFEN consortium increased significantly the investments in the terminal, especially the superstructure facilities. The only requirement in the first five years is that the average port time of ships should not fall below the average port time of ships in the top 10 Mediterranean ports. Taking into account the small call size in Mersin port compared to the top 10 Mediterranean ports, this is not a big deal. Therefore, it seems that in order not to cause any termination in the concession contract the port operator is concentrated on the completion of the obligations. This can be easily seen by the significant increase in the number of yard and quay equipments in 2008. Together with the overall reduction in throughput figures in 2008, this is regarded as one of the most important reason for the declining efficiency in 2008.

Finally, it should also be noted that 3 years period of time is possible an insufficient time for any significant changes to be reflected in enhanced efficiency.

Next, the relationships between efficiency and scale effect will be discussed in detail.

5.4.2 Efficiency vs. Scale (Throughput)

Scale effect is one of the topics that were discussed intensively in the literature regarding the relative efficiency of ports. Except a few studies rejecting that port size alone is one of the primary determinant of port efficiency (Coto-Millan, Banos-Pino and Rodriguez-Alvarez 2000, Tongzon 2001, Cullinane et al. 2004 , Al-Eraqi et al. 2008), scale effect has been proved to be positively correlated to the efficiency level (Liu 1995, Turner, Martinez-Budria et al. 1999, Notteboom et al. 2000, Cullinane, Song and Gray 2002, Windle and Dresner 2004, Cullinane and Wang 2006, Wang and Cullinane 2006, Herrera and Pang 2008).

The results of the analysis of the potential factors affecting the efficiency level through a Tobit regression model in the previous part reveals that scale (throughput), together with private sector involvement, is found to be one of the determinants of terminal efficiency.

The average tendency for the relationship between efficiency scores and container throughput (as a measure for scale) is plotted in Figure 20 and Figure 21 for CCR and BCC efficiencies, respectively. The correlation coefficient of the efficiency scores against container throughput is (0.63) for CCR model. On the other hand, the correlation coefficient of the efficiency scores against container throughput is less than (0.05) for BCC model. However, as seen in the trend of the marks in Figure 21, the container terminals with throughput over 1 million TEU are associated with high efficiencies without any exceptions.

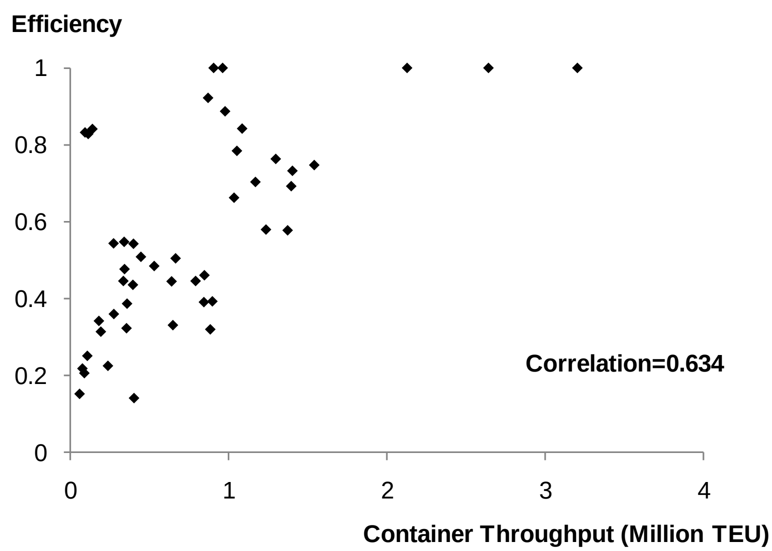

Figure 20: Relationship between Efficiency (DEA-CCR) and Scale (Throughput)
Source: Own elaboration.

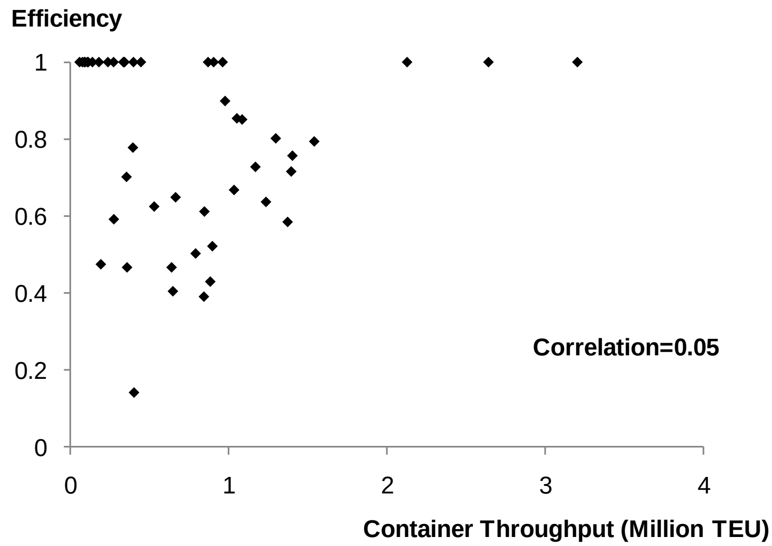

Figure 21: Relationship between Efficiency (DEA-BCC) and Scale (Throughput)
Source: Own elaboration.

All these results imply that the efficiency of a container terminal is influenced by its production scale to some extent and that there is sufficient evidence to support the hypothesis that there exist economies of scale in the container port sector. Wang and Cullinane (2006) explains the existence of scale effect by putting forward the fact that large container terminals are more likely to utilize more state-of-the-art equipment and sophisticated management than their smaller counterparts.

Next, the relationships between efficiency and transshipment ratio will be discussed in detail.

5.4.3 Efficiency vs. Transshipment

In some studies it was empirically proven that high levels of technical efficiency were associated with transshipment as opposed to gateway ports (Notteboom et al. 2000, Cullinane et al. 2006). Therefore, it is found to bring more efficiency being a hub port rather than a feeder port.

Though it is found previously in some empirical studies that being a hub port rather than a feeder port is associated with higher efficiency, in this study, the analysis of the potential factors affecting the efficiency level through a Tobit regression model mentioned previously reveals that there is no significant influence of high transshipment activities on port efficiency. With a low t statistics value as an indicator for the lack of significance of relationship (0.62), transshipment or being a hub port is not found to have a strong impact on the efficiency level of the terminals.

However, when we investigate the transshipment ratios instead of using a dummy variable to categorize the terminals as hub or gateway ports, the relationship seems stronger than the result of the Tobit model. This is clearly due to the fact that there are many container terminals lying between these two categories (hub or gateway). The average tendency for the relationship between efficiency scores and transshipment ratios is plotted in Figure 22 and Figure 23 for CCR and BCC efficiencies, respectively. The correlation coefficient of the efficiency scores against transshipment is (0.794) for the CCR model. On the other hand, in the BCC model, the correlation coefficient of the efficiency scores against container throughput is less than (0.185). However, as seen in the trend of the marks in Figure 23, the container terminals with high transshipment ratios are associated with high efficiencies without exception.

It should also be pointed out that in the sample all the private container terminals with the highest efficiency scores do also have high transshipment ratios. With the highest efficiency scores on average both in CCR and BCC models, Marport container terminal in Turkey, and Port Said, Damietta and Constanta container terminals in the region also have significantly high transshipment ratios.

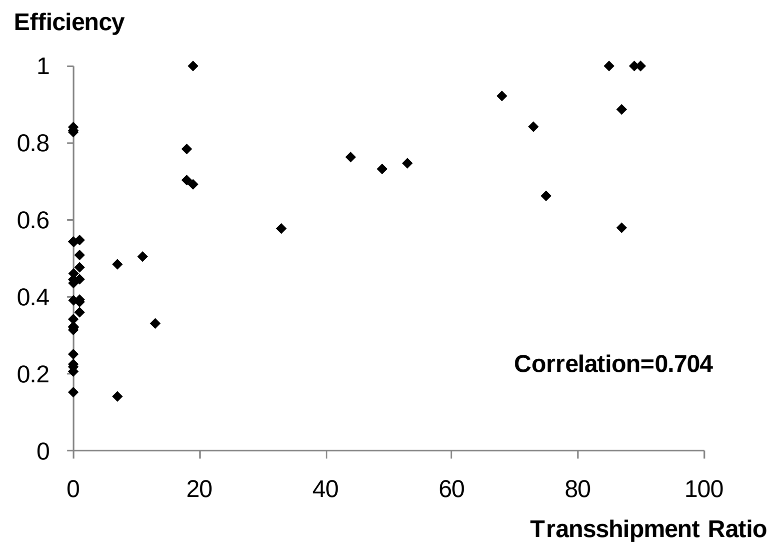

Figure 22: Relationship between Efficiency (DEA-CCR) and Transshipment Ratio
Source: Own elaboration.

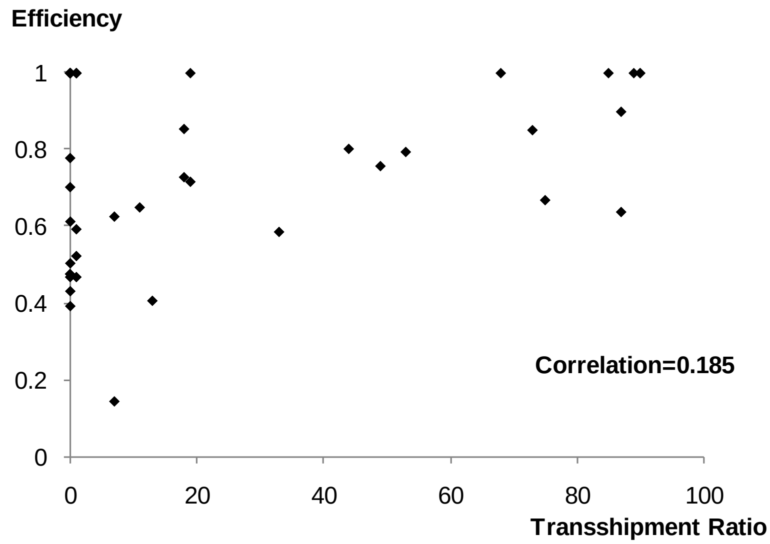

Figure 23: Relationship between Efficiency (DEA-BCC) and Transshipment Ratios
Source: Own elaboration.

Next, the relationships between efficiency and nautical deviation distance will be investigated in detail.

5.4.4 Efficiency vs. Deviation Distance

Though the nautical deviation distance from the trunk route (West-East trade route) may be considered as an exogenous factor, while efficiency of ports are measured principally based on the internal factors of production, the relationship between efficiency and nautical distance is investigated due to the motivation that the container terminals being far from the trunk route theoretically may either offer much more efficient service to the shipping lines so that the time lost during the journey to these terminals are compensated with the time saved in the efficient and relatively fast handling in the terminal, or cheaper service so that the transport cost in overall logistics chain reduced.

The analysis of the potential factors affecting the efficiency level through a Tobit regression model mentioned previously reveals that there is no significant influence of the deviation distance on port efficiency (p value of approximately 0.23). Taking into account the fact that pricing strategy is much easier to control than efficiency improvements, the non existence of any relationship between efficiency and deviation distance may be explained by ports using pricing as a tool to compete with their peers closer to mainline traffic, rather than efficiency to make themselves attractive compared to ports that are nearer to the trunk route. Also, there may be even an inverse relationship between throughput and deviation distance that actually works to suppress efficiency levels. Thus, distant ports may be either more efficient per $ or are more efficient per unit of throughput.

The relationship between efficiency scores and nautical deviation distance from the East West route is plotted in Figure 24 and Figure 25 for CCR and BCC efficiencies, respectively.

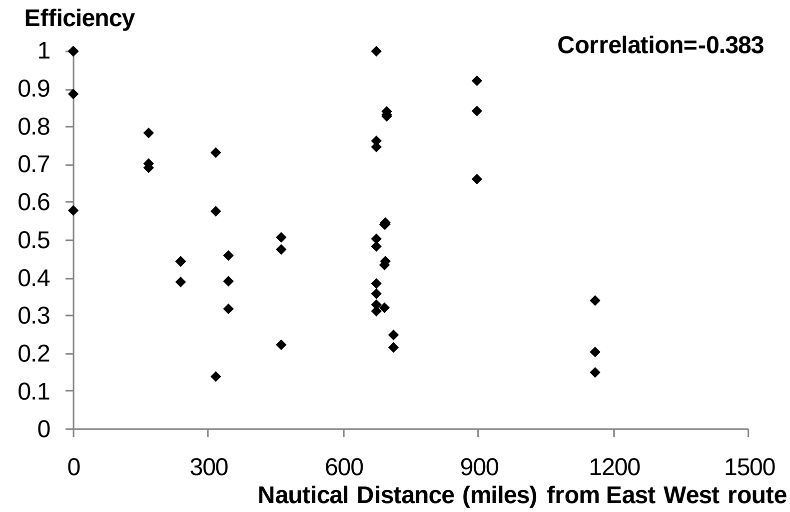

Figure 24: Relationship between Efficiency (DEA-CCR) and Nautical Distance from East West Route
Source: Own elaboration.

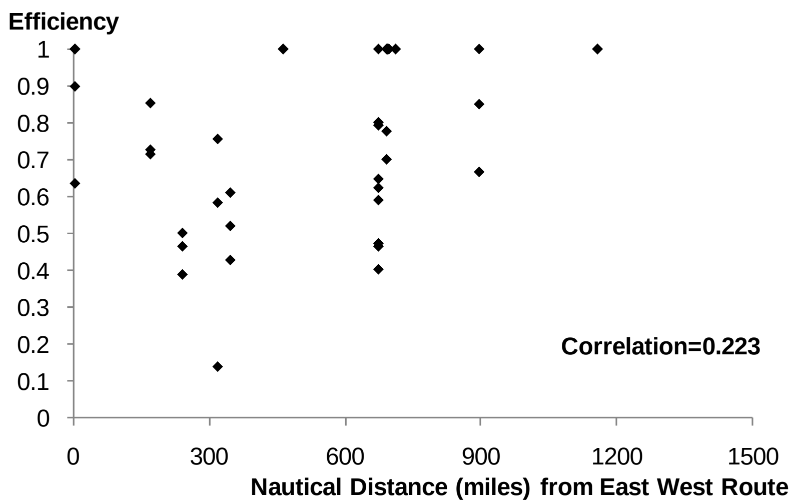

Figure 25: Relationship between Efficiency (DEA-BCC) and Nautical Distance from East West Route
Source: Own elaboration.

In Figure 24, it is seen that there is no clear evidence to support the hypothesis that container terminals, being far from the trunk route have relatively higher efficiency. On the other hand, in Figure 25, where BCC efficiency measures are used, container terminals being far from the trunk route have relatively higher efficiency. However, this relationship is not clear-cut to support the hypothesis.

Next, the scale efficiencies and returns to scales of the container terminals will be investigated in detail.

5.5 Scale Inefficiency and Return to Scales

It is interesting to investigate the sources of inefficiency (technically or scale related) that a container terminal might have. The inefficiency may be caused by the inefficient operation of the container terminal itself (pure technical inefficiency) or by the disadvantageous conditions under which the container terminal is operating (scale inefficiency).

As stated before, the CCR model assumes the constant returns-to-scale production possibility set, and the CCR efficiency score is called global technical efficiency since it takes no account of scale effect. On the other hand, the BCC model assumes variable returns to scale and the BCC efficiency score is called local pure technical efficiency. If a container terminal is fully efficient (1.000) in both the CCR and BCC models, it is said to be operating in the most productive scale size. If a container terminal has full BCC efficiency but a low CCR score, then it is operating locally efficiently but not globally efficiently due to the scale size of the terminal. Thus, it is reasonable to characterize the scale efficiency of a container terminal by the ratio of the two scores (Cooper, Seiford and Tone 2006).

Regional perspective

Table 12 lists the CCR, BCC and Scale efficiency scores of the container terminals in the sample. Of the 47 observations, 5 exhibit constant returns to scale, 42 exhibit increasing returns to scale, and none of the observations exhibits decreasing returns to scale. Port Said in Egypt is the only container terminal having constant return to scale in all years of observation, therefore operating in the most productive scale size. All the rest exhibit increasing returns to scale (smaller than their optimum size) in at least one of the years of observation. This is considered a common phenomenon in container terminals justifying that excess capacity in container terminals is an operational necessity, because it is the only way to guarantee quick turnaround times to ships (Haralambides, 2002).

Table 12: Scale Efficiency Scores of the Container Terminals in the Sample.
Source: Own elaboration.

	Scale Efficiency	*Return to Scale*	*Reason*
2006			
Izmir	0.752	Increasing	Pure technical inefficiency
Haydarpaşa	0.542	Increasing	Scale inefficiency
Mersin	0.951	Increasing	Pure technical inefficiency
Marport	1.000	-	
Kumport	0.774	Increasing	Pure technical inefficiency
Gemport	0.543	Increasing	Scale inefficiency

Mardaş	0.659	Increasing	Pure technical inefficiency
Borusan	0.832	Increasing	Scale inefficiency
Constanta CSCT	0.922	Increasing	Scale inefficiency
Haifa	0.918	Increasing	Pure technical inefficiency
Thessaloniki	0.476	Increasing	Scale inefficiency
Piraeus	0.967	Increasing	Pure technical inefficiency
Novorossiysk	0.151	Increasing	Scale inefficiency
Damietta DCHC	1.000	-	
Port Said SCCT	1.000	-	
2007			
Izmir	0.751	Increasing	Pure technical inefficiency
Haydarpaşa	0.559	Increasing	Pure technical inefficiency
Mersin	0.885	Increasing	Pure technical inefficiency
Marport	0.951	Increasing	Pure technical inefficiency
Kumport	0.777	Increasing	Pure technical inefficiency
Gemport	0.547	Increasing	Scale inefficiency
Mardaş	0.606	Increasing	Pure technical inefficiency
Evyapport	0.217	Increasing	Scale inefficiency
Borusan	0.828	Increasing	Scale inefficiency
Constanta CSCT	0.989	Increasing	Pure technical inefficiency
Haifa	0.966	Increasing	Pure technical inefficiency
Thessaloniki	0.508	Increasing	Scale inefficiency
Piraeus	0.986	Increasing	Pure technical inefficiency
Novorossiysk	0.205	Increasing	Scale inefficiency
Damietta DCHC	0.987	Increasing	Pure technical inefficiency
Port Said SCCT	1.000	-	
2008			
Izmir	0.742	Increasing	Pure technical inefficiency
Haydarpaşa	0.459	Increasing	Pure technical inefficiency
Mersin	0.997	Increasing	Pure technical inefficiency
Marport	0.941	Increasing	Pure technical inefficiency
Kumport	0.815	Increasing	Pure technical inefficiency
Gemport	0.445	Increasing	Scale inefficiency
Mardaş	0.827	Increasing	Pure technical inefficiency
Evyapport	0.250	Increasing	Scale inefficiency
Borusan	0.841	Increasing	Scale inefficiency
Constanta CSCT	0.991	Increasing	Pure technical inefficiency
Haifa	0.966	Increasing	Pure technical inefficiency
Thessaloniki	0.224	Increasing	Scale inefficiency
Piraeus	0.986	Increasing	Pure technical inefficiency
Novorossiysk	0.341	Increasing	Scale inefficiency
Damietta DCHC	0.909	Increasing	Pure technical inefficiency
Port Said SCCT	1.000	-	

National perspective

As seen in Table 12, of the 23 observations in Turkey, only one exhibit constant returns to scale, 22 exhibits increasing returns to scale, and none of the observations exhibit decreasing returns to scale. Marport is the only container terminal having constant return to scale in 2006, therefore operating in the most productive scale size. All the rest of the ports evaluated exhibit increasing returns to scale (smaller than their optimum size) in all the years of observation.

Gemport, Evyapport, Borusan container terminals have scale inefficiency in all years of observation, and the other terminals in Turkey exhibit pure technical inefficiency. It is logical therefore to see the scale inefficiency in these ports as all of them have relatively small throughput values. However, it is striking to note that these three container terminals have some common characteristics. First, all of them are private ports. Second, there are located in the southeast part of Marmara Sea with almost the same deviation distance from trunk route. Finally, as mentioned, their throughput values are relatively small than the rest of the terminals in Turkey.

5.6 Competitiveness Analysis

The analysis of port competitiveness has mainly concentrated on port selection criteria. Eight key determinants of port competitiveness are proposed by Tongzon and Heng (2005) based on the existing literature. These determinants include port (terminal) operation efficiency level, port cargo handling charges, reliability, port selection preferences of carriers and shippers, the depth of the navigation channel, adaptability to the changing market environment, landside accessibility, product differentiation. The authors found that operation efficiency is very important for port authorities and port operators to gain a competitive advantage, implying that partial port privatization is a quite effective way to help port authorities to win in the competition. They also noted that shipping lines do pay more attention to the port operation efficiency when selecting the port services.

Port accessibility and connectivity, port service (including efficient handling), and volume of cargo were found statistically significant component of port competitiveness by Yeo, Roe and Dinwoodie (2008).

In this study, the competitiveness of the container terminals will be briefly discussed at intra-port, intra-Marmara, and inter port levels. In this regard, port efficiency, proportion of transshipment activities, scale as an indicator for the size of the terminals, private sector participation, and nautical distance as an indicator for port accessibility are whenever they are applicable.

5.6.1 Intra-port level

It is largely by consensus believed that intra port competition leads to improved port performance and therefore, it should be encouraged (Cullinane, Ji and Wang 2005). This is partially true in Ambarlı port case in Turkey, which includes more than one container terminal. Ambarlı port includes 3 container terminals: Marport, Kumport and

Mardaş. Of these, Marport is the biggest container terminal in Turkey. The CCR efficiency, scale (throughput) and transshipment of these terminals are provided in Figure 26. Size of the bubbles indicates the throughput of the respective container terminals. At intra-port level, the comparison of nautical distance is not logical as all the container terminals have the same deviation distance.

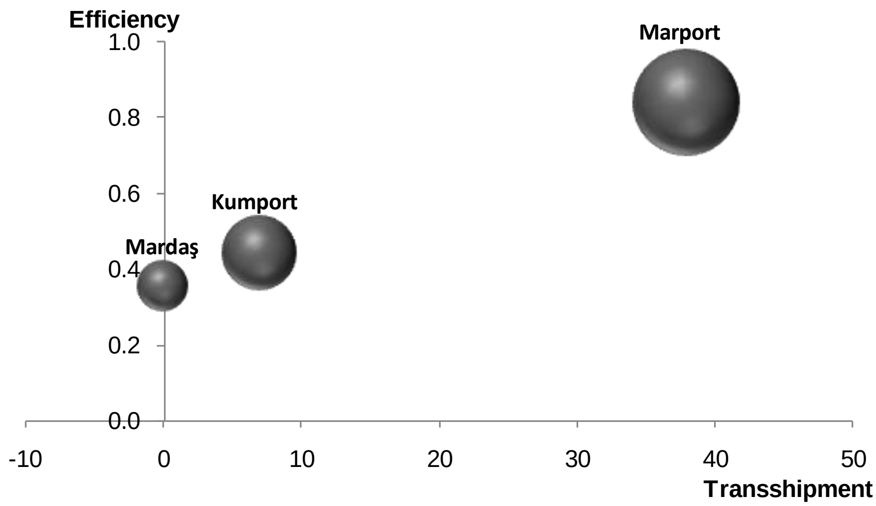

Figure 26: Intra port level analysis (Efficiency (CCR), Transshipment, and Scale)
Source: Own calculations.

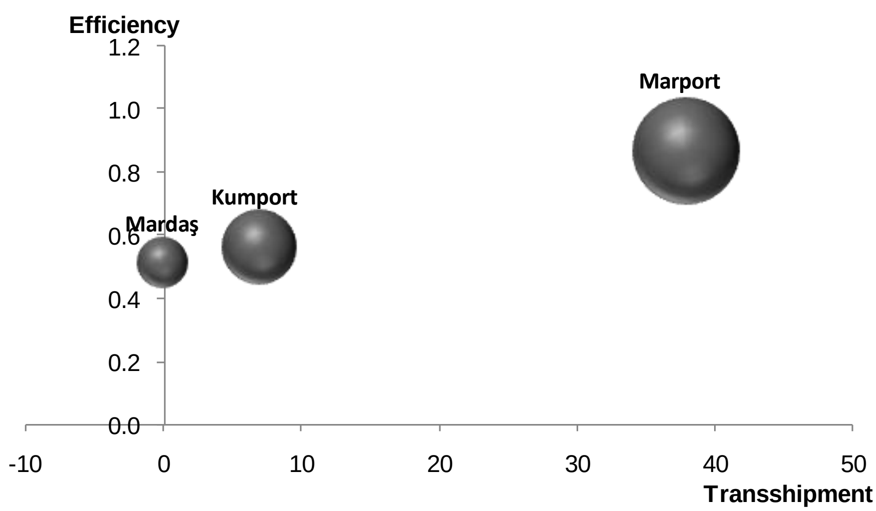

Figure 27: Intra port level analysis (Efficiency (BCC), Transshipment, and Scale)
Source: Own elaboration.

When the average efficiencies are concerned, two of these terminals (Marport and Kumport) have efficiency scores higher than the average of private container terminals in Turkey.

However, the competitive advantage of Marport terminal is seen in Ambarlı port in the combination of high efficiency, high transshipment and size (scale). Similar advantage is clearly observed when Kumport terminal is compared with Mardaş terminal, which has lower efficiency, lower transshipment, and smaller scale.

Similar picture is seen in Figure 27, where in this case BCC efficiency scores are compared. However, it should be noted that efficiency and scale are highly correlated, and scale is found to be one of the determinants of port efficiency. Therefore, though these two parameters are considered as components of port competitiveness, they should be expected to exhibit a similar pattern.

5.6.2 Intra- Marmara level

Similar arguments can be made for the analysis of the competitiveness of the ports in Marmara region. Apart from the terminals in Ambarlı port, the terminals in Izmit Gulf and Haydarpaşa terminal at the Bosphorus are placed in Marmara Sea. The CCR efficiency, scale (throughput) and transshipment of these terminals are provided in Figure 28. Size indicates the throughput (size) of the terminals, and white color indicates the publicly operated terminal (here only Haydarpaşa). The comparison of nautical distance here is similarly not logical as all the container terminals in the region have almost the same deviation distance.

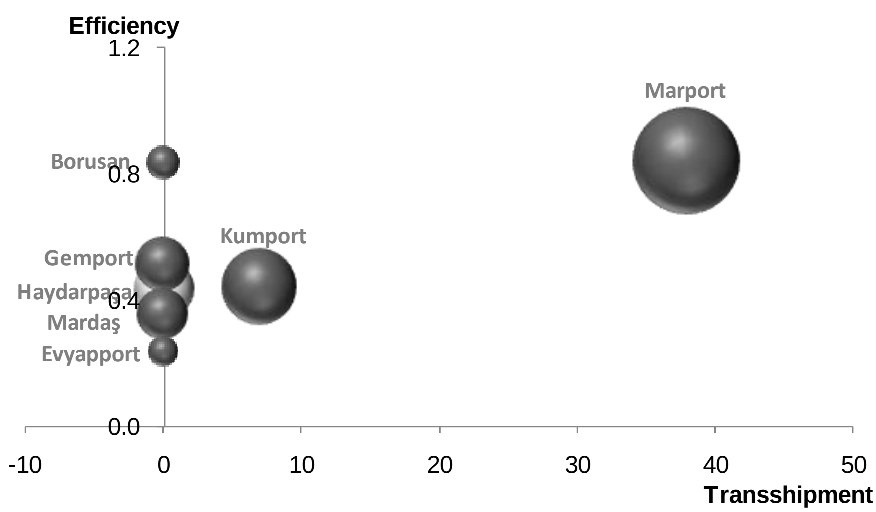

Figure 28: Intra Marmara level analysis (Efficiency (CCR), Transshipment, and Scale)
Source: Own elaboration.

When the average efficiencies are concerned, there is no clear cut conclusion that the competition in Marmara Sea leads to improved port performance. There are both highly efficient and inefficient terminals in Marmara Sea. Though Marport terminal is seen with high efficiency, it is not the only port with high efficiency in Marmara region. Though not very clear as in intra port level in Ambarlı port, scale effect exhibits a parallel relationship with efficiency. Similarly, the terminals with relatively high transshipment activities are associated with high efficiency and moderate size (throughput). From these comparisons, it is also not clear to say that publicly owned terminal Haydarpaşa has a competitive disadvantage in the region as at least 3 container terminals in the region are present with similar characteristics.

Similar results can be obtained if BCC efficiency scores are used instead of CCR efficiency scores.

5.6.3 Inter-port level

As far as the competitiveness at inter port level is concerned, the impact of transshipment and scale effect together with efficiency stick out to be the noticeable factors for success in the region. The CCR efficiency, scale (throughput), transshipment and deviation distance of the terminals are provided in Figure 29. Size of the bubbles indicates the throughput of the respective container terminals and the density of the color indicates the level of efficiency.

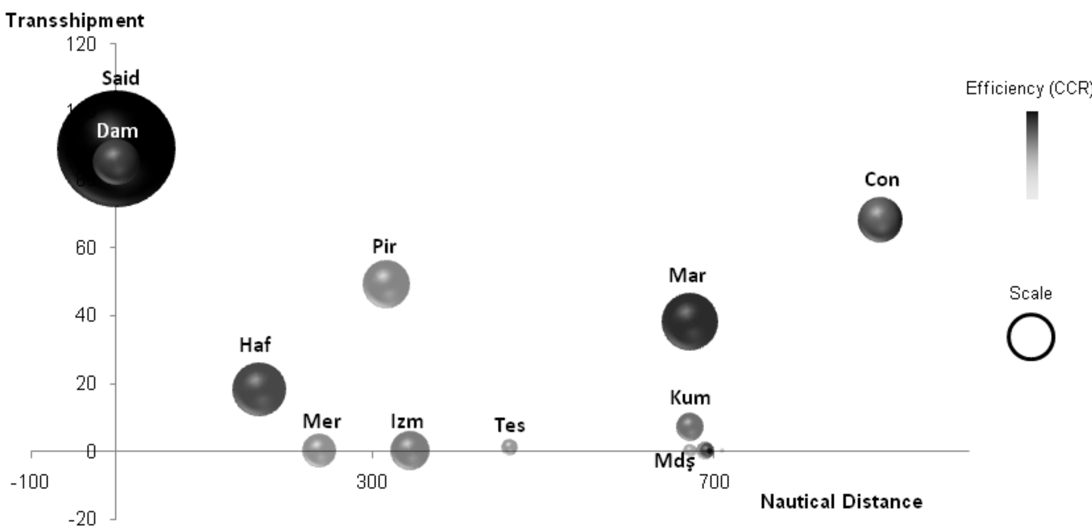

Figure 29: Inter port level analysis (Efficiency (CCR), Transshipment, Scale, and Deviation Distance)
Source: Own elaboration.

As seen on the graph, majority of the terminals with high transshipment activities (Port Said, Damietta, Marport, and Constanta) have also high efficiency level, but not vice versa. This indicates that transshipment contributes high efficiency but is not the only factor for high efficiency.

There is no relationship between deviation distance and efficiency as concluded before. The graph interestingly exhibit that those very close to the main route are associated with relatively higher CCR efficiency (Port Said, Damietta, Haifa) and at least a moderate throughput level. It is logical to have a relationship between throughput level and proximity to the main route since the port accessibility (together with others) is considered one of the important factors of port competitiveness.

The graph also indicates that Marport and Constanta are placed in close neighborhood and have similar characteristics and therefore the closest competitor of Marport in its close region is Constanta terminal, especially in terms of transshipment activities. The congestion in the Bosphorus strait incites this competition and may improve the position of Marport and other Marmara terminals in the distributional activities in Black Sea region.

Similar results can be obtained if BCC efficiency scores are used instead of CCR efficiency scores.

Chapter 6 Conclusions and Recommendations

6.1 Conclusions

The main objective of this paper is to investigate the possible impact of private sector involvement in container terminal operations on port (terminal) efficiency in Turkey. The analysis of efficiency of the container terminals has included the most important container terminals in Turkey and in the Eastern Mediterranean region, where economic and social similarities prevail due to the regional proximity. The efficiency evaluations have been performed applying a non-parametric approach called Data Envelopment Analysis (DEA), and the impact of the private sector involvement in container terminals has been assessed applying a Tobit regression model, with the inputs of DEA scores obtained in CCR DEA model, and some other possible factors which may influence the efficiency in port sector. Apart from private sector involvement, scale (throughput), hub or gateway function, nautical deviation distance from trunk route, and efficiency and effectiveness of customs and other border procedures at country level have been set as the possible factors influencing the technical efficiency scores in the Tobit regression model.

Though this study solely is not conclusive in any policy decisions, but simply adds some supportive and contrastive results to the current empirical researches pool, the obtained empirical results provide some valuable policy implications and guidance for public policy bodies, terminal operators and investors in Turkey, and in the East Mediterranean region.

First, as a result of CCR and BCC models, the sampled container terminals in the East Mediterranean region have produced on average 77 percent, and 27 percent less outputs (container throughput) than potentially possible level, respectively. This indicates that there exists a significant inefficiency in container terminal operations in the East Mediterranean region. In country specific results, average efficiency of Turkish container terminals has been found to be (0.495) and (0.749) as a result of CCR and BCC models respectively. In this regard, the container terminals in Turkey, either public or private, have relatively less efficiency than the average efficiency levels in the region. However, it should be borne in mind that the terminals not included in this study (especially those in other countries in the region) may influence either positively or negatively the efficiency estimates in the sample. After all, the average efficiency has been calculated simply based on the sample size, instead of the size of each container terminal.

Secondly, as a result of Tobit regression model constructed in order to investigate the causal relationship between efficiency (measured in CCR model) and the possible factors, the private sector involvement in container terminals has been found to be one of the statistically significant parameters. Therefore, there is sufficient evidence at least not to reject the hypothesis that private sector involvement in the operation of container terminals is associated with higher efficiency. Under the assumption of constant return to scale (CCR model), private terminals have been estimated to be almost 21 percent on average more efficient than public container terminals in the region. The efficiency estimates from BCC model have produced similar result, but the difference has been found to be not as big (5 percent) as that obtained in CCR model.

Similar to the results at regional level, under CCR model, private terminals have been found almost 22 percent more efficient on average than public container terminals in Turkey. The efficiency estimates from BCC model have produced a similar result. Based on BCC model, private terminals have been estimated to be almost 17 percent more efficient than public container terminals in Turkey. If the average efficiencies were calculated on the basis of weights or size of the terminals, the relative efficiency of private container terminals would be much higher both at national and regional level, as those terminals with the highest efficiencies are in general the biggest container terminals as well.

Comparing the average efficiency level in Turkey with the average in the East Mediterranean region, it has been found that both public and private container terminals have relatively less average efficiency. The private container terminals in the region have been found to be about 14 percent and 5 percent more efficient than those in Turkey according to CCR and BCC models respectively. For public container terminals, the difference is approximately 15 percent and 16 percent at CCR and BCC efficiencies respectively. From the efficiency results in this study, it seems that even though the competition level increased in the course of time in parallel to the entrance of the private sector ports to the market, at least some of these ports or terminals still lack the characteristics to keep pace with the ports in the region.

Thirdly, the scale effect (throughput values are regarded as a measure for scale) has also been found to be statistically significant. Therefore, there is sufficient evidence not to reject the hypothesis that terminal efficiency (measured in CCR model) is positively related with scale (throughput), implying that large-scale production tends to be associated with higher efficiency. The correlation coefficient of the efficiency scores against container throughput has been found to be (0.63) and (0.05) for CCR model and BCC model respectively. However, as seen in the trend of the marks in Figure 21, the observations with throughput over 1 million TEU have been found to be associated with high efficiencies without any exceptions.

Fourthly, contrary to the parameters associated with private sector involvement and scale, the parameters associated with the hub or gateway status of the terminals, the nautical deviation distance from East West route, and the efficiency and effectiveness of customs and other border procedures (CUS) have been found statistically insignificant. Considering the fact that none of the customs and border authorities show an outstanding performance in the region based on the LPI survey of the World Bank, the non existence of statistically any significant relationship between terminal efficiency and customs procedures is not surprising finding of this study. It has also been considered not surprising to find that there is no significant relationship between hub or gateway status of the terminals and efficiency levels. Even though a transshipment container is counted twice in annual container traffic volume of a terminal while occupying a single slot in the yard, this is not a big issue as in the majority of cases, the amount of work associated with the handling of a transshipment container within a terminal does in fact equate very closely to that associated with an import or export container (Wang and Cullinane 2006). It is interesting to see the lack of significant influence of the deviation distance on efficiency. The container terminals being far from the trunk route theoretically are expected to offer either much more efficient and fast service to the shipping lines so that the time lost during the journey to these terminals are compensated with the time saved in the efficient and relatively fast handling in the terminal, or cheaper service so that the total transport costs are minimized. The results indicate that the latter emerges to be a better explanation for the attractiveness of the distant ports.

Lastly, the terminals have been investigated in intra-port level (Ambarlı port), intra-Marmara level and inter-port level. In intra port level in Ambarlı port (Istanbul), it has been concluded that intra port competition at least partially leads to improved port performance as two out of three terminals in the port have higher efficiency level than the average efficiency level in private terminals in Turkey. In intra Marmara level, no clear cut conclusion has been reached that the competition in Marmara Sea leads to improved port performance as the region has both highly efficient and inefficient terminals. Though not clear, scale effect has been found to be in parallel relationship with efficiency. Similarly, the terminals with relatively high transshipment activities are found to be associated with high efficiency and moderate size (throughput). As far as the competitiveness at inter port level is concerned, the impact of transshipment and scale effect together with efficiency stick out to be the noticeable factors for success in the region.

6.2 Research Limitations

The results and the conclusions of the dissertation are advised to be considered in line with the limitations of the research. These limitations may be categorized into time constraint, the methodology, the data selection, and the reliability of the data, and the limited number of relevant researches, directing the study on the correct track.

Like in many researches, this study has been completed under specific time constraints. This limitation has been reflected therefore to the data set, sample size, the research approach and off course the subject of the thesis. The data set, and the container terminals have been selected considering the volume of work needed to collect, analyze and commit to paper environment within the limited time period set accordingly beforehand. The methodology has been selected considering the data set and the limited time to construct them into the models foreseen in the methodology. The time constraint has also affected the research subject and research approach. Nevertheless, the dissertation has not limited the scope of the study to find an empirical evidence to accept or reject only one research hypothesis, but also contribute to the existing literature on efficiency estimation by an attempt to find the other possible determinants of the port efficiency, along with private sector involvement.

The basic methodology of the dissertation is DEA, and this approach has also method specific limitations. First, DEA is a deterministic approach; therefore it takes no account of possible influences of measurement error and other noise in the data. Second, the scores obtained in DEA are not absolute efficiency values, but change depending on the data set. DEA measures the technical efficiency of the DMUs since the focus lies with assessing the extent to which physical resources and facilities. Therefore, it is quite possible that any container port in the sample may be estimated as being technically inefficient while simultaneously achieving allocative efficiency. Last but not the least is the question mark regarding the availability of the homogeneity requirement of DEA in the port sector if the sample includes third country ports. The strengths and the limitations of DEA methodology has been provided in Chapter 4, therefore, the reader is referred to this Chapter for further explanations.

Another drawback is the data requirements. As a rule of thumb, in order to obtain the best results, the number of units or organizations is advised to be at least twice the total number of input and output variables. Some studies advise that the sample size should be at least either the product of number of input and output variables or three times more than the sum of the number of input and output variables, whichever is bigger. The dissertation in this regard, fulfils these entire recommendations only with difficulty.

The reliability of data should also be borne in mind while making any inferences from the results of this study. Majority of the data have been collected from open sources. In cases where there are some differences in the data presented in different sources, the bigger ones are selected with an assumption that those bigger in general reflect more up-to-date situation. Therefore, any inference should be made with some caution in this respect.

Last but not least, there is hardly any research especially in Turkey regarding the econometric estimation of port efficiency, assisting to direct the study on the correct track. Therefore, the hypotheses of the dissertation are mainly based on non empirical evaluations of the port sector in Turkey, and the need for confirmation of the results in order to support the hypotheses have been felt strongly throughout the research.

6.3 Recommendations for Further Research

The dissertation makes some recommendations for further research, some of which have not been made due to time constraint, and some of which have arisen during the research.

The ports in the Mediterranean region are growing faster than those in West Europe, and therefore, attract more and more the attention of public and private actor. The field of efficiency estimation covering the Mediterranean region has not been investigated thoroughly, and therefore opens to further research to find out the efficiency level of the ports in this region. In addition, due to the similarities in terms of economic and social structure and the location on the East-West route, it is also worth further research to evaluate the efficiencies of the ports in the Middle East. It is recommended to make a research including all major ports in the East Mediterranean, Black Sea, and the Middle East.

This dissertation focuses only on the container terminals and excludes the other activities insofar as it’s possible. The other port activities or terminals (bulk, liquid, or even passenger etc) deserves further research considering that there is almost no research done taking into account only the bulk or liquid terminals. There is a clear lack of research interest in other port services as well.

The methodology of this study is DEA and it is strongly advised to apply other efficiency methods, especially SFA. This would enable to compare the results of different methodologies, though in many studies, high correlation has been proved. It is also recommended to extent the time period if possible in order to make a window analysis of DEA so that the evolution of efficiency in time is much better investigated.

The labor factor is an important input for efficiency evaluation; however it has not been included in this research, instead, the yard and quay equipment have been assumed to reflect the volume of labor activity in the container terminals. It is therefore recommended that if accessible to labor data, it should be included as input variable in order to integrate the labor factor as much as possible to DEA models.

Last but not least, DEA measures the technical efficiency of the terminals in this study. It is quite possible that any container port in the sample may be estimated as being technically inefficient while simultaneously achieving allocative efficiency. Therefore, if the cost of infrastructure is included, it would be possible to compare the ports or terminals not only technically, but also in terms of allocative efficiency.

Bibliography

Al-Eraqi, A. S., Mustafa, A., Khader, A. T., Barros, C. P. (2008). 'Efficiency of Middle Eastern and East African Seaports: Application of DEA Using Window Analysis'. *European Journal of Scientific Research*, vol.23, No 4, pp 597-612.

Baird, A. (1997). 'Port privatization: An analytical framework'. *Proceedings of IAME Conference*, London, 22–24 September 1997.

Baird, A. (1999). 'Privatization Defined; Is it the Universal Panacea?'. *Napier University*, 27 June 1999.

Baird, A. (2000). 'Port privatization: Objectives, extent, process, and the UK experience'. *International Journal of Maritime Economics*, vol.2, No 3, pp 177-194.

Baird, A. (2002). 'Privatization trends at the world's top 100 container ports'. *Maritime Policy and Management*, vol.29, No 3, pp 271-284.

Baird, A. J. (1995). 'Privatization of trust ports in the United Kingdom: Review and analysis of the first sales'. *Transport Policy*, vol.2, No 2, pp 135-143.

Barros, C. P. (2003*a*). 'Incentive regulation and efficiency of Portuguese port authorities'. *Maritime Economics and Logistics*, vol.5, No 1, pp 55-69.

Barros, C. P. (2003*b*). 'The measurement of efficiency of Portuguese seaport authorities with DEA'. *International Journal of Transport Economics*, vol.30, No 3, pp 335-354.

Barros, C. P., Athanassiou, M. (2004). 'Efficiency in European seaports with DEA: evidence from Greece and Portugal'. *Maritime Economics and Logistics*, vol.6, No 2, pp 122-140.

Barros, C. P., Managi, S. (2008). '*Productivity Drivers in Japanese Seaports*'. Working Paper 2008/15, Department of Economics at the School of Economics and Management (ISEG), Technical University of Lisbon.

Blonigen, B. A., Wilson, W. W. (2006). 'New Measures of Port Efficiency Using International Trade Data'. *National Bureau of Economic Research Working Paper Series*, No 12052.

Bonilla, M., Casasus, T., Medal, A., and Sala, R. (2002). 'The traffic in Spanish ports: An efficiency analysis with tolerances'. *Proceedings of IAME Panama 2002 Conference*, 12-15 November 2002.

Brooks, M. R., Cullinane, K. (2007). 'Chapter 18: Governance Models Defined', Devolution, Port Governance and Port Performance, *Research in Transportation Economics*, vol.17, pp 405-435.

Cochrane, R. A. (2008). 'The Effects of Market Differences on the Throughput of Large Container Terminals with Similar Levels of Efficiency'. *Maritime Economics & Logistics*, vol.10, No 1, pp 35-52.

Cooper, W. W., Seiford, L. M. Tone, K. (2000). *Data Envelopment Analysis: A Comprehensive Text with Models, Applications, References and DEA-Solver Software*, Boston: Kluwer Academic.

Cooper W. W., Seiford, L. M., Tone, K. (2006). *Introduction to Data Envelopment Analysis and Its Uses*. New York: Springer.

Cooper, W. W., Seiford, L. M., Zhu, J. (2004). *Data envelopment analysis: History, Models and Interpretations*, Handbook on Data Envelopment Analysis, Boston: Kluwer Academic Publishers.

Coto-Millan, P., Banos-Pino, J. Rodriguez-Alvarez, A. (2000). 'Economic efficiency in Spanish ports: some empirical evidence'. *Maritime Policy and Management*, vol.27, pp 169-174.

Cullinane, K. P. B., Khanna, M. (1999). 'Economies of scale in large container ships'. *Journal of Transport Economics and Policy*. Vol.33, No 2, pp 185-208.

Cullinane, K. P. B., Song, D. W., Gray, R. (2002). 'A stochastic frontier model of the efficiency of major container terminals in Asia: assessing the influence of administrative and ownership structures'. *Transportation Research Part A*, vol.36, pp 743-762.

Cullinane, K. P. B., Ji, P., Wang, T.-F. (2005). 'The relationship between privatization and DEA estimates of efficiency in the container port industry'. *Journal of Economics and Business*, vol.57, No 5, pp 433-462.

Cullinane, K. P. B., Song, D. W. (2003). 'A stochastic frontier model of the productive efficiency of Korean container terminals'. *Applied Economics*, vol.35, pp 251-267.

Cullinane, K. P. B., Song, D.-W. Wang, T. (2005). 'The application of mathematical programming approaches to estimating container port production efficiency'. *Journal of Productivity Analysis*, vol.24, pp 73-92.

Cullinane, K. P. B., Song, D.-W., Ji, P., Wang, T.-F. (2004). 'An application of DEA windows analysis to container port production efficiency'. *Review of Network Economics*, vol.3, No 2, pp 186-208.

Cullinane, K. P. B., Wang, T.-F. (2006). 'The efficiency of European container ports: A cross-sectional data envelopment analysis'. *International Journal of Logistics: Research and Applications*, vol.9, No 1, pp 19-31.

Cullinane, K. P. B., Wang, T.-F., Song, D.-W., Ji, P. (2006). 'The technical efficiency of container ports: Comparing data envelopment analysis and stochastic frontier analysis'. *Transportation Research Part A*, vol.40, pp 354-374.

Cullinane, K., Song, D.-K., (2002). ‘Port privatization policy and practice’. *Transport Reviews*, vol.22, No 1, pp 55-75.

Cullinane, K., Song, D-W. (2006). ‘Estimating the Relative Efficiency of European Container Ports: A Stochastic Frontier Analysis’, in Cullinane, K. and Wayne, T. (eds.), *Port Economics*, Research in Transportation Economics Series, No. 16, Elsevier Science, London, pp 85-115.

Cullinane, K., Wang, T.-F. (2007). ‘Chapter 23: Data Envelopment Analysis (DEA) and Improving Container Port Efficiency’. Devolution, Port Governance and Port Performance, *Research in Transportation Economics*, vol.17, No 1, pp 517-566.

Emrouznejad, A., Parker, B. R., Tavares, G. (2008). ‘Evaluation of research in efficiency and productivity: A survey and analysis of the first 30 years of scholarly literature in DEA’. *Socio-Economic Planning Sciences,* vol.42, pp 151-157.

Estache, A., Gonzales, M., Trujillo, L. (2002). ‘Efficiency Gains from Port Reform and the Potential for Yardstick Competition: Lessons from Mexico’. *World Development*, vol.30, No 4, pp 545-560.

Gonzales, M. M., Trujillo, L. (2005). ‘Reforms and Infrastructure Efficiency in Spain’s Container Ports’. *World Bank Policy Research Working Paper*, No 3515.

Goss, R. O. (1990). ‘Economic policies and seaports. Part 2. The economic functions of seaports’. *Maritime Policy and Management*, vol.17, No 3, pp 207-219.

Haralambides, H. E. (1997). ‘Ports and Regional Development in Europe: A historical Perspective’. Report submitted to the European Commission in the context of its preparation of the ‘Green Paper on Ports and Maritime Infrastructure’.

Haralambides, H. E., Ma, S., Veenstra, A.W. (1997). ‘Worldwide Experiences of Port Reform’. In: H. Meersman and E. v.d. Voorde (eds.), *Transforming the Port and Transportation Business*. Acco Publishing, Leuven, 1997.

Haralambides, H. E. (2002). ‘Competition, Excess Capacity, and the Pricing of Port Infrastructure’. *International Journal of Maritime Economics*, vol.4, pp 323-347.

Herrera, S., Pang, G. (2008). ‘Efficiency of Infrastructure: The Case of Container Ports’, *Revista EconomiA,* vol.9, No 1, pp 165-194.

Itoh, H. (2002). ‘Efficiency changes at major container ports in Japan: A window application of data envelopment analysis’. *Review of Urban and Regional Development Studies*, vol.14, No 2, pp 133-152.

Juhel, M. H. (2001). ‘Globalization, privatization and restructuring of ports’. *International Journal of Maritime Economics*, vol.3, No 2, pp 139-174.

Lin, L. C. Tseng, C. C. (2007). ‘Operational performance evaluation of major container ports in the Asia-Pacific region'. *Maritime Policy and Management*, vol.34, No 6, pp 535-551.

Liu, Z. (1995). 'The comparative performance of public and private enterprises: the case of British ports'. *Journal of Transport Economics and Policy*, vol.29, pp 263-274.

Londono-Kent, P., Kent, P. E. (2003). 'A tale of two ports: The cost of inefficiency'. *World Bank Research Report*, No 30140.

Martin, J. C., Roman, C. (2001). 'An application of DEA to measure the efficiency of Spanish airports prior to privatization'. *Journal of Air Transport Management*, vol.7, pp 149-157.

Martinez-Budria, E., Diaz-Armas, R., Navarro-Ibanez, M. Ravelo-Mesa, T. (1999). 'A study of the efficiency of Spanish port authorities using data envelopment analysis'. *International Journal of Transport Economics*, vol.26, pp 237-253.

Notteboom, T., Coeck, C. van den Broeck, J. (2000). 'Measuring and explaining the relative efficiency of container terminals by means of Bayesian stochastic frontier models'. *International Journal Maritime Economics*, vol.2, pp 83-106.

Oral, E. Z., Kisi, H., Cerit, A. G., Tuna, O., Esmer, S. (2007). 'Chapter 8 Port Governance in Turkey', Devolution, Port Governance and Port Performance, *Research in Transportation Economics*, vol.17, pp 171-184.

Oral, M., Yolalan, R. (1999). 'An empirical study on measuring operating efficiency and profitability of bank branches'. *European Journal of Operational Research*, vol. 46, pp 282-294.

Park, R. K., De, P. (2004). 'An alternative approach to efficiency measurement of seaports'. *Maritime Economics and Logistics*, vol.6, No 1, pp 53-69.

Poitras, G., Tongzon, J., Li, H. (1996). 'Measuring Port Efficiency: An Application of Data Envelopment Analysis'. *National University of Singapore*, 15 October 1996.

Roll, Y., Hayuth, Y. (1993). 'Port performance comparison applying data envelopment analysis (DEA)'. *Maritime Policy and Management*, vol.20, pp 153-161.

Sanchez, R. J., Hoffmann, J., Micco, A., Pizzolitto, G. V., Sgut, M., Wilmsmeier, G. (2003). 'Port Efficiency and International Trade: Port Efficiency as a Determinant of Maritime Transport Costs'. *Maritime Economics & Logistics*, vol.5, No 2, pp 199-218.

Soteriou, A. C., Karahanna, E., Papanastasiou, C., Diakourakis, M. S. (1998). 'Using DEA to evaluate the efficiency of secondary schools: the case of Cyprus'. *International Journal of Educational* Management, vol.12, No 2, pp 65-73.

Tongzon J. (1995). 'Determinants of port performance and efficiency'. *Transportation Research*, vol.29A, pp 245-252.

Tongzon, J. (2001). 'Efficiency measurement of selected Australian and other international ports using data envelopment analysis'. *Transportation Research*. Part A, vol.35, pp 113-128.

Tongzon, J., Heng, W. (2005). 'Port privatization, efficiency and competitiveness: Some empirical evidence from container ports (terminals)'. *Transportation Research Part A*, vol.39, pp 405-424.

Trujillo, L, Tovar, B. (2007). 'The European Port Industry: An Analysis of its Economic Efficiency'. *Maritime Economics & Logistics*, vol.9, No 2, pp 148-171.

Turner, H., Windle, R., Dresner, M. (2004). 'North American container port productivity: 1984-1997'. *Transportation Research Part E*, vol.40, pp 339-356.

UNCTAD (United Nations Conference on Trade and Development) (1992). *Development and Improvement of Ports: The Principles of Modern Port Management and Organisation*. UNCTAD, Geneva.

UNCTAD (United Nations Conference on Trade and Development) (1987). *Measuring and evaluating port performance and productivity*. UNCTAD Monographs on Port Management No 6, UNCTAD, Geneva.

Wang, T.-F. Cullinane, K. P. B. (2006). 'The Efficiency of European Container Terminals and Implications for Supply Chain Management'. Maritime Economics & Logistics, vol.8, No 1, pp 82-99.

Wilson, J. S., Mann, C. L., Otsuki, T. (2003). 'Trade Facilitation and Economic Development: Measuring the Impact'. *World Bank Policy Research Working Paper*, No 2988.

World Bank. (2003). *World Bank Port Reform Toolkit (Module 3*). May 2003. Available at World Bank web site: http://www.worldbank.org/transport/ports/toolkit/)

Ximena, C., Dollar, D., Micco, A. (2001). 'Maritime Transport Costs and Port Efficiency'. *World Bank Policy Research Working Paper*, No 2781.