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A meta-analysis on the effect of PPP on container port efficiency

Henriette Iden Hellesen

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Preface and acknowledgement

This Master thesis presents the main results of my academic work as a master student at Molde University College. The main part of the research work was carried out from January 2016 to May 2016 and has been conducted to obtain an MSc degree in Logistics.

I would like to express my deepest gratitude to my supervisor Associate Professor Johan Holmgren for supervising me, giving me his professional help, for his patient guidance and encouragement during the process of writing this thesis.

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Summary

During the last decades the world has seen a steady growth of seaborne trade and as a result the container port industry has experienced increased competition between ports, which has led to port authorities seen the importance of port efficiency. The most discussed and debated topic in regards to improving port efficiency has been on port ownership structure, with an emphasis on public private partnership.

This thesis is studying the effect on Public Private partnership (PPP) on container port efficiency. This research is using a meta-analysis with efficiency scores from 28 different container ports around the world from 16 different individual studies. Other variable is also taken into consideration as they can impact the efficiency scores. These variables include two of the most common approaches to measure efficiencies in ports the non-parametric Data envelopment analysis (DEA) and parametric approach, stochastic frontier analysis (SFA). Geographical location, the use of panel data vs cross-sectional data and the time of when the study was conducted were also been included in the analysis.

The findings from this study matches the vast majority of research within this field. The results indicate that ports that are operating under PPP have greater efficiency than port who do operate under PPP. The results revealed that studies that have used DEA approach to measure port efficiency, tend to have higher efficiency scores than studies using SFA approach.. The results of the study also show that studies that have used panel data produce higher efficiency scores than those who are using cross sectional data.

Content

List of abbreviations

BCC	Banker, Chames and Cooper
BOT	Build, operate and transport
CRR	Chames, Cooper and Rhodes
DEA	Data envelopment analysis
DMU	Decision making unit
GPD	Gross domestic product
MTE	Mean technical efficiency
PPP	Public-private partnership
STS	Ship-to-shore
SPSS	Statistical Package for the Social Sciences
SFA	Stochastic frontier approach
TE	Technical efficiency
TEU	Twenty-foot equivalent unit
UNSTAD	United Nations conference on trade and development

1 Introduction

Ports are significant for international trade; ports are providing a linkage from international to regional or local transport systems and trade chains. In recent years, the world has experienced a major growth in global trade, which has led to importance of having efficient ports. Due to seaports being so critical for trade and the supply chain, both authorities and managers have taking interest in improving port efficiency (UNCTAD 2012).

One unique characteristics of container port industry is that competition between container ports are becoming more intensive than we previously have seen. Ports used to be seen as monopolistic because of their geographical location of the ports being exclusive and immovable. However, there has been a tremendous improvement of international container and intermodal transportation, which has created a change in the market from a monopoly structure to a more competitive structure in many parts of the world. Many container ports no longer enjoy the freedom yielded by a monopoly over the handling of cargoes from their hinterland. Instead they have to compete for cargo with their neighboring ports It is this distinctive feature competition that characterized this industry and that has led to an interest in efficiency with which it utilizes its resources. The world seaborne has continued to grow over the last decades. The average annual growth rate for the last 30 years was about 4%. Studies indicate that annual growth rates would probably be even higher for the next twenty years. Therefore, there will be a substantial increase of international shipping (UNCTAD 2012).

Public–private partnerships (PPPs) are considered by many scholars to be an important mechanism for port development and improvement in port efficiency especially for developing countries. PPP is defined as co-operation between public and private actors, where actors develop mutual products and/or services and in which risk, costs, and benefits are shared and mutual added value is created. In general, there is an increase in the trend of private sector involvement in form of privatization, deregulation, outsourcing and downsizing of government. (Panayidesa, Parolab and Lamc 2015).

At the same time as there has been a growing foreign trade and improving the existing infrastructure facilities, the public private partnership (PPP) model has become the preferred way of founding infrastructure. Internationally there is a trend of financing public works via PPPs (J. Tongzon 2005).

As PPP has become increasingly popular form of ownership it is a topic that is worth studying. It is worth studying to see if it actually has an effect on a port efficiency. There exist several empirical studies on port efficiency, mostly within a geographical area, but also a few worldwide, however these are only from an individual study. Studies that are looking at port efficiency and ownership structure is very limited, only a few published studies have investigated the effect of public-private partnership on a port efficiency and are mostly performed within a country or a region.

What this study is trying to accomplish is to gather efficiency scores from different ports, from a widely spread geographical area, from different studies and with different studies approaches using a meta-analysis. The study will seek to give indications to whether or not PPP has an effect on port efficiency all around the world based on several different studies. This study implements both major ports that have been studied a lot but also includes other ports in developing countries that has been studied less. The results from this research will hopefully be to benefit for both government, port authorities and the private sector. As the study will give an overall idea of what effect PPP has on a port efficiency and whether or not this type of ownership structure is worth investing in.

1.1 Aim

This study is concerned with an evaluation of port efficiency to see if PPP contributes to efficiency in container ports based on already published studies. As well as looking at how the two different approaches to study efficiency DEA and SFA effects the results. The data is again separated into continent to see if that may have an impact on the efficiency. As well as looking if there are any differences in when the studies were conducted or if the data was collected from one time period or over time (cross sectional vs panel data).

This paper is focus on container ports in order to simplify such diverse and complicated research. The majority of studies on port efficiency are studying technical efficiency in container ports. This study will be accomplished by means of (1) conducting a systematic review of the literature, which includes published studies (2) Conducting a meta-analysis of studies, using other factors as control factors to how PPP effect port efficiency (3)

disseminating and critically examining the results of the meta-analysis; and (4) making successive research and practice recommendations for the future.

As there is limited researched published and available data most of what is found to be appropriate for the analysis will be used for the meta-analysis, aiming for a broad worldwide perspective, including ports from all continents with different types of ownership structure and the two different measurement of efficiency used (SFA and DEA).

This study seeks to address the following research question:

- If engaging in PPP in container ports lead to a more efficient port?

With the following research sub question:

- Which of the two frontier methodologies (DEA and SFA) used in the studies lead to higher efficiency scores?

2.0 Literature review

2.1 Container ports and terminals

Container ports and terminals are forming an essential component of today's economy. A container terminal is a facility where cargo containers are transshipped between different transport vehicles, for onward transportation. Since the beginning of the containerization in the middle of the 20th century transports costs has dramatically decreased. Before there was containers, transport of goods was so expensive that few items were shipped halfway across the country, much less halfway around the world. Modern container shipping has been around for over 50 years. It introduced a system, based on a theory of improved efficiency when the same container, with the same cargo, can be transported with minimum interruption via different transport modes from one place to another (World shipping concil 2016).

The importance of maritime transportation weight about 96% of the world's trade which is carried out by sea, according to Rodrique et al (2006). Eighty present of seaborne cargo is moved in containers (Ramani 1996) which confirms the importance of ocean trade by containers. Efficiency in container ports is therefore highly needed and extremely important. Some of the busiest seaports in the world include the Port of Shanghai in China, Port of Singapore, Port of Hong Kong, Port of Rotterdam (Netherlands), Port of Kobe in Japan, and the United Kingdom's Port of Dover (Q. Liu 2010)

2.1.1 Port development

Before the time of containerization inter-port competition was regarded as a minor issue than what we are facing today. Inter-port competition is competition between or among ports. The best indicator to know whether container ports are competing with each other is to see if they are serving the same, or an overlap of hinterlands. Ports used to be considered as either monopolistic or oligopolistic because of the exclusive and immovable geographical location of ports and the unavoidable concentration of cargo traffic that this generated. International container ports and intermodal transportations quick development has changed the situation. Many ports are no longer able to take advantage of the freedom that monopoly or oligopoly can bring in regards to handling of cargo from within the hinterland. Numerus ports no longer only worry if they have the capacity or technology to

handle the cargo, but now they are also dealing with competing for cargo based on price and quality offered. One of the major discussions that has been brought up in this industry has been the relationship between inter-port competition and port performance/efficiency. Those who supports competition attest that it will encourage innovation and increase the staff sense of responsibility, free a port from the constrains of bureaucracy which will eventually promote higher efficiency (Cullinane, Teng-fei, et al. 2005).

Heaver (1995) argues that the industry is moving gradually towards a more competitive market structure brought about decentralization and that the policies to encourage this structure is gradually being accepted by an increased number of governments around the world. However, there are also governments and economist that sees the advantage of a monopolistic market in the port industry, brought about by policy of centralization (Heaver 1995). Some scholars such as Turnbull and Westin (1993) have suggested that these policy changes may not be sufficient, aiming at the policy changes in the UK. They argue that the changes have not resolved the industries more persistent, underlying problems such as over-capacity, the duplication of the investment and the zero sum or redistributive nature of competition. Another disadvantage of interport competition is that it can cause a port to accept a higher risk in order to maintain competitive. In order to compete in the heavily competitive market a port is depended on investing strongly in the best and newest of equipment and technology to accommodate the more advanced container ports. When shipping companies have the choice of more than one port to handle their cargo, ports can end up losing important costumers to competitors (Cullinane, Teng-fei, et al. 2005).

2.2 Port ownership structure

Ports can be classified as to their type of ownership or administration, which has been one of the main debated issues when it comes to port efficiency.
There are basically three types of port ownership according to Cass (1996) public, private and or joint public/private.

2.2.1 Port ownership model

According to the Port Reform Tool Kit of the World Bank1, four main categories of ports have emerged over time, and they can be classified into four main models: the public

service port, the tool port, the landlord port, and the fully privatized port or private service port (Gaur 2005).

Figure 2.1: Port management model

Port Management Models

Port Type	Infrastructure	Super structure	Stevedoring labour	Other functions
Service port (Major Indian Ports	Public	Public	Public	Mainly public
Tool port (France,some African nations)	Public	Public	Private	Mainly public
Landlord port (Antwerp,Rotterdam,Singapore etc	Public	Private	Private	Mainly private
Private port (UK,New Zealand)	Private	Private	Private	Mainly private

Source: (Worldbank 2013)

Service Ports

Service ports are public in their character. There has been a trend of number of service ports to decline. Many of ports that used to be service ports are working towards becoming landlord port structure. To mention a few, we have Colombo (Sri Lanka) and Nhava Sheva (India). However, there still exists ports in developing countries that manage according to this model. In these ports, the port authority offers the complete range of services required for the functioning of the seaport system. The port operates every possible asset, maintenance, and does cargo-handling activities, which are executed by labor employed directly by the port authority. However, in some developing countries ports cargo handling

is done by separate public entity, which is often called a cargo handling company (Alderton 2008).

Tool Ports

In a tool port the port authority own develops, and maintains the port infrastructure as well as the superstructure, including cargo handling equipment such as quay cranes and forklift trucks. All equipment is owned by the port authority. However, other cargo handling onboard vessel as handling on board vessels as well as on the apron and on the quay is usually carried out by private cargo handling firms. Chittagong in Bangladesh is a typical example of a tool port. The problem in this model is conflicting of interests of the port authority and cargo-handling companies who do not own fixed assets. The division of tasks within the tool port system clearly identifies the essential problem with this type of port management model: split operational responsibilities. However, the tool port does have its advantages, especially when thinking about transitioning to a landlord port. Using the tool port model as a way to start transition can be a great option in cases where the confidence of the private sector is not fully established and the risks of investments are considered high (Alderton 2008).

Landlord Ports

One of most growing forms of port ownership is landlord ports. This model is the one that is known as Public Private Partnership. The port authorities lease the infrastructure to the port operating companies or industries. There is a fixed amount of money that has to be paid for the lease based on time and area to port authority. A maintenance of its own superstructure is maintained with private port operating companies, including all equipment that is need to operate the port. Labor is also done by private terminal operators. Many western ports operate under this model, such as Rotterdam, Antwerp and New York. Today most of the medium and large size ports are operated under this model (Alderton 2008).

Fully Privatized Ports

This type of model is less common, the most known example is in the UK and New Zealand. This type of model suggests that the state no longer take part in port sector and is therefore by many other countries considered a bit extreme. In this type of model port land is privately owned. They are operated on the commercial basis where the goal is to

maximize profits. Government only acts as monitoring agency to control the interests of public welfare in this model. Since they are self-regulating there is high risk of converting the land use of port area to non-port activities. UK decided to move to full privatization to modernize institution and installations, to achieve financial stability and to achieve labor stability and a degree of rationalization (Alderton 2008).

Table 2.2 Ownership structure of major world container ports (1991-2004)

Ownership structure of major world container ports, 1991–2004[a].

Ownership categories[b]	1991		2004[c]	
	No.	%	No.	%
Public Operating Port	59	**61**	25	26
Mixed Ownership Port	14	14	18	19
Public Landlord Port	22	23	47	**48**
Non-government port	2	2	7	7
Total	97	100	97	100

Source: (Cheon, dowall and Song 2010)

Table 2.2 Illustrates a notable trend; the increasing level of transfer of world ports' ownership from public to private. As it shows a majority of world major ports were under full public ownership in 1991 (61%) and in 2004 only 26% of these ports were public. All the other ownership has seen an increase, with landlord model having the highest increase from 23% in 1991 to 48% in 2004.

2.3 Public private partnerships (PPP)

2.3.1 Definition

Public private partnerships can be defined as "an arrangement of roles and relationships in which two or more public and private entities coordinate/combine complementary resources to achieve their separate objectives through joint pursuit of one or more common objectives" (Williams 2003). PPPs have seen a tremendous growth and become more and more popular. One of the major reasons for this popularity is because they have the capability to be innovative and get capital from private investors. There exists no single definition on PPP. According to Grimsey and Lewis it can be said that PPP fills a gap between traditionally procured government project and full privatization. PPP can be used to peruse a variety of activities, some studies show evidence that they are most commonly used by government for infrastructure projects (Grimsey and Lewis 1999). When talking

about ports the PPPs are long-term agreements between a public entity and private partners. Studies shows that developing countries are aggressively inviting private participation for infrastructure projects. We also see the trend of PPP in developed countries such as US, UK, EU, Canada, Japan and South Korea. According to François-Marc Turpin the objectives of PPP in ports are to Improve efficiency (higher productivity / lower costs) and introduce innovation in port operation services. He also argues that private sector methods more « market oriented » and competition between private port operator's favors efficiency and innovation (Turpin 2013).

2.3.2 Potential Benefits of Public Private Partnerships

The financial crisis in 2008 led to increased interest for PPP in both developing and developed countries, and governance and management started seeing benefits of implementing PPP. As there were constraints on public resources it led to people seeing the importance of investment in infrastructure to help their economies growth. This way of investment has become an additional source of funding to meet the gap. Governments generally seek to private investment for the following reasons:

- As a way to introduce the private sectors expertize on technology and innovation, in the hope of providing more efficiency operations.
- Motivate the private sector to deliver project on time and within budget
- Implementing budgetary certainty, by putting the costs of projects over time
- Making the country/port more competitive
- Making the country more competitive in terms of its facilitating infrastructure as well giving a boost in regards to infrastructure development such as construction, equipment and support services.
- They can enhance the supply of much needed infrastructure services
- They may not require any immediate cash spending.
- Where there is limited public sector capacity to meet the growing demand for infrastructure PPP can supplement (World bank 2015).

2.3.3 Allocating Risk in PPP agreements

PPPs make it possible for risks to be distributed more efficiently than, if the infrastructure were developed and operated solely by the private or the public sector. According to best principle of risk management, risk should be allocated to that party that is best capable to manage and observe them.

It argues that the party best capable of managing the risks also bears it costs, it faces a strong incentive to do all it can to manage or reduce the impact of the risk, that is as long as the expected profit (gain) from doing so is higher than the cost of reducing the risk. In order for these arrangements to work and be effective the part to which a risk is allocated should also have control over decisions related to the risk factor. For instance, the party that takes on the construction-related risks should then also be able to select the construction materials and techniques that should be implemented.

The benefit with allocating risk like this is that typically some risks the government will be best at handling and controlling, whereas some can be handled and controlled better by the private sector. For instance, the government is also best able to control land acquisitions, so typically guarantees the availability of suitable sites, which is the case of many of the world ports using the "landlord model" as previously discussed. The private sector on the other side is best-placed to manage construction, commercial and operating risks (PPIAF 2012).

These are risks that the private sponsor can pass on to sub-contractors for instance, a construction company's. Their contract then usually contains a penalty clauses for late completion that compensate the sponsor for the delay in revenues. However some risks cannot be controlled by neither the public or the private such as land or soil quality, or force majeure risks. These risks may accept by the private party and insured against, where possible. Otherwise, the parties may simply share and absorb such risks (PPIAF 2012). The public sector can also be seen as a kind of insurance since it can spread the risk over the entire population.

2.3.4 Critisme and potential risks with Public Private Partnership.

Although lots of what is being published about PPP refers to the benefits of implementing it, PPP also have critics as well as potential risk, many of which include costs.

Government should determine whether the greater cost involved are justified, as PPP cost of developing, bidding and ongoing costs are likely to be greater than for traditional government procurement processes. There is a cost along with debt. The private sector can make it easier to get finance, finance will only be available where the operating cash flows of the project company are expected to provide a return on investment (i.e., the cost has to be borne either by the customers or the government through subsidies, etc.)

Project with PPP may be socially or politically challenging to implement. Especially if there is an existing public sector workforce, that this will shift them to a more private sector workforce, as well as if there are significant tariff increases that are required or if there are significant land or resettlement issues, etc.

Although PPP allows for risks to be allocated more efficiently private firms (and their lenders) will be cautious about accepting major risks beyond their control, such as exchange rate risks/risk of existing assets. If, however they do take on these risks the price for their service will most likely reflect that. It is also expected that the private sector will expect more control over operations when accepting these risks. When combing these two sectors for one project it is important to ensure that there are clean and detailed reporting requirements imposed in order to reduce potential imbalance as it often will lead to one party having an advantage in the data relating to project. A clear legal and regulatory framework is important to achieve a sustainable solution.

As PPP projects tends to be long term, it is difficult to identify all potential occurrences during the project development, problems may occur where it was not expected in the documents at the time of the contract. It is very likely that the two parties will need to make a new contract. Some project may also experience failure or may be terminated before the project even begins due to changes in government policy, failure by the private operator or the government to perform their obligations or indeed due to external circumstances such as force majeure (Worldbank 2013).

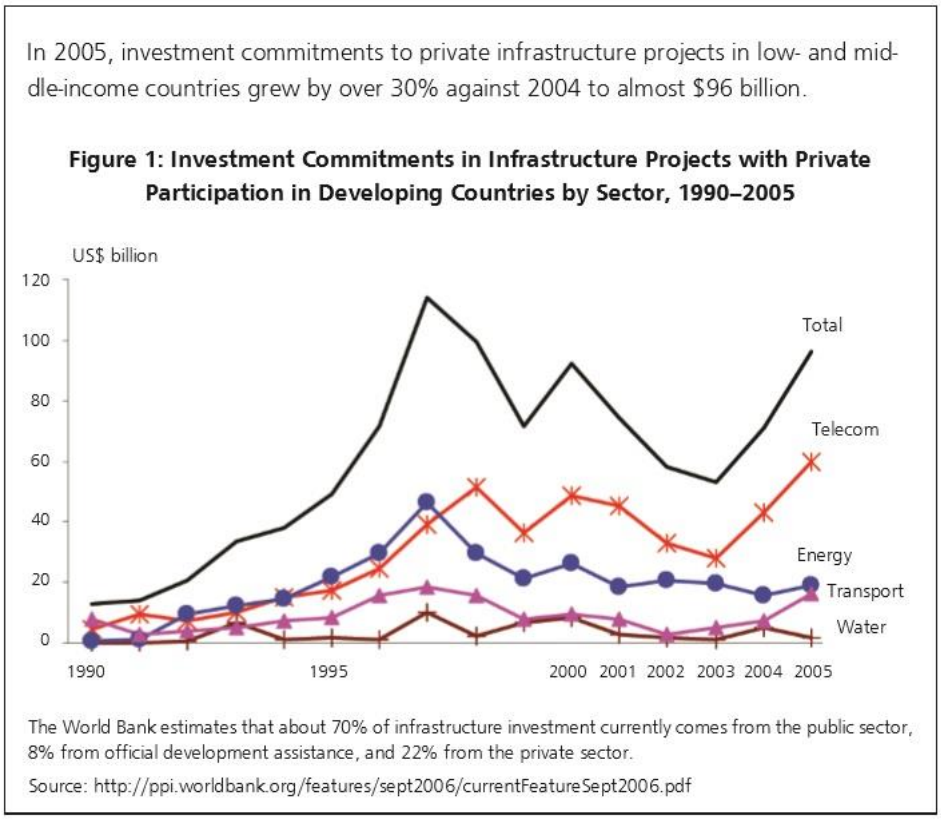
2.4 How Public-Private partnership can be related to efficiency

This research is investigating if it statistically can be proven that public private partnership can lead to more efficient ports. The main reason for looking into this issue is that it is a relevant topic within all of transportation, but has been specifically discussed and highlighter within seaports the last couple of decades. There is a growing trend of more and more ports, not only in the western world but all around the globe allowing for greater private participation in ports. Therefor it is wort looking at if there any statically connection between the two.

There consists a lot empirical evidence with results confirming that PPPs can indeed lead to improvements in efficiency but not necessarily so. The reason for that being that PPP creates an industry with a combination of specific know-how from both private and public partnership. One of the main arguments for private partnership is that research shows that private sector is able to build an infrastructure for a lower cost than the public sector (Wright 1987). If the conditions are right, they can earn money by building at lower cost. Wallace and Junk (1970) claimed that the investment costs of public enterprises are 40% higher than those of private enterprises.

The public sector might have poor incentives to be efficient as politicians and public servants might not gain anything from being efficient. They might be more interested in winning elections and having large budgets to control. Often a critical challenge for government is the efficient use of scare resources, where governments tend to fall far short of goals. This is because the public sector tends to have few or no incentives for efficient structure into its organization and process and is therefore poorly positioned to efficiently build and operate infrastructure. Implementing such incentives into an entrenched public sector is difficult, but not impossible.

Figure 2.3: Investment commitments in infrastructure projects with private participation in developing countries by sector (1990-2005)



SOUCE: (Asian development bank 2006)

Figure 2.3 shows that investment by private infrastructure projects developing countries grew by over 30 % from 2004 to 2005.

When private sector operators invest they often have the clear goal of maximizing profits, which are generated by increased efficiency in investment and operations. If these investors can pursue these goals within the PPP structure, the efficiency of the infrastructure is likely to be improved. What PPP allows is for the government to give operational roles to the private sector, while they work on an improve core public responsibilities such as regulation and supervision. If this implementation is done correctly it can result in lower aggregated cash outlay for the government, and better and cheaper service to the consumer (Asian development bank 2006). The private and public organizations tend to have different goals, and target functions that might affect the possibility to increase efficiency.

Typically, public sector supply services to the public, and they are not competing with any other institution for profit. On the other hand, Private sectors have goals of overtaking their competitors, and maximizing their profit. When it comes to policy decisions, the activities in the public sector have a goal of sticking to what is indicated by law, while the private sector is managed under the rules of shareholders and corporate owners.

2.5 Efficiency

2.5.1 Definition

Efficiency is the (often measurable) ability to avoid wasting materials, energy, efforts, money, and time in doing something or in producing a desired result. It can be defined as level of performance which describes a process that uses the lowest amount of input to produce a specific level of output (Oxford Dictonary 2010).

2.5.2 Port efficiency

It is vital for a for any business to understand the concept of performance, in order to reach goals and keep up with competition. The same goes for world seaports.
The only way to evaluate performance is though comparison. However, measuring ports is complex as they have many different sources of inputs and outputs, and comparisons between different ports can be quite difficult. This is a subject which makes it even more complicated as we consider the different types of port ownership that exists around the world. Ports have changes from being in the hands of national or local government into either wholly or partly privately owned over the two last decades. This change of privatization has attracted both academics and people working with in the industry to see if it improves performance and competitiveness (R.Gray 2000).

The Characteristics of port efficiency studies is that they are data driven. Most of the data is usually available from publications, therefor easy to collect and cheap. Most of the studies are focusing on container terminals. Although there is a wide availability of studies using mostly DEA and SFA software data is usually the problem in port efficiency studies.

For this study we are looking what is called technical efficiency (TE), which is a measure predominantly used in container port assessment, which is defined in economics as the ability of a decision making unit (seaport) to transform a given set of input and into

maximum output. One of the main reason for the use of TE in port efficiency studies is that it does not require price/cost data, which is difficult to obtain. It only requires physical data on input and output.

2.5.3 Why measure port efficiency?

There is numerous reason why it is important to measure port efficiency. It can determine the most suitable benchmark and identify good operating practices.
As this paper has already mentioned ports are the backbone of international trade, with a high percentage of the world trade being transported by sea. The increasing globalization of economics calls for a higher efficiency from all parts of the transportation industry. Especially seaports have been under pressure lately to keep up with international standard and to be able to compete in the market. The efficiency if a port can be said to be a countries indictor of its economic development. Comparison between other ports and their efficiency has become an important part of microeconomics reform programs in many countries (Liu 2008). An innovative and improved operational system can help make the most use of container port resources and infrastructure (Vacca, Salani og Bierlaire 2010). Standing in the crucial interface between the of sea and inland transportation the importance of container port and its production capabilities cannot be ignored.
After the containerization period and the increase in private participation has led to such a competitive environment that, port efficiency measures is not only a powerful management tool for port operators but also represents the most important input for informing regional and national port planning and operation.

2.5.4 Measuring Port efficiency

Measuring seaport efficiency is a complex task because it provides a wide range of services and operates in significantly diverse context. Efficiency is a relative concept that requires a clearly defined benchmark in order for operators to compare themselves with others and with their own performance over time, it can be defined in several ways, each serving a different purpose. This study is focusing on TE, which is the most frequently measure of performance in seaport literature, the most important reason for the use of TE in this industry is that it does not require a price/cost data, which is difficult to obtain and it only requires physical input and output (Odeck and Bråthen 2012).

According to Penayides et al (2015) the number of port/terminals researched in each study usually lies somewhere between 6 to 104 with an average of 28. The different studies within port efficiency are using cross sectional data or panel data. Usually the type of data determines the specific objective of the studies. Cross sectional data is data collected from multiple ports/terminals at a single point in time. This type of data enables researchers to evaluate and compare the efficiency of different ports / terminals and to study the structure of the industry at a single point in time. On the other hand, panel data is data collected from multiple ports/terminals over multiple time periods, can be used to observe ad study changes in efficiency, management and the impact of regulation of containers ports/terminals (Almawsheki and Shah 2008).

In recent years, significant progress has been made concerning the measurement of efficiency in relation to productive activities. The efficiency frontiers from which efficiency scores of individual seaports can be estimated through a number of frontier models. Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA) have been increasingly utilized to analyze port production and performance. Both the DEA and SFA approaches have their individual strengths and weaknesses (Culliane, Wang and Wook 2005). There have been many studies on performance of container ports in order to optimize the operational productivity of cargo handling at the berth and in the terminal area. In recent years, DEA approach and SFA have been used increasingly to analyze this matter. DEA is the most frequently used technique that has the largest amount of application within this sector and is increasing within port operations. It normally produces higher efficiency scores in comparison to the Stochastic Frontier Analysis (SFA) (Schøyena and Odeckb 2013). Which can be expected as DEA always identify at least one DMU as being efficient (score=1).

2.5.4.1.1 Data envelopment analysis (DEA)

Data Envelopment Analysis (DEA) is an established statistical technique which measures the relative efficiencies of units where simple efficiency measures are difficult to obtain. DEA is able to handle multiple inputs and outputs. The units dealt with in DEA are usually homogeneous and independent units performing the same function. It is mostly used where there is a large number of units providing identical service (Szczepura 1992).

To begin with DEA was developed as a way of measuring service units by Charnes et al. (1978), but has since been developed. DEA has been used a lot to test efficiency where there are multiple centers of inputs and outputs such as airports, local government authorities, courts, hospitals general medical practices and bank branches.
The DEA technique allows for each weighted input/output to be seen in its most favorable light. The number of variables entered into the formula cause for there to be more of a discriminatory power of DEA. This means that the more variables included into the equation may lead to a lack of emphasis on particularly important piece of data. In regards to the frontier it is obtained by identifying the highest potential output under different input combinations through linear programming, and the degree of efficiency is measured using the distance between the observation and the frontier. A downside with this method is that sample measurement error and random variation are simply assumed away and deviation from the frontier are attributed solely to inefficiency (Sarriera, et al. 2013). The DEA model normally applies cross sectional data, where time is ignored and DMU are compared with the others at the same period.

There are two variations of DEA that have been used for the individual studies included in this thesis which is the basic CCR model and the BCC model.

The basic CCR model
The most basic model of DEA is the CCR model, which was initially proposed and named after Charnes, Cooper and Rhodes in 1978. The CCR (ratio) model is probably the most widely used and best known DEA model. It is the DEA model used in Frontier Analyst when a constant return to scale relationship is assumed between inputs and outputs. This model calculates the overall efficiency for each unit, where both pure technical efficiency and scale efficiency are aggregated into one value (DEAzone 2012).

The BCC model
The BCC model was introduced by baker et al (1984), who it is also names after. The BCC (ratio) model is the DEA model used in Frontier Analyst when a variable return to scale relationship is assumed between inputs and outputs. The BCC model measures technical efficiency. The convexity constraint in the model formulation ensures that the composite unit is of similar scale size as the unit being measured. The efficiency score obtained from this model gives a score which is at least equal to the score obtained using the CCR model.

Those DMUs with the lowest input or highest output levels are rated efficient. Unlike the CCR model, the BCC model allows for variable returns to scale (DEAzone 2012).

2.5.4.1.2 Stochastic frontier approach (SFA)

Stochastic Frontier Approach (SFA) is the other commonly used approaches to assess port efficiency. Introduced simultaneously by Aigner et al. (1977) and Meeusen and van den Broeck (1977). The difference from DEA is that SFA is parametric approach. Which is a branch of statistics which assumes that sample data comes from a population that follows a probability distribution based on a fixed set of parameters. Nonparametric which the DEA method uses is statistics not based on parameterized families of probability distributions. The great characteristics of SFA is that it not only allows for technical inefficiency, but also acknowledge the fact that random shocks outside the control of producers can affect output. Therefore, the idea is that SFA the error term is composed of two parts; a one-sided component that captures the effects of inefficiency relative to the stochastic frontier, as well as symmetric component that permits random variation of the frontier across firms and captures the effect of measurement error, other statistical noise random shocks outside the firms control (Cullinane, 2006). In short, the SFA approach is based on a production function that requires knowledge of the input variables explaining the observed output.

2.5.4.2 Comparing the two DEA and SFA

Table 2.4 shows the main differences between the two approaches. It shows the frontier approaches with their advantages and potential weaknesses. The two approaches are determined by best possible performance drawing on information from the sample.

Table 2.4: Characteristics of DEA and SFA

DEA	SFA
Non-parametric approach	Parametric approach
Deterministic approach	Stochastic approach
Does not consider random noise	Considers random noise
Does not allow statistical hypothesis to be contrasted	Allows statistical hypothesis to be contrasted
Does not impose assumptions on the distribution of the inefficiency term	Imposes assumptions on the distribution of the inefficiency term
Does not include error term	Includes a compound error term: one of one side and the other symmetrical (two queues)
Does not require specifying a functional form	Requires specifying a functional form
Sensitive to the number of variables, measurement errors, and outliers	Can confuse inefficiency with a bad specification of the model
Estimation method: mathematical programming	Estimation method: econometric

Source: (Gonzalez and Trujillo 2009)

The frontiers from DEA is found by identifying the highest potential output under different input combinations through linear programming, and the degree of efficiency is measured using the distance between the observation and the frontier (Liu 2010). A downside with this method is that sample measurement error and random variation are simply assumed away and deviations from the frontier are attributed solely to inefficiency.

SFA on the other side uses parametric estimation of a production function with a stochastic component. The error term is put together of two random effects, one capturing the statistical noise and the other the technical efficiencies. The efficiency is measured once the frontier is estimated, the efficiency is measured using the distance between the observation and the frontier.

On the other side, one of the main critiques of these methodologies is the role measurement error can play in the results, and the potential for stochastic frontiers to deliver biased estimates due to problems with the specification of the underlying production technology. As for deterministic frontier model the entire shortfall of observed output from maximum feasible output is attributed to technical inefficiency, whereas the stochastic frontier model includes the effect of random shocks to the production frontier. (Biswas and Verma 2013)

In the case of DEA, a port can achieve 100% technical efficiency only if it achieves the maximum output. Other ports, which do not achieve 100% technical efficiency, can see their distance to the maximum output. One of the big advantages of SFA is that it is an

econometrics approach which is able to capture noise in the dataset. In short stochastic frontier approach is based on a production function that requires knowledge of the input variables explaining observed output. The key features of SFA are the assumptions imposed over the error term, which to disentangle statistical noise (random shocks) from the residual term representing inefficiency (Serebrisky, et al. 2015).

2.6 Previous work

1.4.1Previous work using DEA approach on Port efficiency

It exists an extensive literature on data envelopment analysis, that is applied to many different fields of economics and in particular to seaport and container terminal efficiency. This approach is the most common one used within port efficiency as well as for this thesis where 12 of the 16 studies included are from studies that have used DEA for the simple reason that it exists more studies using this approach. The most notable researcher with in port efficiency is Kevin Cullinane (2005) who has applied DEA to several of his work of on port efficiency. One of his article that can be related on the topic of this thesis deal with the relationship between privatization and efficiency in the container port industry, where he included a sample of 30 container ports. He focuses mostly on the world major container port excluding smaller ports and ports located in Africa and south America. In this research he concluded based on the results of his study that efficiency does not improve with the increasing involvement of private-sector in the ownership and control of container port industry.

1.4.2 Previous work SFA approach on port efficiency

Compared to the two approaches the SFA approach has been used less frequently than DEA when measuring port efficiency. In this study only 5 out 15 of the studies included have been done using the SFA method. There are only a few studies on port efficiency that have been done using only SFA. Culliane is again a researcher that come up, as he has done studies using both methods. Culliane has done a research using SFA on efficiency on major ports in Asia assessing the influence of ownership structure. It looks at 15 major container major ports in Asia where it is using the cross sectional and panel data version of Stochastic frontier model who concludes based on the results from this study

that weak link between privatization and port efficiency. It also concluded that the efficiency of a container port or terminal appears to be closely correlated to its size as measurement in terms of throughput.

Jose Tongzon and Wu Heng (2005) used SFA to analyze the world major ports and looked at the relationship between privatization and efficiency. With a sample of 25ports, mostly in Europe and Asia and including one from Canada. From the results of this study it was concluded that port privatization in port industry is useful for improving port operational efficiency, however it showed that full privatized participation is not effective way to increase port operation efficiency, concluding that port authorities should introduce private finance, operations and management instead of state funds and administration while they remain in place as regulators.

1.4.3 Previous work comparing DEA and SFA

There are few studies that seeks to compare the results from the two different approaches. Culliane (2005) aim to fill the gap of the lack of empirical evidence in relation to their comparative effectiveness in application to the container port industry. His paper applies both approaches to the same set of data set of some of the world's largest container ports and compares the findings. The results indicate a high degree of correlation between the efficiency estimates derived from all models applied, indicating that the results are somewhat fairly to the DEA applied or the distributional assumptions under SFA. High levels of TE are associated with scale and greater private-sector participation.

Odeck and Bråthen (2012) looked at DEA and SFA studies on port efficiency through a meta-analysis as well as comparing fixed and random-effect regression models. This is a research that can be related to this study in the sense that it is looking at port efficiencies through a meta-analysis with studies using SFA and DEA approach. However, Odeck and Bråthen are not looking at individual ports but looking at the mean technical efficiency score, as well as it does not seek to explore what effect how public private partnership can effect port efficiency. They concluded based on their results that studies that used DEA approach had higher MTE scores than those that used SFA with a 10% significance level. It also indicated that recent studies had lower MTE and that MTE scores have decreased over time.

1.4.4. Previous studies on PPP effect on port efficiency

There are no published studies that have investigated the quantitative relationship between port ownership structure and port efficiency, from a broad perspective of studies using a meta-analysis including both DEA and SFA. Most of the current studies on PPP's effect on port efficiency comes from a single research manly done within one geographical area. For instance, Jose Tongzon and Wu Heng (2005) studied port privatization where they based the research on a sample of selected container terminals around the world, by using a SFA approach to show whether or not port privatization in necessary strategy for ports to gain competitive advantage it also studies the determinants for port competitiveness. The results of their study have shown that private sector participation can lead to improve port operations efficiency, which in return will lead to increased port competitiveness.

The study that can be most related to this research is Culliane (2005) which was explained above using DEA to study relationship between privatization and DEA estimates of efficiency on the container port industry. Where the paper concludes with a rejection of the hypothesis that private sector involvement in container port sector irrevocably leads to improved efficiency. Jose Tongzon and Wu Heng also concluded that privatization in a port industry is useful for improving port operational efficiency as mentioned above.

The studies on individual countries or geographical area are more common within studies on PPP on port efficiency. For instance, Wanke and Barros (2015) used a DEA approach to study the impact of PPP on major ports in Brazil. The results indicated a strong positive impact of public-private partnership on port efficiency. This is where this research seeks to fill the gap. To find statistical evidence from a wide range of studies on port efficiency using different approaches and with ports located all around the world.

3.0 Methodology

3.1 Research design

A research design is the framework or appropriate plan for a study (research) used for formulating research problems, administration of data and analysis. The purpose of a research is either to explore, to describe and to explain something.

The study will be based on published studies on port efficiency were both DEA and SFA approach has been used, as well as using both cross-sectional data and panel data. By selecting a sample of 28 ports from Asia, Africa, Europe, North America, south America and Oceania from 16 different studies, a Meta-analysis will be conducted to see if there are any common similarities.

3.2 Meta-analysis

3.2.1 Definition

Meta-analysis can be defined as the study of studies. It is a statistical analysis of a large collection of results from individual studies for the purpose of integrating the findings (Glass 1981). A meta-analysis looks if there is common truth behind all conceptually similar studies, that has been measured with certain error within individual studies. It provides an estimate for the unknown common truth but it also has the capacity to contrast results from different studies and identify patterns among study results, sources of disagreements among results and or other relevant relationships that may become known. A meta-analysis is mostly known and conducted with in medical science, for instance with clinical trials of medical treatment to understand how a treatment work and what effects there are to it (Greenland S 2008).

3.2.2 Why conduct a meta-analysis?

There are many benefits of doing a meta-analysis, the key benefit is that it leads to a higher statistical power than what would be possible from an individual study. However, when conducting a meta-analysis what previous studies the researcher chooses will have an effect on the results, so electing the right studies is important. Because a meta-analysis

combines the results from several studies it can be said to have an increase power over individual studies. Power in the sense that basing a study on results found in multiple other studies will lead to a more sufficient overall results, which is typically seen within medicine studies. Meta-analysis usually requires quantitative data able to be subject to statistical analysis. Meta-analysis by definition should be comprehensive. For this thesis, a meta-analysis will be conducted and will look into efficiencies studies on some selected ports. It will look at both of the two common approaches that has been discussed earlier DEA and SFA to see what or if there are any differences within the results of these two approaches. A similar study has been done by Odeck and Bråthen (2012) however this meta-analysis will also look at each ports ownership and see whether or not PPP has effect on port efficiency. Thus, the basic comparison regarding methodology will be between nonparametric DEA and parametric SFA frontiers. A question that needs to be addressed is how does involvement in PPP effect a port efficiency. How the different methods used or geographical are or time of study can affect the results.

3.2.3 Criticism of META analysis

Although meta-analysis is widely recognized and used it does exist criticism to this type of research.

The following are some of the typical criticism to meta-analysis:

(1) One number cannot summarize a research field

This criticism regards to some critics believing that the analysis focuses on the summary effect, and ignores the fact that the treatment effect may vary from study to study. For this thesis it might be that the effects of PPP (and other variables) might be so different between different settings so that there is no point in trying to find a single number to describe the effect.

(2) Mixing apples and oranges

One of the criticism to meta-analysis is that the researcher is mixing different studies in the same analysis. The main argument for this is that the summary effect will ignore potential important differences across studies. This research is likely to have this problem. For instance, different studies are using different input, are comparing against

different geographical areas, measuring effect over time as well as using different approaches to measure the efficiency. However, port operations are quite alike all around the world despite conditions. By looking at appendix 1 it shows that the inputs and output measures from the different studies are almost identical with only a few variations.

(3) Garbage in, garbage out

Another common criticism is the metaphor garbage in, garbage which refers to the concept that if a meta-analysis incorporates low-quality studies, errors in the primary studies will be carried over to the meta-analysis, where the errors may be harder to set apart. Conducting the Meta-analysis this study assumes that studies included do not cooperate low-quality studies.

(4) Important studies are ignored

As the previous mentioned criticism regards to including studies that maybe should have been avoided, this criticism regards to important studies that are missed from the study. Again in issue that can effect this study, however as there is limited studies out there this will be less of a problem in this study.

(5) Meta-analyses are performed poorly

Others argue that those mistakes outline above are so common that the result of the actual analysis can be performed very poorly. The main argument is that a meta-analysis is inherently so complicated that mistakes by the persons performing the analysis are all but inevitable (Borenstein, et al. 2009). This is also relevant for this study as it contains several studies with almost 200 observations a mistake in the dataset can easily occur.

3.3 Data

3.3.1 Primary data and secondary data

There are general two types of data in theory namely primary and secondary data. Primary data is collected by the researcher itself, secondary data is already existing and the researcher is not involved in the collection of it (Bryman and Bell 2011).

This study is heavily relying on what we normally refer to as secondary data. All the efficiency scores from ports are collected from a variety of different studies. Studies that have already been published. However, this research can be said to be using primary data, as data is collected for the purpose of this study. As the meta-analysis is using primary data as the objective is to study the results of these studies.

The main sources of data will be found through already published studies on ports. Since there is limited amount of data on this topic, every study that is found to be relevant will be used for in the analysis. As it is close to impossible to find a broad study on PPP on port efficiencies homepages of individual ports will be used to find out what type of ownership it has, but also journal articles on different ports ownership. Publications on seaport efficiency measurements were found though searches in several databases such as Science direct and researchgate.

3.3.2 Data selection

When collecting data for this study, it started with an extensive review of existing studies on port efficiency using both DEA and SFA approach. A majority of the studies are using the same ports, which are the major ports in Asia, Europe and North America. Relatively few have been done for Africa, south America and Australia. As the focus for this research was to include a worldwide perspective, and extensive search was done to find studies on these areas as well. Some studies, but relatively few where found from these areas, which naturally leads to an uneven distribution of studies focusing on these continents compared to the others. Several of the studies done on port efficiency was also done by combining efficiency scores for the whole country rather than individual ports, excluding these studies as well. Data from DEA and SFA approach have been included, where the majority of the studies are using DEA, (see appendix 2). Altogether 28 ports have been included in this research, 6 in Asia, 5 in Europe, 4 from North America, 4 from south America, 4 from Oceania and 5 from Africa. The illustration 3.2 later in this chapter shows an illustration of the ports included geographical location.

3.3.2.1 Data selection according to ownership

As this study is looking into whether or not PPP can have an effect on a ports efficiency, knowing the ports ownership became an import aspect of the data collection. Without knowing the ownership of a port there would be no reason to add it and therefor automatically some ports had to be removed from the dataset. Collecting information on port ownership turned out to be a bit challenging. However, there were some published articles on PPP that listed some of the major ports ownership, such as Wanke and Barros (2015) listing the ownership of Brazilian ports, Cullinane and Wang (2005) listing the ownership of 30 of the world's major ports 13 of which were included in this study. The ownership of the African ports that were included was found in African bank (2010). For the Australia and north American ports, the information on port ownership were found on the individual homepages of each port.

When we are referring to PPP in the analysis we are talking about Tool ports and landlord ports, however from the available data that is obtained of the port ownership structure the majority of the ports included for this study have a landlord port model. If ports have changed their ownership structure from the different time periods the studies were done, were taken into consideration. None of the ports included have changed ownership structure from the different time periods from the different studies included or during the different studies. The table below shows a list of ownership of all the ports included in this study.

Port	*Public-Private Partnership(PPP)*	*Public*	*Private*
Singapore	1	0	0
Shangahi	1	0	0
Hong kong	1	0	0
Dubai	1	0	0
Mumbai	0	1	0
Qingdao	0	1	0
Europa			
Hamburg	1	0	0
Felixtowe	0	0	1
Antwerp	1	0	0
Bremen/Bremenhaven	1	0	0
Rotterdam	1	0	0
South/central america			
Belem	0	1	0
Fortaleza	0	1	0
Salvador	1	0	0
Parangua	1	0	0
North America			
Vancouver	1	0	0
New york/New jersey	1	0	0
Los Angeles	1	0	0
Long Beach	1	0	0
Oceania		0	
Sydney	1	0	0
Melbourne	1	0	0
Brisbane	1	0	0
Fremantle	1	0	0
Afrika			
Dar es Salaam	1	0	0
Sudan	0	1	0
Mombassa,kenya	0	1	0
capetown, South Africa	0	1	0
apapa Nigeria	1	0	0
Totalt with PPP / without	**20**	**8**	

Table 3.1 Ownership of the ports included for this thesis.

As the table shows the majority of the ports have PPP, and only one port that has been included is a private port. That is because there is done and exists very little published research on private ports. The public ports included are located in Africa, Asia and south America.

Asia was by far the one content with most available data on port efficiency, studies from this region has been done both regional and compared to other world ports. It contains data from both public and PPP ports, and the ports included in for this study is spread evenly through the continent, aswell as having studies where both DEA and SFA has been used. In *Europe* most of the ports where located central Europe with most of the ports being located in Germany and Belgium, again this is due to available data on PPP and port efficiency. These major ports in Europa have been included in several studies on Port efficiency and they have used both DEA and SFA approaches.

In *North America* their major ports which were most often included in studies were Los Angeles, Long beach and New York/New Jersey. Another one which was added to this study where the port of Vancouver which had been less frequently studied than the other ports. In studies of world's major ports *African* ports have been excluded. This region does not have many studies done on efficiency as well as finding ownership structure is not always easy. However, there has been done some studies on some African ports using DEA, all of them being compared to either ports within their own country or within Africa and not compared to the major ports of the rest of the world.

Oceania was another country which surprisingly turned out to be difficult to find enough data on, and for this study it is the one continent having the least amount of studies on port efficiencies. Several studies have been done on ports in South America however, the limited information on port ownership resulted in only ports from brazil being included for this research. The illustration below shows all the geographical location of all the ports that have been included in this research.

Illustration 3.2: Map of the ports location

3.3.3 Input and output variables

All studies included are studying efficiency of container ports either through a DEA or SFA approach, with either cross-sectional or panel data. Appendix 1 show the different inputs and output each of the studies have used.

Many of the studies have found their database from the containerization international yearbook from the period of 1999-2009, which indicates key port infrastructure indicators such as berth length, port area, number of mobile and quay cranes and number of ship-to-shore (STS) gantry cranes.

It also container annual container throughput in TEU's. Since all the studies are focusing on container terminals, the database is limited to output measures related to the volume of containerized cargo. The input and output variables should reflect the actual objectives and process of container port production as accurately as possible. For the studies included the main port objective is assumed to be the minimization of the use of input (s) and maximization of the output (s) as container ports are heavily relying upon sophisticated equipment and information technology, rather than being labor-intensive. In the light of strong competition this objective is important.

The output of container ports that has been used in all studies is TEU throughput, the number of TEUs that pas through the port from one transport carrier to another. Container with greater TEU throughput have been claimed to be more productive than ports with less container throughput (Talley 2012).

The other output which have been included in some of the studies are is ship working rate which measures the number of container handling aspect of port operation is the largest component of total ship turnaround time, the speed of moving cargoes off and onto ships at berth has considerable implications for the port users.
To produce the two output mentioned above and to facilitate port operations, varieties of inputs are required. Based on production framework, port input can be generalizing as land, labor and capital.

4.0 Data analysis

4.1 Regression analysis

To analyze the independent variables effect on port efficiency (dependent variable) we have conducted a standard linear multiple regression model using SPSS.

A regression analysis can be defined as *analysis which is concerned with the study of dependence of one variable, the dependent variable, on one or more other variables, the explanatory variables, with a view to estimate and/or predicting the (population) mean or average value of the former in terms of the known of fixed (in repeated sampling) values of latter* (Gujarati 2003).

In regression analysis the dependent variable is frequently influenced not only by ratio scale variables (e.g., income, output, prices, costs, height, temperature) but also by variables that are essentially qualitative, or nominal scale in nature, such as sex, race, color, religion, nationality, geographical region etc. Since such variables usually indicates the presents or absence of a "quality" or an attribute, such as male or female, democrats or republican, they are essentially nominal scale variables. One way to "quantify" such attributes is by constructing artificial variables that take the values of 1 or 0, which indicates the presence or absence. These variables are called dummy variables. (Gujarati 2003). All the independent variables for this study are using dummy variables from 0-1, in order to quantify the variables as they are essentially qualitative by nature.

A linear regression analysis tells how much of the variance in our dependent variable can be explained by our independent variables. It also gives an indicator of the relative contribution of each independent variable. The test allows us to determine the statistical significance of the results, in terms of both the model itself and individual independent variables (Pallant 2010). In the standard multiple regression, all the independent variables are entered into the equation simultaneously. Each independent variable is evaluated in terms of its predictive power, over and above the offered by all the other independent variables. All independent variables that show no significant contribution to the dependent variable (efficiency) is excluded from the further analysis.

Our multiple regression model includes several categorical variables. These could not just be entered directly inn to the regression model as they are continuously measured variables. For instance, for studies before and after year 2000 we would only need one dummy variable with a coding where=1 BEFORE, and 0 after. Then AFTER becomes the base case (groups coded with zero). For geographical location, with 6 different categories, only 5 could be included (6-1) as it always need to be k-1 dummy variables. Thus we would create 5 X variables and insert them in our regression. The choice of which category to leave out is *totally arbitrary* and has no effect on the final results. The actual coefficients of the regression equation do, of course, depend on the category left out (called the base case), but because we interpret a dummy variable coefficient relative to the base case, the predicted values end up the same, base category against which the others are assessed in order to avoid the dummy variable trap (Michigan state University 2009).
The Dummy Variable trap is when the independent variables are multicollinear. A scenario in which two or more variables are highly correlated; in simple terms one variable can be predicted from the others. For instance, if when including the independent variables of BEFORE2000 and AFTER2000 these two can be predicted by each other if BEFORE2000 has a value of 1 it means that the study was not conducted after year 2000.

After running the regression analysis in SPSS the following independent variables showed no significant contribution to the dependent variable with 10% level (p-values over 0,1) in the model.

These were:

- ➔ Studies conducted before year 2000
- ➔ Studies conducted after year 2000
- ➔ Public ownership
- ➔ SFA
- ➔ CCR model (of the DEA)
- ➔ Cross sectional data
- ➔ Regional data
- ➔ Worldwide data.
- ➔ South America and Europa.

And have therefor been excluded from the further analysis.

4.1.1 Assumptions of multiple regression

Multiple linear regression analysis makes several key assumptions about the data and it is not all that forgiving if they are violated, these assumptions are:

- Linear relationship
- Multivariate normality
- No or little multicollinearity
- Homoscedasticity

Linear relationship

In a linear regression it needs to be a relationship between the independent and dependent variables to be linear. It is also important to check for outliers since linear regression is sensitive to outlier effects. A regression equation is linear when it is linear in the parameters. A model is linear when each term is either a constant or the product of a parameter and a predictor variable. A linear equation is constructed by adding the results for each term. This constrains the equation to just one basic form further on we develop an equation for our model which show that a linear relationship does exist.

Before analyzing the data, it is essential to check the data for errors, as it is very easy to make mistakes when entering the data for this many efficiency scores. These are potential errors which can have an impact on the result if not discovered and should therefore be removed from the dataset. According to Kline (2011) outliners are observations with extreme values. In our dataset all independent variables have dummy variables ranging from 0 to 1 and the dependent variable (efficiency) has a range from 0-1 as well, which makes it easy to detect errors in the dataset. A frequency test was run in SPSS, which checks categorical variables for errors. It looks at the minimum and maximum values, to see if they make sense, which is not being higher than 1 and lower than 0 in our case. Running the frequency there were not any value higher than 1 or lower than 0 (appendix 3). The presence of outliners can also be seen from the scatterplot. Tabacknick and Fidell (2007) defined outliners as cases that have standardized residual of more than 3.3 or less than -3.3. We do not have any point violating these values and we do therefor not have any *outliners* in the dataset (see appendix 5)

Multivariate normality

Secondly, the linear regression analysis requires all variables to be multivariate normal. This assumption can best be checked with a histogram and a fitted normal curve or a Q-Q-Plot. In the normal P-P plot we want to see the point lie in a reasonable straight diagonal line from bottom to left to top right. Which they do in our case. This suggest that we have no major derivation from *normality,* see appendix 4.

Multicollinearity

The Classical Normal Linear Regression assumes that there is no absolute multicollinearity between explanatory variables. Multicollinearity occurs when the independent variables are not independent from each other. The collinearity diagnostics in SPSS can pick up problems with multicollinearity that may not be evident in the correlation matrix. The results are presented in appendix 6. The two values are given: tolerant and VIF. Tolerance is an indicator of how much of the variability of the specified independent is not explained by the other independent variables in the model and is calculated using the formula 1-R square for each variable. If the value is very small less than 0.10 it indicates that the multiple correlation with other variables is high, suggesting the possibility of multicollinearity. The other value given is the VIF (variance inflation factor), which is just the inverse of the tolerance value (1 divided by tolerance). VIF values above 10 would be a concern here, indicating multicollinearity. In our case the tolerance value for each independent variable is 0.644 or higher, which is not less than 0.10, meaning we have not violated the multi collinearity assumption. Which is also supported by having all VIF values which are all less than 10. If the violation of this assumption (of absolute multicollinearity) we would not get any result at all in your regression.

Homoscedasticity

The assumption of homoscedasticity is that the residuals are approximately equal for all predicted DV scores. Violations of homoscedasticity make it difficult to find the true standard deviation of the forecast errors, usually resulting in confidence intervals that are too wide or too narrow. Heteroscedasticity may also have the effect of giving too much weight to a small subset of the data (namely the subset where the error variance was largest) when estimating coefficients. (Tabachnick and Fidell 1989)

We can check our homoscedasticity by looking at the same figure that also shows linearity and normality obtained from the SPSS (appendix 5). Data are homoscedastic if the residuals plot is the same width for all values of the predicted DV. Heteroscedasticity is usually shown by a cluster of points that is wider as the values for the predicted DV get larger. What we want to see is that these clusters are about the same width all over. Our residuals plot shows data that are fairly homoscedastic. In fact, this residuals plot shows data that meet the assumptions of homoscedasticity, linearity, and normality (because the residual plot is rectangular, with a concentration of points along the center).

5.0 Empirical findings

The following chapter presents the results from the Meta-analysis of the efficiency of 28 ports from and 16 individual studies using a linear regression model in SPSS.

5.1 Regression analysis

Determining how well the model fits

After running the regression model in SPSS we first want to evaluate the regression model, which provides information about the regression line's ability to account for the total variation in the dependent variable. By looking at the model summary box below (table 5.1) and check the values given under R square. The R square for this analysis is **0.334,** expressed by percentage that is 0,33,4% which means that our model is explained by **33,4%** of the variance of our dependent variable efficiency.

The *R* value represents the simple correlation and is 0.578 from our regression which indicates a medium degree of correlation. R is $\sqrt{R^2}$ and show the correlation between the predicted variables from the model and the real observations.

Table 5.1 Model summary

Model	R	R Square	Adjusted R Square
1	,578[a]	**,334**	,309

When we look at the ANOVA we can assess the statistical significance of the results. This table below (table 5.2) indicates that the regression model predicts the dependent variable significantly well. By looking at the "Regression" row and the "Sig." column. It indicates statistical significance of our regression model. Here, $p < 0.0005$, which is less than 0.05, and indicates that, overall, the regression model statistically significantly.

Table 5.2: Anova

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3,313	7	,473	12,993	**,000**[b]
	Residual	6,593	181	,036		
	Total	9,906	188			

a. Dependent Variable: Efficiency

b. Predictors: (Constant), Africa, Oceania, Private, BCC, NorthAmerica, Asia, PPP

Statistical significance of the independent variables

Table 5.3 shows which of the variables included in the model contributes to the prediction of the dependent variable (efficiency) and is the most important model for this study.

Table 5.3 Coefficient model – Dependent variable: Efficiency

Independent variables	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
1 (Constant)	**,441**	,050		8,898	**,000** [a]
BCC	,138	,030	,293	4,646	**,000** [a]
PPP	,124	,043	,227	2,877	**,004** [a]
Private	,156	,074	,159	2,094	**,038** [b]
Asia	,210	,036	,436	5,771	**,000** [a]
NorthAmerica	,168	,043	,293	3,855	**,000** [a]
Oceania	,233	,073	,205	3,170	**,002** [a]
Africa	,385	,063	,493	6,085	**,000** [a]
Paneldata	-,080	,041	-,155	-1,955	**,052** [c]

[a] Significant at p < 0.01

[b] Significant at p < 0.05

[c] Significant at p < 0.10

[d] Not significant

The first coefficient, "(Constant)", is the intercept term.
The base categories are described by the constant α and is about the ports where the dummy variables are 0. This means that α shows the expected value for a study of a port which does not use BCC (DEA) (0) , is a public port (PPP and Private=0), use cross sectional data (Paneldata=0) and is located in Europe or South America. **0,441** represents the expected efficiency values for the base alternative mentioned above. We will later on talk about the regression model where and take a closer look at these values.

By peforming the regression analysis, SFA shows no signs of having a significant contribution to efficiency, but DEA did. For the two methods of DEA: BCC and CCR, BBC showed significant results on efficiency. The coefficient of BCC is 0, 138, which means that studies that have used BCC model for efficiency score have an expected value of 0,138 above base case aswell as being significang with p values below 0,01.

Public private partnership coefficient is 0,124 and Private has a coefficient of 156, meaning that these are the expected efficiency values above the base case. These values are very close meaning that the effect of PPP and private is almost the same. However PPP is significant at a 1% level and private is significant at a 5% level. Although they are fairly similar in contributing to the dependent variable PPP shows stronger significance level than private.

4 out of 6 of the geographical areas included gave a significant contribution to the dependent variable. Of the once that were significant The Beta value which has the largest number is the one that makes the strongest unique contribution to explain the dependent variable efficiency, when the variance explained by all other variables in the model are controlled. In our case that is Africa with a Beta value of 0.385. North America has the lowest b value of all the areas making it less of unique contribution to the dependent variable. However, all of the areas being P values below 0,01 besides Oceania with b values below 0,05, meaning that they are all quite significant.

Finally, Panel data is significant at a 10% significance level. Panel data also has the lowest Beta value of all the independent variables with -0,080 indicating that it makes less of a unique contribution and does not serve as strong significant results as the other intendent variables show.

5.1 Regression model

A regression equation describes the average relationship between a dependent variable and a set of explanatory variables. It is one of the most common uses of regression and takes the form

In simple linear regression the equation of the model is

$$y = a + bX + e \quad \text{…Equation (5.1)}$$

Where *y* is the dependent variable, *X* the independent, *a* the intercept, *b* the slope, and *e* the error term.

For this regression the equation may be presented following equation:

$$E = \alpha + \beta_1 BCC(DEA) + \beta_2 PPP + \beta_3 Privat + \beta_4 ASIA + \beta_5 NORTHAMERICA + \beta_6 OCEANIA + \beta_7 AFRICA + \beta_8 Paneldata + \varepsilon \quad \text{…Equation (5.2)}$$

Where:

E = efficiency in container ports

BCC(DEA) =1 if results are estimated using BCC, 0 if not

PPP =1 if results are estimated using PPP ports, 0 if not

Private = 1 if results are estimated using Private ports, 0 if not

Asia =1 if results are estimated using Asian ports, 0 if not

North America = 1 if results are estimated using North American ports, 0 if not

Oceania =1 if results are estimated using Oceanian ports, 0 if not

Africa =1 if results are estimated using African ports, 0 if not

Panel data = 1 if results are estimated using panel data, 0 if not

α = constant: B1, B2, B3, B4, B5, B6, B7= regression coefficient: and ε =error term.

By substituting equation 5.2 with the unstandardized B values from table 5.3 above, the regression equation can be reformulated as follows:

$$E = 0{,}441 + 0{,}138\text{BCC} + 0{,}124\text{PPP} + 0{,}156\text{PRIVATE} + 0{,}210\text{ASIA} + 0{,}168\text{NORTHAMERICA} + 0{,}233\text{OCEAIA} + 0{,}385\text{AFRICA} - 0{,}080 + \varepsilon$$

...(equation (5.3)

0,441 represents the expected efficiency values for the base alternative mentioned above. With these values we are able to find the expected efficiency values of the many variations of the independet variables.

6.0 Summary and discussion

This chapter is based on the empirical findings from the previous chapter, it gives a brief summary of the findings and further it gives a discussion around key findings of the study in light of the research question and objectives. It ends of the chapter with implications of research and suggestion for further research within this field.

6.1 Summary findings

The key objective of this study was to identify if public-private partnership has an effect on port efficiency. As well as investigating other important factors that can influence the efficiency scores of individual studies such as, frontier approach, year of study, where data has been collected as well as if data had been collected over time or at one point in time. This paper hopes that the finding could help governments, port authorities, management, operators, public investors etc. to give a better idea on what type of ownership statistically leads to a more sufficient container port in order to compete in this globalized and highly competitive industry.

The key findings from this analysis is presented in table 5.3. In the beginning of this thesis a research question and a sub research question was developed. From our regression analysis we found that there were only 7 of the independent variable that were significant and had an effect on the dependent variable efficiency. Our main finding obtained from the results of the regression analysis shows that PPP had an effect on container port efficiency gave a P value of 0.004 indicating that it is highly significant, as well as private ports showing clear evidence on improving port efficiency with a P value of 0.038, which gives can tell us based on this study that private sector participation in ports lead to more efficient ports. This results are consistent with a great majority of existing literature with in this field. The study also found that studies using DEA approach gave higher efficiency scores than the once used SFA.

6.2 Discussion

The primary focus around this thesis has been around the increasingly popular from of port ownership Public private partnership, and if it can lead to more efficient container ports. As there exists no studies combing efficiency scores from ports around the world, looking at the impact of PPP in a Meta-analysis this thesis tries to fill that gap to give empirical evidence on the effect. The main discussion will be in regards to PPP as it is main research

question, but also give discuss the sub research question about the two approaches to estimate the efficiency scores SFA and DEA. There will also be a brief discussion the other independent variables that were tested.

PPP and ownerships effect on port efficiency

As mentioned throughout this paper the increase of competition between ports have led to a more focus and interest of improving port efficiency in order to compete in this highly competitive industry. PPP has emerged as the preferred ownership structure and method to be used to improve container port efficiency, as a way for which port authorities and operators can achieve and maintain their competitive advantage.

The obtained empirical results from this study, indicates that PPP have a significant impact on container port efficiency. These are results that also a majority of other studies on port efficiency have concludes with. Amongst others are Tongzon (2005) who also found that private sector participating leads to improved port efficiency, however he concluded that full privatization is not an effective way to increase port efficiency. The results from our study suggests that private ports are significant and they are effecting the port efficiency. That being said as there was a lack of available data on private ports and there are also very few ports that are fully privatized, only one port has been included in this study (Felixtowe) and can therefor give a biases result. Not having enough data on private ports we cannot give a valid conclusion that they do lead to more efficient ports or that they do not lead to it like Tongzon (2005) concluded.

However, the dataset for the analysis contains several public ports, and therefore makes it more valid to compare the results from public ports to port with PPP. The results obtained from the analysis show clear significant evidence that PPP does lead to port efficiency. Whereas Public port show no evidence of significance. As both PPP and private ports gave significant results this indicates that private sector participation in the port industry is useful for improving port efficiency and it is therefore also very important for port authorities and port operators in order to gain a competitive advantage.

What is worth looking into then is what type of private participation is it that leads to efficiency. There were only a few ports in Africa there was no able proper information on what kind of PPP ownership they have, however as many of the PPP ports in Africa have

only recently moved to a PPP port model it is likely to assume that they are operating under tool ports. The rest of the ports are operating under the landlord model.

Landlord ports has generally experienced greater success than public service port and is the best way to attract private sector. From the obtained results from this study we can say that when the authority owns only the basic infrastructure, leasing it out to operators, mostly on long term concession basis, while retaining all regulatory functions this type of port model will leads to efficient ports, where port operations are carried out by private companies. If we only based or result on the on the one private port it does also show that that ports which are fully privatized to contribute to improved efficiency. As a matter of fact, since private port model gave a slight higher beta values meaning that they are have higher expected efficiency values above the base case, but all in all the two show vary similar results on the dependent variable.

What appears very clear from the analysis was that public ports are not contributing to efficiency of ports compared to PPP and private ports. Most of the public ports included in this analysis performed substantially worse than the other ports. Indicating from the output of the studies that it might be due to lower containers handled per call with smaller vessesls and that handling cargo in service ports. Expanding containerization, in ever-larger vessels, requires port facilities to handle large vessels quickly and efficient, by international standers many of the public ports, port capability is low, and its performance is poor, bringing high costs and further loses in world trade shares. It might not just be that public ports necessarily lack basic quay capacity. However, they are inefficient in using their basic infrastructure. The lack of modern superstructure, particularly cranes, inhabits fast vessel turnarounds and imposes costs on costumers.

The efficient movement of goods is crucial to economic growth. In developing countries, the lack of proper infrastructure, can mean the difference between sustainable progress and persistent under-development. Public-private partnerships for container terminals are becoming increasingly popular globally, and particularly in emerging markets, as a way to introduce efficiency and innovation into port operations. In particular, we see these results when we look at ports in Asia and South America where the ports included that have PPP perform better than public ports (see appendix 7).

Oceania, Asian and African ports with PPP had the most efficient ports according to analysis. It is not so surprising to find Asia on the list as the ports that were included are some of the major ports in the world. This is consistent with various literature on port efficiency, such as Culliane (2005) showing clear evidence to ports such as Hong Kong and Singapore to have some of the highest efficiency scores of the world container ports. PPP ports in Australia had high contribution to improved efficiency scores. The port of Brisbane has the highest score of 1 from all the studies that were included for this analysis.

What is more surprising to find is that African ports were also significant. This might be due to the fact that the efficiency scores obtained from African ports were comparing African ports against each other and not against the best performing container ports in the world. However, if we look at the mean score (appendix 7) from the African ports included we find that there is not any clear sign that PPP ports are performing better than public ports. This might be due to the fact the most of the African ports that have private sector participation are tool ports rather than landlord ports. Where the port authority own develops, and maintains the port infrastructure as well as the superstructure, including cargo handling equipment such as quay cranes and forklift trucks. However, other cargo handling onboard vessel well as on the apron and on the quay is usually carried out by private cargo handling firms, which can cause the problem of split operational responsibilities. However, as mentioned earlier on the tool port does have its advantages, especially when thinking about transitioning to a landlord port. It can be a way to start transitioning as it might be problems in regards to confidence of the private sector is not fully established and the risks of investments are considered high, especially as ports in Africa have mainly been private and is just recently discussing and implementing PPP to some of their ports.

Ports in Europe showed no evidence of effecting port efficiency, this means that they (all other factors held equal) have the same efficiency as the base case. All studies that have been included from the European ports are comparing them up against the major and most efficient ports in Asia and north America. Although most of the European ports in literature and other studies are considered to some of the more efficient ports in the world, especially in Europe, this analysis shows that when compared to the major ports of Asia and Africa they seem to have less of an impact on efficiency.

Comparing DEA and SFA

Studies that uses non parametric approaches DEA seems to generate higher TE scores than SFA. As expected as DEA forces at least one DMU to "be" efficient. This is consistent with the work of Bråthen and Odeck (2012) who also found that MTE were higher for DEA than SFA. Other previous Meta-analysis aswell have concluded that MTE scores are higher for DEA than SFA with a significance level of 5% or higher, such as Ekanayake and Jayasuriya (1987). This result might be explained by the fact that DEA studies typically generate more TE indexes equal to 100%. This study also has more DEA studies than SFA studies as there exists more litterature on it. This might also have an effect on the results of the efficiency scores of conitenent. As the studies from such as Africa, were highly significant might be bias as it only included DEA studies, where as the others are using both DEA and SFA giving different efficiency scores.

Under DEA, when the two methods BCC and CCR where compared only BCC showed a significant level. This means that it was not possible to see could not see any difference between CCR and your base case (SFA). So what the study found was that BCC gives higher scores than SFA but not CCR. This might be because in the BCC model The efficiency score obtained gives a score which is at least equal to the score obtained using the CCR model.

Location of port

Asia, Africa, north America and Oceania showed a significant result on port efficiency. As previously already discussed there are several reasons as to why Europe showed no level of significant. For South America the results were more expected, as many of the ports included have low efficiency scores with the use of both DEA and SFA. PPP ports in Oceania also proved to have a significant effect on efficiency, with the efficiency scores from the use of both DEA and SFA. The scores from the Australian port have used been compared using both regional data and worldwide data, and Brisbane gave the highest MTE score of all the ports included in the study. However, there were fewer studies on Australia then there were from Asia, North American and Europe. Although Brisbane got the score of 100% from all the studies it had been used in, however ports such as Long beach, Los Angeles and Singapore also got the score 1 from these studies, but also other studies where used for these ports, resulting in a lower mean technical efficiency score.

Panel data and cross sectional data

Panel data used from this study has a P value of 0,52, which puts it in less than 10% significance level which is considered marginal, and fairly good in saying that studies using panel data give higher efficiency scores. This is contradicting Odeck and Bråthen (2012) results which showed that panel data produced significantly lower MTE scores than cross sectional data.

Regional and Worldwide studies

As most of the studies included in this research looked at the major world container ports and some studies included regional data, such as the once from Africa, regional and worldwide studies were added as independent variables assuming that they might have an impact on the results. Surprisingly neither one of them showed any evidence on impacting the efficiency scores. This result is inconsistent with Braathen and Odeck (2012) who found that where the cross world data produced higher MTE scores.

Year of study

Year of when the study was another independent variable that was added to analysis. This turned out to be insignificant, meaning that there is no indication that studies undertaken before year 2000 leads to any higher efficiency scores than studies undertaken after year 2000. This contradict to the results from Odeck and Bråthen (2012) who found that recent studies produced lower mean technical efficiency scores and that MTE scores have decreed over time.

7.0 Conclusion, Limitations and further research

7.1 Conclusion

This study has analyzed the effects on public private partnership on container port efficiency by conducting a meta-analysis from 16 different studies on the port efficiency. The analyses have been done with efficiency scores from both the DEA and SFA approaches, as well as comparing the two methods of data; panel data and cross sectional data, geographical area, time of study, and if the study has been compared in a regional area or world wide area.

The study revealed that revealed that that ports with PPP have higher efficiency scores than those who do not have it, also ports with private partnerships show significant evidence on improving port efficiency. Which can give us an indication from this study that private sector participation in the port industry lead to more efficient port. Public port showed no evidence of improving port efficiency and are performing the worst with technical efficiency.

For this study it does not have an effect on the results if the studies were obtained from before year 2000 or after year 2000. However, the study shows that studies that have included panel data have higher efficiency scores than those who have used cross sectional data.

If the study was conducted in only a regional area or worldwide had no effect on the efficiency scores. Asia, Africa, North America, Oceania gave higher efficiency scores and Europe and south America did give a significant contribution the dependent variable (efficiency).

7.2 Limitations of the research

This study does contain limitations, some of which have already been discussed. The two major limitations of this thesis is data availability and limitations in regards to downsides of meta-analysis.

Data availability

For this research the lack of data has been a problem. As there is less data of some ports than other, and as choices of ports where chosen base on available data the results can be effected by this. To starter with there was limitations in finding relevant sources for the port ownership structure, which immediately excluded many ports from the research. Studies on port efficiency in private ports and ports located in Africa, south America and Australia were very limited. Some studies included not only cargo ports but passenger ports etc. Since most of the ports are major world ports it can effect the results with the respects to level of market regulation of container terminal operations, particularly on the supply side.

Meta-analysis

Besides the lack of data availability, the meta-analysis in itself can cause some limitations for the research. For the actual meta-analysis itself there is an important limitation that the results can only be as good as the original data is valid. Meta-analysis can only analyze the role of independent variables in explaining variance in dependent variables if sufficient data is provided in the original studies. Relying only on studies published in journals may lead to biased conclusions.

7.3 Further research

As this thesis has shown there is a lack of published data on port efficiency hence there is also a lack of PPP on port efficiency from a broad perspective. This is most definitely a study should be researched further, as it hopefully will more of the need data available to this kind of research. It would be interesting to see this type of research been done with different ports than the once that were chosen for this study. Again due to limitations in data the ports and the data that has been included are mostly from the world's major ports, it interesting view for further research would to see what the outcome would have been if it included smaller ports. There is a lack of published articles on port performance from

especially Africa and South America and most of the studies analyzing port efficiencies of the world major ports are mainly located in the three dominated continents of Asia, Europe and north America. Another thing that can be studied further is how ports who have recently implemented PPP the differences in TEU and other aspects of the container port, not only efficiency.

As there has been many discussion and debates about PPP and how it improves efficiency it could also be worth looking at how ports that are private are performing. As there was a lack of data on private ports this study is not sufficient enough to decide on how private ports are performing against PPP and public ports. As there only are a few ports in the world practicing this kind of ownership and management.

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9.0 Appendices

Appendix 1: Inputs and outputs variables for each study

Author	Input	Output
Cullinane et al (2006)	Terminal length (M), terminal area (ha), Quayside qantry(number), Yard gantry (No.) Straddle barrier (No.)	Container throughput (TEU)
Tongzon (2001)	Cranes (No), berths (No.), Tugs (No.), Terminal area, delaytime, labor	Container throughput (TEU)
(Wang, Song and Cullinane 2003)	Quay length (m), terminal area (ha), quayside gantry (No.), Yard Gantry (no.), straddle carrier (no.)	Container throughput (TEU)
Cullinane et al (2005)	Terminal length (M), terminal area (ha), Quayside qantry(number), Yard gantry (No.) Straddle barrier (No.)	Container throughput
Cullinane et al (2001)	Terminal quay length, Terminal area, No. of pieces of cargo handling equipment employed.	Container throughput (TEU)
Tongzon et al (2001)	Terminal quay length, terminal area, No. of quay cranes used	Container throughput (TEU)
(Kaiser, et al. 2006)	Berths (no.) length of berths, total area berths, storage, shipshore cranes, front end handlers, Yard tractors, yard classics	Container throughput (TEU),

(Al-Eraqi 2008)	Berth length, storage area, handling equipment, ship calls (units)	Container throughput (TEU), ship calls (unit)
(Lu and Wang 2009)	Terminal area, ship-shore container gantry(No.) Container berth (No.) Terminal length (m)	Container throughout (TEU)
Jiang et al (Jiang and Li 2009)	Import/eksport by costumer, GDP by region, Berth length, cranes numbers	TEU
(Nwanosike, S and Warnock-Smith 2012)	Berth length, No of Berths, total No. of equipment, total No. of staff	TEU, No. ship calls
(Carine 2015)	Terminal area, Total quayside crane, Total Yard equipment, berth length	TEU
(Serebrisky, et al. 2015)	Berth length, Area, Mobile cranes with capacity>14t (unit), STS gantry cranes (units)	TEU
(Lee, Chou and Kuo 2005)	No. Of cranes, No. of container berths, No of tugs, terminal area (m), Delay time (h), Labor (units)	TEU, Ship rate
(Rajasekar and Deo 2014)	No of berth, berth, No of equipment's, No of employees	Container throughput (TEU), Total traffic
(Sarrierea, et al. 2013)	Average berth length (m), average Area, Average mobile cranes, Average STS Cranes.	Container throughput (TEU)

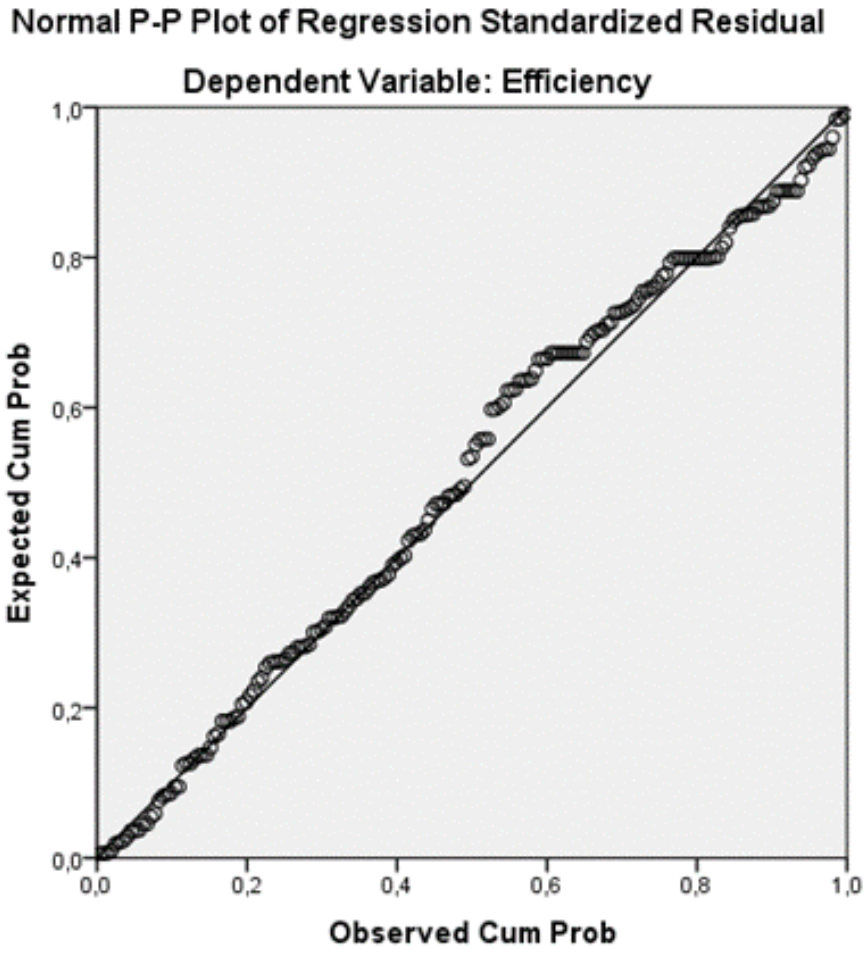
Appendix 2: Overview of studies used for this thesis

Authour	Article	Publicatic	Basic model	Data type	Year of data
Cullinane et al	A stochastic frontier model of the efficiency of major con	2001	SFA	Cross sectional/Panel d	1989-1998
Tongzon	Effciency measurement of selected Australian and other i	2001	DEA	Cross sectional	1996
Wang et al.	Container port production efficiency	2003	DEA	Cross sectional	2001
Cullinane et al	The technical efficiency of container ports: comparing DE	2005	DEA/SFA	Cross sectional	2001
Cullinane et al	The relationship between privatization and DEA estimate	2005	DEA	Panel data	1992-1999
Tongzon et al.	Port privatization, effiency and competivness	2005	SFA	Cross sectional	2004
Kaiser et al.	Developing Measure of US ports productivity and Peform	2006	DEA	Panel data	1996-2000
Al-Eraqi et al.	Efficiency of middle estern and east african seaports	2008	DEA	Cross sectional/panel	2000-2005
Hung et al	Benchmarking the operating efficiency of Asian container	2009	DEA	Cross sectional	2003
Jiang et al	DEA-based performance measurement of seaport in Nor	2009	DEA	Cross sectional	2007
Nwanosike et al.	An evaluation of nigerian ports post concession peforma	2012	DEA	Panel data	2004-2012
Floria Carina	Analysing the operational efficiency of container ports in	2015	DEA	Panel data	2012
Serebrisky et al.	Exploring the drivers of port efficiency in Latin America ar	2015	SFA	Panel data	1999-2009
Sarrierea et al.	Benchmarking Container Port Technical efficiency in Latin	2013	SFA	Panel data	1999-2009
Rajasekar	Measurement of effciency of major ports in India	2014	DEA	Panel data	1993-2011
Lee et al.	Evaluating port effciency in Asia Pacific region with rescus	2005	DEA	Cross sectional	1996

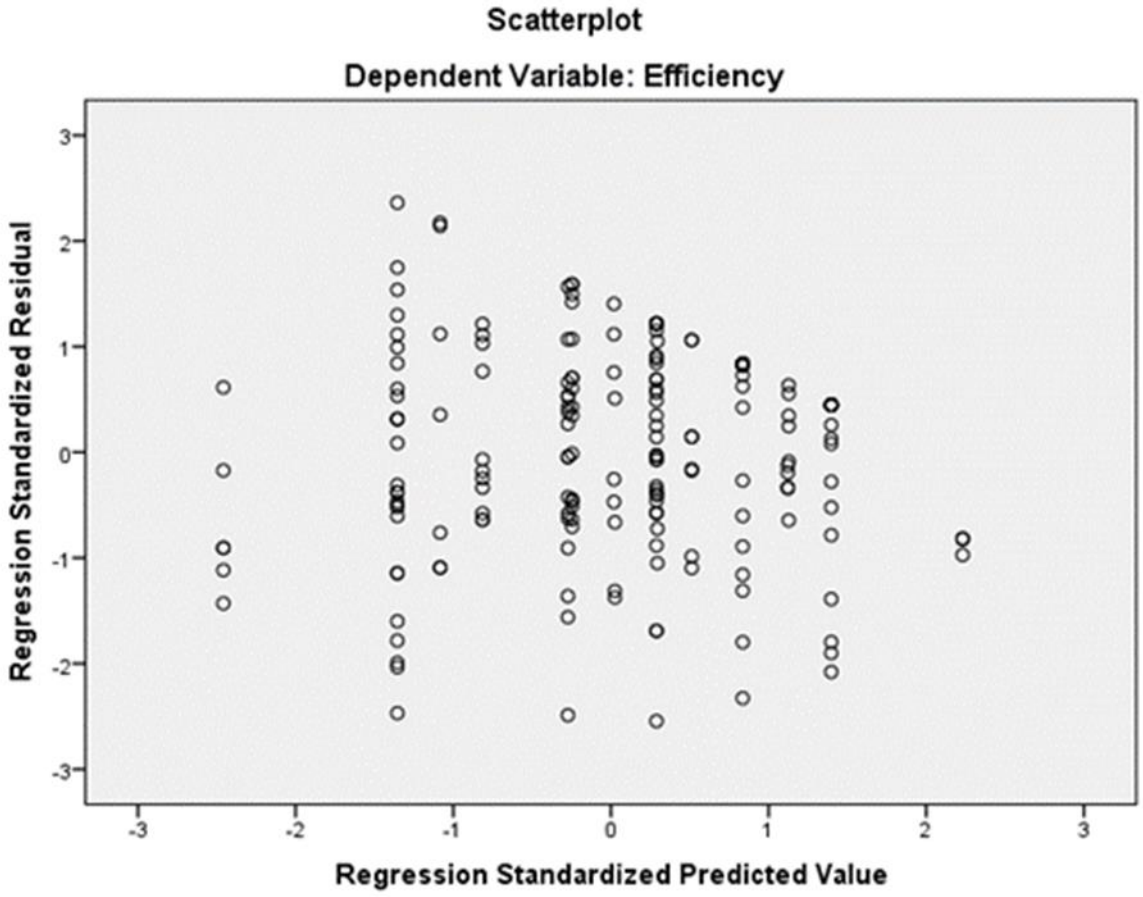
Appendix 3: Descriptive statistics

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
Before2000	189	,00	1,00	,4921	,50126	,032	,177	-2,020	,352
After2000	189	,00	1,00	,5291	,50048	-,118	,177	-2,008	,352
BCC	189	0	1	,39	,488	,471	,177	-1,797	,352
CCR	189	0	1	,48	,501	,075	,177	-2,016	,352
DEA	189	,00	1,00	,8571	,35086	-2,058	,177	2,258	,352
SFA	189	,00	1,00	,1429	,35086	2,058	,177	2,258	,352
PPP	189	,00	1,00	,7725	,42034	-1,310	,177	-,286	,352
Private	189	,00	1,00	,0582	,23475	3,804	,177	12,606	,352
Public	189	,00	1,00	,2434	,43027	1,206	,177	-,553	,352
Asia	189	,00	1,00	,3439	,47627	,662	,177	-1,578	,352
Europe	189	,00	1,00	,2593	,43939	1,108	,177	-,782	,352
SouthAmerica	189	,00	1,00	,0582	,23475	3,804	,177	12,606	,352
NorthAmerica	189	,00	1,00	,2011	,40186	1,504	,177	,264	,352
Oceania	189	,00	1,00	,0423	,20187	4,583	,177	19,205	,352
Africa	189	,00	1,00	,0952	,29432	2,780	,177	5,789	,352
Crosssectional	189	,00	1,00	,7831	,41325	-1,385	,177	-,084	,352
Paneldata	189	,00	1,00	,2698	,44506	1,045	,177	-,917	,352
Regionaldata	189	,00	1,00	,1693	,37602	1,778	,177	1,172	,352
Worldwidedata	189	,00	1,00	,8307	,37602	-1,778	,177	1,172	,352
Valid N (listwise)	189								

Appendix 4: Normal Probability Plot for normality assessment



Appendix 5: Graphical portrayal of heteroscedasticity



Appendix 6: Collinearity statistics

Model		Collinearity Statistics	
		Tolerance	VIF
1	(Constant)		
	PPP	,583	1,714
	Private	,628	1,592
	BCC	,908	1,102
	Asia	,636	1,573
	NorthAmerica	,626	1,599
	Oceania	,867	1,154
	Africa	,551	1,815
	Paneldata	,573	1,745

APPENDIX 7: MEAN EFFICIENCY SCORES

Mean efficiency Ports	
Port	Mean TE
Singapore	0,892925
Shangahi	0,8438
Hong kong	0,88059
Dubai	0,6935
Qingdao	0,6791
Mumbai	0,6235
Bremenn/Bremenhaven	0,6801
Hamburg	0,627
Felixtowe	0,6389
Antwerp	0,56
Rotterdam	0,629
Belem	0,23
Fortaleza	0,326
Salvador	0,55
Parangua	0,681
Vancouver	0,609
New york/New jersey	0,674
Los_Angeles	0,9599
Long_Beach	0,8661
Sydney	0,7655
Melbourne	0,5985
Brisbane	1
Fremantle	0,825
Dar_es_Salaam	0,84911
Sudan	0,767
Mombassa,kenya	0,904
capetown, South_Africa	0,914
capetown, South_Africa	0,945
apapa,Nigeria	0,854