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The relation between port performance and economic development

Literature review and case study of the Hamburg-Le Havre Range

Erasmus University Rotterdam
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Bachelor Thesis

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Date:	27th of July 2015

Abstract

Since the new Maasvlakte II in the port of Rotterdam, the port is ready for the biggest ships and the most modern industries. It is expected that the port will continue to growth for the next 20 to 25 years. The port accounts for 3.5 percent of the Dutch economy, but the growth in employment is expected to decline the coming years. Therefore the question arises which relation exists between the port performance and the economic development of the corresponding country or region. This paper will answer this question. First, a literature reviewed will be conducted, showing that the relation between port performance and economic development seems positive and have two plausible directions. Also the other determinants of port performance will be discussed. Then a quantitative analysis will be performed on data from the most important container ports in the Hamburg-Le Havre Range – Hamburg, Bremerhaven, Amsterdam, Rotterdam, Zeeland Seaport, Antwerp, Ghent, Zeebrugge, Dunkirk and Le Havre - for the period 2002-2011. A panel data analysis will be performed using a linear fixed effects model. Of the various economic factors, the import of goods and services has the largest significant effect on port performance. In general, there is a positive influence of the economic development of a country and region on the performance of a port.

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1. Introduction

1.1. Introduction

From 2008 to 2013 a new area has been built in the port of Rotterdam, Maasvlakte II. This was because there were hardly any business growth opportunities on the old Maasvlakte due to too little room for business establishments. The port is now ready for the biggest ships and the most modern industries. With this new area the port of Rotterdam is expected to continue to grow at least the next 20 to 25 years, which is good for the international trade, for the position of Rotterdam as a gateway to Europe and for the employment in the region (Port of Rotterdam, 2013).

The port of Rotterdam is the largest and one of the most important ports in Europe. In 2014, the total throughput of goods counted almost 445 million tonnes (Havenbedrijf Rotterdam, 2014). Especially the throughput of containers increases, which indicates a higher consumer spending. The port of Rotterdam is the largest container port in Europe and worldwide Rotterdam is in twelfth place (Vossers, 2015). A port is very important for the economy and employment in a country or region. The port of Rotterdam accounts for 3.5 percent of the Dutch economy (Vossers, 2015). In 2013, it was announced that in the future a lot of new workers would be needed in the port of Rotterdam (Intermediair, 2013). Two years later, the container transport turns out to become completely automated in a few years, leading to a decrease of employment (Spijkerman, 2015). These two statements contradict. There seems to be an effect of the performance of a port on the economic development of the country or region. However, it would also be possible that the economic development of the country or region influences the port performance. In the port of Rotterdam, Maasvlakte II was built because of the economic growth in the region, the country of the Netherlands and even Europe. The development was necessary, because of the high demand from industry and business (Port of Rotterdam, n.d.-b). In general, it is not clear which direction of the relation predominates, so this will be the subject of this paper.

Some scientific research has been done on this subject in the last years. For example, Tongzon (1995), Tongzon & Heng (2005) and Loo & Hook (2002) investigated the determinants of port performance and port efficiency; Langen (2004) and Langen & Chouly (2004) focussed on seaports as economic clusters; and Seabrooke, Hui, Lam & Wong (2003), Chou, Chu and Liang (2008) and Caldeirinha, Felício and Coelho (2009) focussed on the economic conditions as a determinant for port performance. Other researchers examined the influence of port performance on the economic development of a country or region (Li-zhuo, 2012; Deng, Lu, & Xiao, 2013; Bottasso, Conti, Ferrari, Merk & Tei, 2013). In the literature review, these and other

researches will be reviewed and used as a theoretical framework for the empirical part of this paper. Most of these researches are not very recent and focussed on ports worldwide or in the Middle East, while this paper will be focussed on the ports of the Hamburg-Le Havre Range in Europe.

1.1. Research question

The research question of this paper is the following:
Which relation exists between the economic development and the port performance for ports in the Hamburg–Le Havre Range?

1.2. Structure of the paper

The structure of the paper is as follows. In section 2, a literature review will be conducted. The relation between port performance and economic development will be discussed in both directions. Section 3 contains the quantitative analysis. In this section hypotheses will be stated based on the literature review, the data and methodology will be discussed and the relation between the port performance and the economic development will be tested in an empirical analysis with the stated hypotheses. The results of the analysis will be discussed. In section 4, conclusions will be drawn and recommendations will be made.

2. Literature review

In the past years a lot of research has been done to examine both the factors that influence economic development and the factors that affect port performance. Some of the existing literature relevant for this study will be discussed in this section. Firstly, the different methods for measuring port performance will be mentioned. Secondly, some determinants of port performance – including the economic development of a country or region – will be discussed. Thirdly, the impacts of port activities on the economic development of a country or region will be discussed. Finally, the direction of the relation between port performance and economic development will be discussed.

2.1. Measuring port performance

Port performance can be measured in a number of ways. The most widely used indicator is the throughput volume of goods (the number of containers in TEU or tons of cargo), but other methods can be used as well (Langen, Nijdam, & Horst, 2007). Traditionally, the actual throughput was compared to the optimum throughput in order to indicate whether the port performance had improved or deteriorated over time. For ports not located in a competitive environment, the engineering optimum of throughput – the maximum throughput a port can handle under certain circumstances (the port's capacity) – can be compared to the actual throughput. In a competitive environment, the economic optimum – the throughput for which the port achieves an economic objective such as maximum profit – is compared to the actual throughput. Another way to measure port performance is to use port performance indicators and/or the comparison of these port performance indicators with the performance indicator standards or benchmarks. This comparison also indicates an improvement or deterioration over time (Talley, 2006). Examples of port performance indicators are the throughput volume, the value added generated in the seaport, the port value added as percentage of regional GDP, the profitability of firms in the port, the investment level of private firms in the port, the establishment of companies in the port and the employment in the port region. Some of these indicators are used for specific port products, while others are used for the port as a whole (Langen, Nijdam, & Horst, 2007). To determine the optimum throughput and/or the port performance indicator standards, the port's economic objective function is required and a lot of uncertainty is involved (Talley, 2006). Therefore, and because the throughput volume is still the most widely used indicator, the absolute throughput volume will be used as a port performance indicator in this paper.

2.2. Determinants of port performance

The many characteristics of a port and the economic environment have an effect on attracting shippers and therefore on the cargo throughput in the port. Seven main determinants of port performance will be discussed: the location and hinterland, the hinterland access, the draft and accessibility, the presence of firms in the port, the port and terminal efficiency, the port charges and the economic activities and development.

Location and hinterland

The most significant characteristic as a port selection criterion is the geographical location of the port (Malchow & Kanafani, 2004). Researchers Malchow and Kanafani (2004) found that the inland distance from the origin to the port turned out to have the greatest explanatory power with a negative effect on the port choice. Also the oceanic distance from the port to the destination has a large, negative impact. A study by Caldeirinha, Felício and Coelho (2009) showed that the distance between a port and the urban centre has a positive relation with the port financial performance, but the location near the sea or the city does not have a significant relation with operational performance and port efficiency. Caldeirinha et al. (2009) concluded that, nevertheless, location is an important determinant of port performance.

The location of a port is very important because of the function the port has for the hinterland, as stated by Tongzon (1995). For example, the transhipment ports of Singapore, Hong Kong and Rotterdam have geographical advantages relative to the ports of Melbourne and Sydney because of their role for the hinterland. The ports of Melbourne and Sydney are mostly used for their isolated and small economy, while Singapore, Hong Kong and Rotterdam have better access to the sea and the hinterland (Tongzon, 1995). As explained by Notteboom and Rodrigue (2005), seaports as the port of Rotterdam currently act primarily as transhipment hubs for their hinterland and other destinations, because of their favourable location. These ports are heading towards a new phase in port development, which is called regionalisation. Also offshore hubs – ports on locations without a significant local hinterland – such as Malta and Freeport (Bahamas), are emerging because of the technical advantages of their location (Notteboom & Rodrigue, 2005). Also in a case study analysing the Spanish inter-port container traffic distribution, the location between the port and the hinterland proves to be a relevant factor for the port selection and so for the throughput volumes (Garcia-Alonso & Sanchez-Soriano, 2009). This indicates that the location of a port can be highly important in determining the port performance.

Although the research by Tongzon (1995) for a selected sample of 23 container ports all over the world showed that the effect of port location on port performance was not statistically

significant, the other – more recent – articles do show that location is important. For this reason, the location of a port will be taken into further consideration in this paper.

Hinterland access

In addition to the previous determinant, the access to the hinterland plays an important role in achieving a high port performance. As discussed by Langen and Chouly (2004), access to the hinterland is highly important for the competitiveness of a port and for the throughput volumes. The last years, ports have become parts of intermodal networks in complete transport chains. Because of this development, ports have to pay more attention to the quality of the hinterland services and the access to the hinterland. In order to remain competitive, ports need to improve the hinterland transport services and access. Hinterland access is mainly relevant for ports with high throughput volumes, for example transit ports where a large part of cargo is transported to the hinterland (Langen & Chouly, 2004). In the case of the ports of Amsterdam, Rotterdam and Antwerp, the infrastructure to the hinterland is an important factor for the throughput volume of goods in the port. There is a good connection between the Port of Rotterdam and the sites for oil refining, steel production, energy production and the petrochemical industry. Liquid bulk is transported from the Port of Rotterdam to these sites via pipeline, while dry bulk is shipped by barge to the hinterland. Because Amsterdam, Rotterdam and Antwerp have good access to the river Rhine, these ports have a competitive advantage over other ports in Germany and France (Langen, Meijeren, & Tavasszy, 2012). The access to the hinterland will be further taken into account in this paper.

Draft and accessibility

Other important port characteristics are the size, draft and the accessibility of the port. The last years the average container vessel size has increased continually, from 400-1000 TEUs in 1960 to 7000-9000 TEUs in 2000 and 18000-20000 TEU in 2015 (Loo & Hook, 2002; Shen, 2015). This trend was due to cost savings of running larger ships and lower prices for large containerships. The larger ships cannot enter all ports in the world. Only container ports with sufficient modern equipment to handle the vessels and a good draft and accessibility are entered (Loo & Hook, 2002). In this respect, the size of a port is also one of the most important characteristics when explaining the performance of a port. However, it is not clear whether the port size influences the growth rate of the port or the growth rate influences the port size (Caldeirinha et al., 2009). In contrast, there is evidence that the depth of the navigation channel is highly important for attracting the largest vessels and therefore has an important influence on the port performance (Tongzon & Heng, 2005; Langen et al., 2012; Caldeirinha et al., 2009). The deeper the navigation access to the port, the more large vessels are willing to enter the port and

the higher the total throughput (Caldeirinha et al., 2009). Insufficient water depths can prevent some ports from growing and being a transhipment port (Tongzon & Heng, 2005). An insufficient water depth can also result in less competitive vessels, lower efficiency and a limited influence area (Caldeirinha et al., 2009). Thus, if a port has a good draft and a high depth, the chance to attract more enormous container vessels is relatively high. This can result in a higher port performance. Examples of these ports are the Port of Hong Kong and the Yantian Port in China, which both enjoy a natural advantage of a deep-water channel of about 14 metres (Loo & Hook, 2002). In the case of the Port of Rotterdam, the location and draft of the port are highly important. Rotterdam is the busiest port in the Hamburg-Le Havre Range with the highest throughput volumes for dry bulk, liquid bulk and containers. This can be explained by the natural advantage of a large draft of the port (the depth of the channels is 23 metres) and the open access to sea (there are no locks) in comparison to other ports such as Hamburg and Antwerp (Langen et al., 2012).

Tongzon and Heng (2005) also took in consideration the quay length of the terminal as an independent variable for the total throughput in a container port and it turned out to have a statistically significant, positive effect. In addition, the port infrastructure is necessary for explaining performance, but not sufficient. Other variables, such as maritime and inland accessibility, are always necessary to completely explain the link between the port infrastructure and port performance (Caldeirinha et al., 2009). Because of the importance of the draft and accessibility for the port performance, these characteristics will be taken into account in this paper.

Presence of firms in the port

Seaports are mostly seen as nodes in a transport chain, but they can also be seen as regional clusters of economic activities. A cluster is a group of geographically concentrated and related business units, associations and organisations (Langen, 2004). This homogeneous group of firms is clustered around an economic specialisation, a common product or process (Nijdam & Langen, 2003). Several activities are concentrated in the port, including cargo generating firms. The development of an individual firm in the cluster depends on the development of the whole cluster. In seaport clusters, the core activity is cargo handling (all activities that concern loading and unloading the cargo), but other components of the cluster are transport, logistics, manufacturing and trade (Langen & Chouly, 2004). Because storage, production and transport firms are also located in the port cluster, the total value added of the cluster is higher than the sum of the parts and trade is easier (Langen, 2004). An example is the Dutch Maritime Cluster, consisting of ports, offshore firms, a navy firm, maritime suppliers, inland waterway firms,

shipping firms, maritime services, shipbuilding firms, dredging firms, yacht industries and fishery. All these firms work together in the cluster. The port sector is the largest sector in the cluster, while the shipbuilding sector is has the central position and is connected to all other sectors (Nijdam & Langen, 2003). Because the presence of firms in the port seems to be influential for the port performance, this will be taken into account in this paper.

Port and terminal efficiency

One of the most important determinants of port performance is the efficiency of the port and the terminal (Tongzon, 1995; Tongzon & Heng, 2005). Terminal efficiency can be defined as the number of containers loaded and unloaded per berth hour. In fact, this reflects the productivity level of labour and capital in the port (Tongzon, 1995). When the efficiency level increases, more cargo can be handled and throughput increases (Tongzon & Heng, 2005). The research by Tongzon (1995) showed that terminal efficiency has a statistically significant, positive influence on port performance, but port efficiency itself is also influenced by many factors such as the container mix, the vessel size and the crane efficiency. Port efficiency is also influenced by the work practices, consisting of the delays in commencing and the delays during stevedoring. The difference between berth time and gross working time represents the delays in commencing. The difference between the gross working time and net working time are the delays during stevedoring, due to meal breaks, weather and ship problems, equipment crashes etcetera. Due to the unavailability of data, Tongzon (1995) could not examine the link between these variables and the port efficiency, but he argued that these variables have a negative effect on the efficiency of a port and terminal. A paper by Loo and Hook (2002) focussed on the case of Hong Kong, where operational efficiency in the port is very important for the performance of the container port. The container throughput in Hong Kong grew from 9.2 million TEUs in 1993 to 16.1 million TEUS in 1999 at an annual growth rate of 9.8%, despite the negative effect of the Asian financial crisis. This enormous growth was made possible by a boosted productivity and a record level of operational efficiency measured by the container moves per crane (Loo & Hook, 2002). Because the port and terminal efficiency seems to be an important determinant for port performance, this factor will also be taken into account in this paper.

Port charges

Another influential factor is the level of the port charges. These are the charges that the port users must pay for the services and facilities in the port and are a major source for shipping lines to decrease the total operation costs. Therefore shippers prefer ports that offer low service charges. The level of port charges affects the competitive position of a port (Tongzon & Heng, 2005). However, a research by Tongzon (1995) showed that the port charges do not have a

significant effect on the port performance. Shippers are more concerned with other (higher) costs, for example costs of delays and inefficient services. Port charges are just a small part of the overall costs of trading (Tongzon, 1995). Malchow and Kanafani (2004) also did not take into account the port charges in their research, because of complexities making it difficult to measure the charges and because industry representatives suggested that port charges are relatively insignificant. Liu & Park (2011) did examine the effect of port charges on port performance, but found a non-significant effect in the case of Korean and Chinese ports. For these reasons, the port charges will not be taken into account in this paper.

Economic activities and development

Demand for port usage is a derived demand from import, export and transhipment, because people and sectors exchange goods that are produced and consumed at different locations (Tongzon, 1995; Seabrooke, Hui, Lam, & Wong, 2003). This occurs both within a country and across countries. Therefore it is reasonable that the macroeconomic conditions, for example measured by countries' GDP, should be taken into account as a determinant for the port performance. Research by Tongzon (1995) showed that this factor indeed has a significant influence on the port performance. Of various economic factors, the value of direct imports turned out to be the most reliable and influential determinant of throughput volumes (Seabrooke et al., 2003). The non-stationary relationship between the import container volume and economic growth in Taiwan was examined by Chou, Chu and Liang (2008). The focus of their research was on economic data, including the volumes of export containers, the volumes of import containers, the population, the industrial production index, the gross national product (GNP), the GNP per capita, the wholesale price, the gross domestic product (GDP), the agricultural GDP, the industrial GDP and the service GDP for the period 1989-2001 (Chou et al., 2008). The results showed that there is a significant correlation between all these economic variables, which indicates that the macroeconomic conditions of a country are very important for the performance of a port. Also Caldeirinha et al. (2009) showed that the economic development of a region has a significant influence on the port performance, because the economic development is largely responsible for the port expansion.

As a part of the macroeconomic conditions, the labour regulations in a country can be a determinant of the performance of a port. According to Barton and Turnbull (2002), labour is the main and most flexible component of transportation in terms of cost, time and risk. They argued that operating costs consists for 60 to 70 percent of labour costs. Labour demand and labour costs fluctuate daily, because of the variable activities in a port. Therefore, labour regulations must be flexible to match the fluctuating demand for labour to the supply of labour,

without high costs. Labour regulation can have a significant effect both in the short term on port efficiency and in the long term on competitive advantages between ports and investment decisions. In their empirical research, Barton and Turnbull (2002) focussed on the social institutions and informal processes of labour regulation and the influence of these social institutions on the economic competitiveness of an economy. The main question was if marked-based organisations (with minimal institutions) do better or worse than socially regulated organisations (with a lot of institutions). The evidence showed that one of the most important differences between the ports of London (with a laissez-faire, marked-based approach), Le Havre (with socially regulated approach) and Antwerp was the inflexibility of the labour caused by permanent employment instead of flexible workers (Barton & Turnbull, 2002). In this context, more flexible labour had a positive influence on the port performance. However, this is a somewhat older study, and in the past thirteen years a lot of innovations may have changed the situation a lot. The rise of the container industry has made shipping extremely cheaper because of the lower amount of workers needed. Previously, workers loaded and unloaded the ships in every port, but nowadays a row of enormous cranes and trolleys have taken over most of the work (Levinson, 2010). Because of these innovations, the labour costs have significantly decreased in the past years, so labour is not the main component of operating costs anymore. Therefore, the labour force, labour costs and labour regulations will not be the most important determinant of port performance is this paper. The focus will lie on the other economic variables.

Not only the economy of the port's country plays a role for port performance, but also the economy of the hinterland. Empirical evidence by Liu & Park (2011) showed that the economic development of the hinterland has a significant influence on port performance. They measured the hinterland economic level by the hinterland's GDP and the hinterland's import-export volume. In the case of Chinese ports in the period from 2001 to 2007, these variables presented the most significant effects on the container throughput. Also in the case of Korean ports the hinterland economic level was a significant determinant for the container throughput (Liu & Park, 2011). Another research that took into account the economic development, was conducted by Langen et al. (2012). Because economic development, trade flows and logistics are surrounded by uncertainties, they used four different scenarios to make long-term projections of port throughput in the Hamburg-Le Havre Range. The scenarios consisted of assumptions about the future development. One of the uncertain factors they took into account was the economic development. The results showed that the different scenarios had a different influence on the throughput volumes (Langen et al., 2012). This suggests that the economic development seems

to be an important determinant of port performance measured by throughput volumes. The development of the local economy will be further examined in this paper.

2.3. The impacts of port activities on the economic development of a country or region

As explained in the previous paragraphs, one determinant of the port performance is the economic activity in a country, region or the hinterland. However, the link between port performance and the macroeconomic conditions can also be seen the other way around. Because ports play an important role in domestic and international trade, they seem to have an effect on the local and national economic development (Jung, 2011). The port activity can have an impact on the economy in terms of GDP or other measures, but also in terms of employment.

It is widely accepted that ports play an important role in the growth and development of economies on local, regional and national levels (Li-zhuo, 2012; Deng, Lu, & Xiao, 2013). Li-zhuo (2012) argued that the development of port logistics influences the cost and efficiency of the production sector and that investments in the logistics infrastructure have a positive effect on the economy. This can be explained by the fact that better port logistics help reduce the transportation costs in the production sector and increase the efficiency. This will have effects on economic growth. Li-zhuo (2012) describes the multiplier effect: the national income will increase several times as a result of the investment in port logistics, because the need of factors of production, materials and new technologies and equipment will be stimulated. To test whether this argumentation is correct, an empirical research for the Qinhuangdao port in China from 1995 to 2010 was conducted by Li-zhuo (2012). The gross domestic product (GDP) of Qinhuangdao was used as a variable of economic growth, while the ports logistics were indirectly measured by the throughput of goods. So actually, the study examined the link between port throughput and GDP. The results showed that the port logistics or throughput growth influences the increase of GDP, but the impact of GDP on port logistics or throughput was small and not significant (Li-zhuo, 2012). This indicates that the growth of port logistics and therefore the port throughput are important for the development of the local economy, but not the other way around. In this context, one can also refer to the port as an industrial cluster, as already mentioned in the first part of this literature review. A port cluster is a group of geographically concentrated and business related companies. They all supply port-related services in the port area such as storage, production and transportation, relying on the advantages of port location, infrastructure and services (Langen, 2004). In the end, the port becomes a cluster and an economic centre and contributes to the national, regional or local economy (Langen, 2004; Li-zhuo, 2012). Because the location and infrastructure of a port can

attract firms of the same business, the port area and its throughput seem to have a positive influence on the economy.

Deng, Lu and Xiao (2013) studied the impact of port demand, port supply and value added activity in port on the development of the regional economy for five coastal port clusters in China. The results showed that port supply had a significant positive relation with port demand, port demand turned out to be significantly related to value added activity and value added activity had a significant influence on the regional economy, while port supply and port demand turned out not to have a direct significant effect on the regional economy. Instead, port supply proved to have an indirect impact on the regional economy via port demand and value added activity in port. In the same way, port demand had an indirect effect on the regional economy via the value added activities.

Because employment is a part of the local or national economy, the question raises whether the port activity has an impact on the employment. On the one hand, ports seem to have a great positive impact on local economies and create a higher employment. On the other hand, the developments of more capital intensive handling systems in the shipping industry and the container market reduced the effect on direct employment. Bottasso, Conti, Ferrari, Merk and Tei (2013) conducted an empirical research to study the impact of port throughput on local employment and found a statistically significant, positive effect. They used different measures of throughput: total throughput (including liquid bulk) and net throughput (excluding liquid bulk), because of the smaller labour force needed to handle liquid bulk and therefore the probably minor effect on the employment. Both measures of throughput turned out to have a significant effect on employment, but the effect of net throughput was twice as large as the effect of total throughput. This result suggests that the commodity type of cargo has an interaction effect on the relation between port throughput and employment. Another difference was created when service employment and industrial employment were taken separately as dependent variables instead of the total local employment. The impact of port activities on service employment is lower than on the industrial employment, probably because some port related services are not located in the port region but at some distance (Bottasso et al., 2013). This indicates that the port throughput has a significant effect on local employment, but the effect can differ by commodity group and type of employment.

A note should be made about the big differences in the availability of port and transport infrastructure between developed countries, such as North America, Europe and Oceania, and developing countries, such as Africa, Central and South America and Asia (Hilling, 2003). Most

countries in the Third World have a lack of mechanised transport, transport is unreliable, expensive and labour-intensive and the infrastructure is poorly maintained. In these developing countries there are no sufficient skills and resources to improve the transport system and infrastructure. On the other side, in the advanced countries, the last years can be characterised as a transport revolution: the expansion of air travel, car ownership, containerisation and restructured distribution channels (Hilling, 2003). In order to compete with global and regional markets, the trade and transportation systems of a country should be efficient. In the developing countries in the Middle East and North Africa, there are significant weaknesses in the trade infrastructure. These countries need to improve the efficiency of their trade logistics in order to participate in the world economy and to attract foreign direct investment. This requires a lot of national and regional actions (Devlin & Yee, 2005). As already described in the previous paragraphs, there seems to be a positive relation between port performance or port development and economic development. However, this is not always the case. Three relations between transport and development can be distinguished: a positive, permissive and negative relation. When there is a positive relation, innovation in transport directly leads to an expansion of economic activity. With a permissive relation, transport innovations do not directly increase economic activity, but also do not inhibit economic growth. A negative relation occurs when the return on investment in the transport innovation is less than a similar investment in a direct productive activity. A negative impact can be caused by for example a high demand for capital, high interest rates for borrowed money and a disappointing generation of income. This negative relation between the port development and the economic development is a main problem in the developing countries, while there is a positive relation in the developed countries (Hilling, 2003). In most developing countries, a development in port infrastructure will not cause an increase or even cause a decrease in economic development. This issue has to be taken into account in the empirical research of this paper.

2.4. The direction of the link between port activities and economic development

For the convenience of this research, only one causal effect will be examined in this paper. On the one side, as described in the literature review, a lot of literature and empirical researches show that the economic activities of a region or country have a significant effect on the port performance. On the other side, some papers argued that port activities have an impact on the local or national economy. In this respect, both directions can be correct. Jung (2011) describes the discussion between different ideas among scientists. Traditional scientists argue that ports are the accelerators of the economic development, while another group of scientists states that ports respond to economic demand.

The effect of the port activities on the local economy has changed over time. Ports used to be mainly loading and unloading places between sea and land, but nowadays other logistics activities and value added activities also take place in the port or in the vicinity of the port. Due to these extra activities, the impact of ports on the regional and national economy has increased. Also the innovation of transport technologies increased the interdependency among economies and port activities. In contrast, these technology innovations in the transport sector lead to a more capital intensive sector. Therefore, the effect of ports on the creation of employment decreased. Also the growth of vessel size requires a large depth of the channels and a good port infrastructure. Old ports in the cities cannot serve these large ships, resulting in a weaker relation between ports and the economies. In the case of Korea in the period 1990-2008, the employment of port activities decreased over time, because of the labour saving investments in the industry. Since the 1980's, the ports turned out to have a minor influence on the regional economies and port cities (Jung, 2011), while the effect of the economy on the port activities is still relevant. For this reason, the impact of a port on the economy will not be further examined. The focus of this paper will be on the determinants of the port performance and especially on the influence of the local economy on the port performance.

3. Quantitative analysis

In this section, a quantitative analysis on the relation between port performance and economic development will be performed. As described in the literature review, only the influence of the economic development of a country or region on the port performance will be examined. Also the other determinants of port performance will be taken into account.

3.1. Hypotheses

The following hypotheses can be drawn from the literature review.

H_1: The location of a port has a positive influence on the port performance.

H_2: The hinterland access has a positive effect on the port performance.

H_3: The draft of a port positively affects the port performance.

H_4: The maritime accessibility positively influences the port performance.

H_5: The presence of firms in the port has a positive influence on the port performance.

H_6: The port and terminal efficiency positively affects the port performance.

H_7: The local economy has a positive influence on the port performance.

H_8: The hinterland's economy has a positive influence on the port performance.

3.2. The Hamburg-Le Havre Range

In this research, the most important ports in the Hamburg-Le Havre Range will be selected. The Hamburg-Le Havre Range is an area in the North-West of Europe and consists of ports in France, Belgium, the Netherlands and Germany (Langen et al., 2012). The most important ports are Hamburg, Bremerhaven, Wilhelmshaven, Amsterdam, Rotterdam, Zeeland Seaport, Antwerp, Ghent, Zeebrugge, Dunkirk and Le Havre (PoR, 2014). In Table 1 the ports and their corresponding regions and countries are shown.

Port	**Region**	**Country**
Hamburg	Hamburg	Germany
Bremerhaven	Bremen	Germany
Wilhelmshaven	Weser-Ems	Germany
Amsterdam	Noord-Holland	The Netherlands
Rotterdam	Zuid-Holland	The Netherlands
Zeeland Seaport	Zeeland	The Netherlands
Antwerp	Prov. Antwerpen	Belgium
Ghent	Prov. Oost-Vlaanderen	Belgium
Zeebrugge	Prov. West-Vlaanderen	Belgium
Dunkirk	Nord-Pas-de-Calais	France
Le Havre	Haute-Normandie	France

Table 1: The ports in the Hamburg-Le Havre Range. Source: PoR (2014); (Eurostat, 2015e).

As described in the literature review, there is a big difference in the port and transport infrastructure between the developed countries and the developing countries in the world. This can affect the relation between the port performance and the economic development. Because all ports and countries in the Hamburg-Le Havre Range are developed countries, this potential problem is eliminated in the quantitative analysis.

3.3. Data

Because in 2014 the container throughput in the port of Rotterdam represented a large part of the total throughput and because the container throughput still increases every year (Havenbedrijf Rotterdam, 2014), this analysis will be focussed only on the container transport in the ports in the Hamburg-Le Havre Range in Europe. This is also because the container throughput best reflects the consumer demand (Vossers, 2015). Therefore, the port performance will be measured by the throughput volume of containers in Twenty-foot Equivalent Units (TEUs) per year.

Information about the location of ports is not readily available. It is difficult to reflect the port location in a quantitative variable and this goes beyond the scope of this paper. Thus, although location seems important, this will be kept out of the empirical analysis. Also data about the hinterland access is not available. The draft of a port will be measured by the maximum depth of the channels in the port. The maritime accessibility will be measured by a dummy variable indicating if there are locks before entering the port. The presence of firms in the port would be measured by the number of firms located in the port area, but these data is not available. The port efficiency should be measured by the container volume in TEUs per crane per hour. However, the necessary data is not available, so the port efficiency will not be analysed. The local economy will be represented by the regional and national economy. For both of these economies the Gross Domestic Product (GDP) can be used. As indicators for the national economy, the GDP in Purchasing Power Standards (PPS), the GDP per capita, the export of goods and services as percentage of GDP, the import of goods and services as percentages of GDP and the export to import ratio will be used. For expressing the regional economy, the NUTS 2[1] regions will be used. The regional GDP will be measured in PPS per inhabitant in order to eliminate the differences in price levels between countries and the differences in absolute region size, respectively (Eurostat, 2015e). Because the ports in the Hamburg-Le Havre Range all serve the same North-Western European hinterland (Langen et al., 2012), there is no comparison possible between the

[1] The NUTS classification is a hierarchical system consisting of NUTS 1, NUTS 2 and NUTS 3. The NUTS 2 regions are the basic regions for the application of regional policies (Eurostat, n.d.).

hinterland's economies. Therefore, the hinterland's economy will not be used as an independent variable for port performance in this case study.

Information about the container throughput per year of all ports in the Hamburg-Le Havre Range is used from the Port of Rotterdam statistics (PoR, 2014). The depth of the channels is found at the Port Directory (Port Directory, n.d.). The information about locks is consulted from the various port authorities (Hamburg Port Authority, n.d.; Seestadt Bremerhaven, 2015; Wilhelmshaven, 2011; Port of Amsterdam, n.d.; Port of Rotterdam, n.d.-a; Zeeland Seaports, n.d.; Port of Antwerp, 2012; Port of Ghent, 2015; Port of Zeebrugge, n.d.; Dunkerque Port, n.d.; Le Havre Port, 2011). The national economic variables are consulted from Eurostat (2015a; 2015b; 2015c; 2015d). Also the regional GDP in PPS per inhabitant is found at Eurostat (2015e).

The data will be analysed over the period 2002-2011, because only of this period complete data is available. Because the Wilhelmshaven showed zero throughputs of containers in the period 2002-2011, this port will be eliminated from the data set. The analysis will be based on the remaining ports in the Hamburg-Le Havre Range, which do handle containers. Due to some unavailable data, only the hypotheses H_3, H_4, and H_7 can be tested. The focus of the analysis will be on the economic determinants of H_7.

3.4. Methodology

This research contains data about multiple ports for multiple years, so this is a panel data analysis, also known as cross-sectional time series analysis. There is data of 10 ports for 10 years (2002-2011), so the data contains 100 observations. The panel data is strongly balanced.

First, a correlation matrix of all variables will be made. This can give a general overview of the two-sided relations between the variables. Next, a linear regression will be performed with the container throughput as the dependent variable. This can be done by estimating a fixed effects model or a random effects model, depending on the nature of the unobserved (omitted) variables. When the omitted variables are uncorrelated with the independent variables in the model, then a random model is best. When the omitted variables are likely to be correlated with the explanatory variables, the fixed effects model is best because this model controls for the variable bias (Williams, 2015a). In this research a lot of data is not available, but it is reasonable that the unobserved variables are correlated with the observed explanatory variables in the model – for example the port's location, maritime accessibility, hinterland connection, hinterland economy and local economy may be correlated – so a fixed effects model seems most appropriate. A Hausman test has been conducted to statistically test which model is best. This

test showed that the fixed effects model is best (p=0.0167 < 0.05). Therefore, fixed effects will be used in this analysis. The regression equation takes the following form (Seltman, 2015; Hill, Griffiths, & Lim, 2012):

$$THROUGHPUT_{it} = \beta_1 + \beta_2*DEPTH_{it} + \beta_3*LOCKS_{it} + \beta_4*NGDP_{it} + \beta_5*NGDP\_CAP_{it} + \beta_6*EXPORT_{it} + \beta_7*IMPORT_{it} + \beta_8*EX\_IM_{it} + \beta_9*RGDP\_CAP_{it} + e_{it} \quad (Eq.\ 1)$$

where
THROUGHPUT = the container throughput per year in 1000 TEU
DEPTH = the depth of the port channels in metres
LOCKS = a dummy variable, where 0 indicates one or more of locks and 1 indicates no locks
NGDP = the national GDP in million PPS
NGDP_CAP = the national GDP per capita in PPS
EXPORT = the export of goods and services as a percentage of GDP
IMPORT = the import of goods and services as a percentage of GDP
EX_IM = the export to import ratio
RGDP_CAP = the regional GDP per capita in PPS
the subscript i denotes the individual (port); t denotes the time period (year); β_1 is the intercept; β_2 till β_9 are the slope coefficients for the independent variables; e_{it} is the error term.

The parameter estimates and the significance of the parameters will be analysed. Variables with an insignificant effect on the port throughput can be eliminated, if there is a good and logical reason. A new model can be estimated with fewer variables. A model with as little insignificant variables as possible will be tried to create. The various models will be compared using the Bayesian information criterion (BIC). The model with the lowest BIC number will be selected. Then the parameter estimates and the R^2 of the model will be discussed, which is a goodness-of-fit measure (Park, 2011). The R^2 indicates the fraction of variance in the dependent variable explained by the model (Field, 2013). Due to the unavailable data, some estimates could be incorrect and the R^2 of the models could have been higher when more variables would be included. The results have to be interpreted cautiously.

3.5. Results

Correlation

A correlation matrix showing the two-sided Pearson correlations between all variables is showed in *Appendix A*. The correlations show that most economic variables are interrelated with

each other. The container throughput is only significantly correlated with the presence of locks, the national GDP, the export to import ratio and the regional GDP per capita. The throughput seems to be not significantly correlated with the depth of the port channels, the national GDP per capita, the export percentage and import percentage. Furthermore, the import percentage and the export to import ratio are not correlated, while the export percentages and the export to import ratio are. Because of the many significant correlations between the different economic variables, multicollinearity could be a problem in the further analysis.

Linear fixed effects models

In order to test the influence of the various determinants on the container throughput, three linear models with fixed effects has been made. In the first step, all available variables are included in the analysis, which is called Model 1 and matches Equation 1 on the previous page. The estimates of the fixed effects of Model 1 can be found in *Appendix B*. As can be seen, the estimated effect of EXPORT, IMPORT and EX_IM are not statistically significant (p=0.535; p=0.181; p=0.980, respectively). The variable EX_IM has the most insignificant effect. As described above and resulted from the correlation matrix in *Appendix A*, EX_IM is significantly correlated with EXPORT (r=0.283, p=0.004). Therefore, the variable EX_IM is omitted from Model 2 of the fixed effects model analysis. As shown in *Appendix C*, the estimated effect of NGDP has become more significant but smaller in Model 2. The effect of IMPORT is now statistically significant (p=0.001), but the effect of EXPORT is still not significant (p=0.147). The EXPORT variable is highly correlated to the IMPORT variable (r=0.987, p=0.000, see *Appendix A*) and most other independent variables, so there is some multicollinearity. Therefore, in Model 3 also the variable EXPORT is omitted (see *Appendix D*). In this model, all estimated effects are statistically significant.

Model selection

In order to select one of the three models, the Bayesian information criterion (BIC) can be used. The absolute value of the BIC number has no interpretation, but the BIC values of two or more models can be compared. A smaller BIC number indicates a better model (Seltman, 2015; Field, 2013). Table 2 shows the BIC numbers of the three models. The BIC number of Model 3 is the lowest, indicating that this model is the best one.

Table 2 also shows the R^2 of the three models, indicating the percentage of the variance in the dependent variable THROUGHPUT explained by the independent variables (Field, 2013). Because the estimates of the fixed effects model only use the within-individual differences, the R^2 of the within-individual differences are relevant and shown in the table (Williams, 2015b).

The table shows that the R^2 decreases from 0.5396 in Model 1 to 0.5037 in Model 2 as a result of omitting the variable EX_IM in Model 2. When also the variable EXPORT was omitted in Model 3, the R^2 decreased slightly from 0.5037 to 0.4994, so this omission did not have a large effect on the explanatory power of the model, probably because of the multicollinearity. The decrease in R^2 between the different models is logical, because the fewer variables used the less variance can be explained. The R^2 is not used for selecting the best model, the BIC number has been used for this.

Model	Independent variables	BIC	R^2
Model 1	(intercept), LOCKS, DEPTH, NGDP, NGDP_CAP, EXPORT, IMPORT, EX_IM, RGDP_CAP	1771.951	0.5396
Model 2	(intercept), LOCKS, DEPTH, NGDP, NGDP_CAP, EXPORT, IMPORT, RGDP_CAP	1767.346	0.5037
Model 3	(intercept), LOCKS, DEPTH, NGDP, NGDP_CAP, IMPORT, RGDP_CAP	1764.853	0.4994

Table 2: Comparison of BIC number and the R^2 for the different linear fixed effects models. In all models, the dependent variable is the container throughput per year in 1000 TEU (THROUGHPUT).

Interpreting the model

From now on only Model 3 will be discussed. In Table 3 the parameter estimates of the fixed effects and their p-value are shown. These results indicate that the variables LOCKS, DEPTH, NGDP, NGDP_CAP, IMPORT and RGDP_CAP have a significant effect on the container throughput. The R^2 of this model is 0.4994, which indicates that 49.9 percent of the variance in THROUGHPUT is explained by the independent variables.

Parameter	Estimate	P-value
Intercept	-938.961107	.676
[LOCKS=0]	-8188.329076	.000
[LOCKS=1]	0[a]	.
DEPTH	283.958083	.000
NGDP	.002341	.000
NGDP_CAP	-.451608	.000
IMPORT	158.078423	.000
RGDP_CAP	.316493	.000

Table 3: Parameter estimates for Model 3. The dependent variable is the container throughput per year in 1000 TEU (THROUGHPUT). *a. This parameter is set to zero because it is redundant.*

H_3: The draft of a port positively affects the port performance.

The presence of locks (LOCKS=0) has a significant negative effect on the container throughput. On average, a port with one or more locks has a container throughput of 8,188,329 TEU per year less than a port without locks. In other words, the good draft of a port (without locks) has a positive effect on the port performance. Therefore, hypothesis H_3 is adopted.

H_4: The maritime accessibility positively influences the port performance.

The depth of the channels in the port has a significant positive effect on the container throughput. When the depth increases by one metre, the container throughput increases by 283,958 TEU per year. The depth of the channels was used as measurement for the maritime accessibility. Thus, the results indicate a positive influence of the maritime accessibility on the port performance. Therefore, hypothesis H_4 is adopted.

H_7: The local economy has a positive influence on the port performance.

The last hypothesis that has been tested in this case study is H_7. This hypothesis was tested by multiple variables. The local economy was represented by the national economy and the regional economy. The national economy was measured by the national GDP in million PPS and the national GDP per capita in PPS. Both effects are statistically significant. However, the estimated parameter of the national GDP in million PPS is quite small. When the national GDP increases by one million PPS, the container throughput increases by only 2.3 TEU, which is negligible. When the national GDP per capita increases by a thousand PPS, the container throughput even decreases by 451,608 TEU. This parameter has a large negative effect on the container throughput. This is a very striking observation, because one would expect a strong positive relation between the national GDP and the national GDP per capita on the one side and the port performance on the other side. The striking effect can partly be explained by looking at the graphs of these two variables in Figure 1.

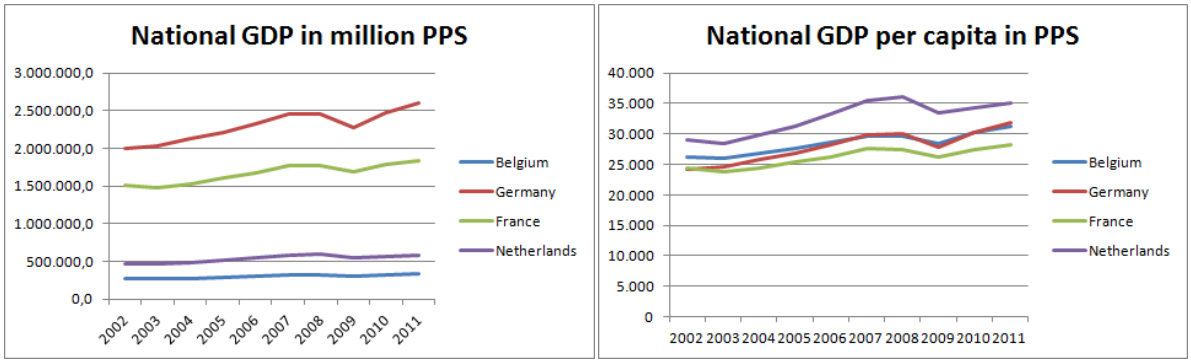

Figure 1: Graphs of NGDP (left) and NGDP_CAP (right) for Belgium, Germany, France and the Netherlands in the period 2002-2011.

Overall, the national GDP and the national GDP per capita of the four countries in the Hamburg-Le Havre Range are rising till 2008. Then the countries show a decline in GDP in the years 2008-2009, indicating the beginning of the economic crisis. Since 2009 there is again a rising trend, although the crisis is still going on. There may be a link between the effects of the economic crisis and the port performance. So the national GDP and the national GDP per capita already increases after 2009, while the port throughput is still low because of the economic crisis. This may explain the weak positive effect of the national GDP in million PPS and the negative effect of the national GDP per capita in PPS.

Another possible explanation is given by Musso, Benacchio, Ferrari and Haralambides (2002). They described the fact that the national economy is getting less and less important for the port performance. The international economies and the hinterland is getting more important than the local or national economy, so therefore the effects of the national GDP and the national GDP per capita on the port performance can be small. The economic crisis has enlarged this effect and even made the effect of the national GDP per capita negative.

The import of goods and services as a percentage of GDP has a positive influence on the container throughput. When the import increases by one percentage point of GDP, the container throughput increases by 158,078 TEU. Beside the national economy, also the regional economy is of significant importance for the container throughput in the port. When the regional GDP per capita increases by a thousand PPS, the container throughput increases by 316,493 TEU.

Because some of the economic parameters showed significant effects while others didn't, hypotheses H_7 cannot be rejected or adopted strictly. The national GDP per capita even showed a negative effect on the port performance. However, most economic variables showed a significant positive influence on the port performance and some effects were insignificant because of multicollinearity between the various economic variables. Therefore, the hypothesis seems to be correct.

4. Conclusion and discussion

4.1. Research question and hypotheses

In this paper, the relation between port performance and economic development has been researched. The research question was: *Which relation exists between the economic development and the port performance for ports in the Hamburg–Le Havre Range?*

The literature review showed that there seems to be both an influence of economic development on port performance and an influence of economic development on port performance. It was also shown that there are a lot of other determinants of port performance that are highly important, namely the location and hinterland, the hinterland access, the draft and accessibility, the presence of firms in the port and the port and terminal efficiency. In contrast, the port charges do not seem so important. Although both directions of the relation between port performance and economic development seem to be correct, the relation has changed over time and the impact of a port on its local economy has weakened. Therefore, the quantitative analysis of this paper only focussed on the impact of the economic development of a country or region on the performance of a port and the other determinants of the port performance.

In the empirical analysis, three hypotheses were tested via a correlation analysis and a linear regression model with the port performance measured by container throughput as dependent variable. Hypothesis H_3 – *The draft of a port positively affects the port performance* – was adopted. Hypothesis H_4 – *The maritime accessibility positively influences the port performance* – was also adopted. However, hypothesis H_7 – *The local economy has a positive influence on the port performance* – was neither adopted nor rejected. The quantitative analysis showed that the national GDP, the import of goods and services as percentage of GDP and the regional GDP per capita had a positive significant influence on port performance, while the export of goods and services as percentage of GDP and the export to import ratio did not have a significant effect and the national GDP per capita even negatively affects the port performance. Because this effect was probably raised by multicollinearity, in general there seems to be a positive effect of the local economy on the port performance.

The regression model, including the depth of the channels, the presence of locks and the local economy explains 49.9 percent of the variance in the container throughput in the port. The presence of locks has the largest effect on port performance, followed by the depth of the channels and the import of goods and services. Of the economic determinants, the import of goods and services has the largest impact on port performance. This is in accordance with the

results of Seabrooke et al. (2003) and therefore seems plausible. In contrast, the export of goods and services as a percentage of GDP and the export to import ratio do not have a significant influence on the container throughput. Apparently, the import of goods and services is more important for the container transport in the Hamburg-Le Havre Range than the export of goods and services. Probably the ports in this region mainly import containers from other ports in other regions of the world. This may be a result of the regionalisation, where seaports act as transhipment hubs for the hinterland and therefore import more than export (Notteboom & Rodrigue, 2005).

To answer the research question, it can be said that there exists a positive relation between the performance of a port and the economic development of the country or region, at least for the effect of the economy on the port performance. The import of goods and services is the largest economic determinant of the port performance, while the export of goods and services is not significantly important. The national GDP has a small or even negligible effect, but this may be influenced by the economic crisis since 2008. The regional GDP per capita has a larger effect on the port performance. The effect of the port performance on the economic development is plausible, but not empirically examined in this paper.

4.2. Research limitations

In this research, the biggest limitation is that only some determinants of port performance could be tested by the statistical analysis due the absence of a lot of data. As a result, the analysis was smaller and simpler than expected. The explanatory power of the model, measured by R^2 could have been higher when more variables were added. Now, 49.9 percent of the variance in port performance is explained by the draft of the port, the maritime accessibility and various national and regional economic variables. Because the potential relations between the missing variables could not be tested, the problem of confounding variables is lurking. Therefore, some results could be incorrect and should be interpreted cautiously. Also not all country, region and port specific characteristics were taken into account. For example the regime, population, crises, wars, culture, health or well-being of the people can be influential. These characteristics should be used as control variables.

4.3. Recommendations for further research

In this research, only data over the period 2002-2011 is used for the container ports in the Hamburg-Le Havre Range. This is fine for a specific case such as this one, but for further research it is recommended to analyse a longer period, for example from 1980 to 2015 to better investigate the developments in the port and transport sector. Also a larger region could be

used, for example all ports in Europe or all container ports in the world. Another important recommendation is to research the impact of the port performance on the local economy. This was left out in this paper for convenience and in order to focus on only one direction. However, the literature review showed that there could be a reverse relation, so this should be examined in further research. Another point for improvement is to find out the final destinations of the incoming cargo in the various ports. In this way the main hinterland can be determined for each port in order to take account of the hinterland's economy. Also more control variables should be added in further analyses.

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6. Appendices

Appendix A: Pearson correlations

Pearson correlations

	THROUGHPUT	DEPTH	LOCKS	NGDP	NGDP_CAP	EXPORT	IMPORT	EX_IM	RGDP_CAP
THROUGHPUT	1	-0.008 p=0.936	0.577** p=0.000	0.206* p=0.040	0.163 p=0.106	0.045 p=0.654	0.011 p=0.917	0.323** p=0.001	0.594** p=0.000
DEPTH	-0.008 p=0.936	1	0.046 p=0.649	0.315** p=0.001	-0.401** p=0.000	-0.629** p=0.000	-0.561** p=0.000	-0.662** p=0.000	-0.427** p=0.000
LOCKS	0.577** p=0.000	0.046 p=0.649	1	-0.211* p=0.035	0.358** p=0.000	0.199* p=0.047	0.146 p=0.148	0.229* p=0.022	0.016 p=0.873
NGDP	0.206* p=0.040	0.315** p=0.001	-0.211* p=0.035	1	-0.338** p=0.001	-0.849** p=0.000	-0.865** p=0.000	0.020 p=0.845	0.387** p=0.000
NGDP_CAP	0.163 p=0.106	-0.401** p=0.000	0.358** p=0.000	-0.338** p=0.001	1	0.593** p=0.000	0.530** p=0.000	0.333** p=0.001	0.325** p=0.001
EXPORT	0.045 p=0.654	-0.629** p=0.000	0.199* p=0.047	-0.849** p=0.000	0.593** p=0.000	1	0.987** p=0.000	0.283** p=0.004	0.060 p=0.554
IMPORT	0.011 p=0.917	-0.561** p=0.000	0.146 p=0.148	-0.865** p=0.000	0.530** p=0.000	0.987** p=0.000	1	0.143 p=0.156	-0.020 p=0.841
EX_IM	0.323** p=0.001	-0.662** p=0.000	0.229* p=0.022	0.020 p=0.845	0.333** p=0.001	0.283** p=0.004	0.143 p=0.156	1	0.653** p=0.000
RGDP_CAP	0.594** p=0.000	-0.427** p=0.000	0.016 p=0.873	0.387** p=0.000	0.325** p=0.001	0.060 p=0.554	-0.020 p=0.841	0.653** p=0.000	1

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

*. Correlation is significant at the 0.05 level 2-tailed.

Appendix B: Linear Fixed Effects Model 1

Estimates of Fixed Effects[a]

Parameter	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Intercept	791.991445	10751.784395	100.000	.074	.941	-20539.242568	22123.225458
[LOCKS=0]	-8479.978951	558.829311	100.000	-15.175	.000	-9588.680387	-7371.277515
[LOCKS=1]	0[b]	0	.	.	.	.	.
DEPTH	229.718381	56.979418	100.000	4.032	.000	116.672839	342.763924
NGDP	.001717	.000741	100.000	2.318	.023	.000247	.003187
NGDP_CAP	-.403049	.096910	100.000	-4.159	.000	-.595315	-.210782
EXPORT	-128.030136	205.894040	100.000	-.622	.535	-536.518047	280.457774
IMPORT	258.079098	191.566959	100.000	1.347	.181	-121.984293	638.142489
EX_IM	-236.124635	9358.025685	100.000	-.025	.980	-18802.181064	18329.931795
RGDP_CAP	.346032	.037050	100.000	9.340	.000	.272526	.419539

a. Dependent Variable: Container throughput per year in 1000 TEU.

b. This parameter is set to zero because it is redundant.

Appendix C: Linear Fixed Effects Model 2

Estimates of Fixed Effects[a]

Parameter	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Intercept	527.721716	2430.525216	100	.217	.829	-4294.371087	5349.814519
[LOCKS=0]	-8478.296036	554.836637	100	-15.281	.000	-9579.076122	-7377.515951
[LOCKS=1]	0[b]	0	.	.	.	.	.
DEPTH	230.066553	55.283553	100	4.162	.000	120.385558	339.747548
NGDP	.001709	.000677	100	2.527	.013	.000367	.003052
NGDP_CAP	-.401298	.067661	100	-5.931	.000	-.535536	-.267060
EXPORT	-132.692526	90.825681	100	-1.461	.147	-312.888091	47.503039
IMPORT	262.527209	74.973922	100	3.502	.001	113.781083	411.273334
RGDP_CAP	.345774	.035614	100	9.709	.000	.275118	.416431

a. Dependent Variable: Container throughput per year in 1000 TEU.

b. This parameter is set to zero because it is redundant.

Appendix D: Linear Fixed Effects Model 3

Estimates of Fixed Effects[a]

Parameter	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Intercept	-938.961107	2237.001950	100.000	-.420	.676	-5377.109263	3499.187048
[LOCKS=0]	-8188.329076	523.622271	100.000	-15.638	.000	-9227.180748	-7149.477405
[LOCKS=1]	0[b]	0	.	.	.	.	.
DEPTH	283.958083	41.614322	100	6.824	.000	201.396454	366.519711
NGDP	.002341	.000526	100.000	4.454	.000	.001298	.003384
NGDP_CAP	-.451608	.058861	100.000	-7.672	.000	-.568386	-.334830
IMPORT	158.078423	22.818238	100.000	6.928	.000	112.807689	203.349157
RGDP_CAP	.316493	.029751	100	10.638	.000	.257468	.375518

a. Dependent Variable: Container throughput per year in 1000 TEU.

b. This parameter is set to zero because it is redundant.