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Thesis

The relationship between port throughput and economic performance of the surrounding region

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Abstract

The effect of different businesses and clusters on the regional economy has been a field of interest for different economists for quite some time. In the last decades the effects of port throughput on the regional economy has also become an often debated topic. However these effects have not been estimated for the European Union as a whole. Only the effect of total throughput on the economy of the surrounding region has been estimated for multiple countries. This thesis tries to learn what the relationship is between port throughput and the economic performance of the regions surrounding the ports for the regions of the European Union, while it also tries to incorporate different categories of port throughput in this relationship. This relationship is estimated by a panel data regression including both regional as well as year fixed effects. The effect of port throughput on the economic performance of the surrounding region is negative, while there could not be drawn a conclusion for the separate categories of port throughput. Finally, this thesis investigates the impact of port throughput on the regional economy seen in a broader welfare perspective. This is done by estimating the effect of port throughput on the quality of life of the region surrounding the port with an ordinary least squares model. The effect of port throughput on the regional quality of life is positive.

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1. Introduction

Differences between countries in terms of economic performance have been a field of interest among economists for a long time, dating way back to Smith (1776). However the difference in economic development between regions has been a relatively new field of interest. While these differences in economic development can be influenced by a wide range of interesting subjects. The effect of the presence of certain natural resources in a region have for instance been a field of interest since the work of Dunning (2001), while the clusters different types of industries form in different regions are also regarded as facilitators of a economic superiority of regions (De Langen, 2004). Taking this into account, a next topic could of course be the influence ports have on the economy. Although there have been some studies on this subject including regions, countries and even multiple countries, such as parts of the European Union, for the European Union as a whole the relationship between port activity and the economic performance of the region has not been studied so far. And hence one could be curious what the effect of activity in a port is on the economic situation in the region surrounding the port for the European Union.

This thesis will try to establish the relationship between the level of port activity and the economic performance of the surrounding region for European port regions, hence the research question:

What is the effect of the activity of a port on the economic performance of the surrounding region?

Apart from the total throughput of a port the different goods that account for the throughput of a port can also have an effect on the economic activity of the surrounding region. Ports do not only differ in size but also in types of businesses present within its boundaries or within the port cluster and as if ports differ in relative size of different types of handled goods. The existing literature has not marked the level of different activities or handled goods within a port as a potential facilitator of economic activity. This thesis will examine whether the levels of the different kinds of handled goods have a different relationship with the level of economic activity.

The effect a port has can be divided in two parts, on the one hand there are the direct economic effects of a port on a region's economy, while on the other hand ports have different externalities. As mentioned the direct economic effect has been an issue in various articles, while the externalities were not a, or only a small, topic in these papers. However the effect of externalities has been an issue in various papers in the field of clusters. For a cluster to form diseconomies have to be outperformed by economies of the cluster (De Langen, 2004), making the economies or externalities that spill over between firms a topic in literature. Since the 1990's ports have often been regarded as clusters (Kuipers, 2018), implying that externalities are also important for ports and surrounding regions. That is why this thesis will also try to look beyond the direct economic effect of ports on their surrounding region and also try to establish the relationship with the welfare of the region.

This thesis contributes to the scientific debate regarding the impact of ports on the economic and social environment due to the fact that this thesis does not only look at the effect of port throughput for the entire European Union but also makes a differentiation of port throughput into different categories. After which the effect of these different categories on the economic situation of the region surrounding the port is tested. Another subject this thesis aims to introduce is the effect port throughput has on the welfare of the surrounding region, broadening the debate with the subject of welfare effects of port throughput.

These contributions to the scientific debate also impose different implications for the society as a whole. Since the effect of the different kinds of port throughput is tested, this thesis tries to examine which category of port throughput has the most positive, or least negative, impact on the economic and social situation of the region surrounding a port. And hence this thesis also contributes to the knowledge on the basis of which policy makers make decisions regarding public investment in ports, infrastructure around ports or businesses in ports. While another contribution this thesis tries to make is to distinguish the effect port throughput has on welfare in a broader sense from the impact port throughput has on only economic variables in a region.

2. Conceptual framework

The conceptual framework covers a number of subjects on the topic of the impacts ports have on the surrounding region. First of all the economic relationship between a port and the surrounding region will be introduced and illustrated by earlier work on this topic, after which the different kinds of effects ports exert will be introduced. The next chapter covers the topic of clusters, why ports can be seen as cluster and which externalities are related to clusters. Another topic that will be introduced is the types of port activity and the types of throughput, on the basis of which this thesis will try to establish the relationship between the level of different kinds of throughput and the economic performance of a region. A last subject that will be introduced is the effect of externalities of a seaport and what this effect is on the welfare of the region.

2.1 Economic relationship between port and region

''Ports have traditionally been considered as a strategic economic endowment able to connect global and local markets favouring the globalization process'' (Bottasso et al., 2014). While port related economic activities are also argued to be of substantial importance for the regional economy in many port regions (De Langen, 2004). These relationships are important to acknowledge and to investigate because both political and business decisions might depend on these, as already stated by Danielis & Gregori (2013); the economic role of a port is a relevant topic in both the political and the scientific debate. Although there have been a number of studies on this topic, surprisingly there is no analysis available of the impact of ports on economic performance of regions in the European Union, hence the scope of this thesis will be to extent this analysis on the level of the European Union.

The idea behind the relationship between port activity and regional or national economic performance is that ports provide a comparative advantage to the region or city where they are located in. The most important theoretical contribution supporting this idea is the Fujita & Mori (1996) model, which shows how a port may create endogenous growth by providing a competitive advantage to the economic activities located around it. The model also explains the positive effects of transport nodes (such as ports) in the process of spatial economic development (Bottasso et al., 2014). Another theory regarding the economic performance resulting from port activity is that because of increased competition and enlargement of market areas for firms consumer prices are reduced (Goss, 1990).

For parts of Europe, there is evidence that port throughput is positively correlated with regional employment and employment in the hinterland (Bottasso et al., 2013) while there is also evidence for an effect of port activity on local GDP in parts of Europe (Bottasso et al., 2014). Moreover a number of case studies found positive relationships for different port areas, such as for the New York Metropolitan Area (Warf & Cox, 1989) and for the Friuli Venezia Giulia region in northern Italy (Danielis

& Gregori, 2013). There is also evidence that the GDP of port regions grows faster than the GDP of landlocked regions, resulting in a GDP gap (Bottasso et al., 2014). For South Korea however, the relationship between ports and the local economic environment is negative (Jung, 2011). One of reasons given by Jung are the non-economic externalities, such as traffic congestion, which result from the activity in a port region, the issue of externalities will be covered later in this paper. It is however important to acknowledge that the relationship between port activity and local economic development can be a two way relationship, implying that there is a possibility of reverse causality.

The way in which the relationship between port activity and economic activity is measured in the past varies in a number of ways. The activity in the port itself is has been measured in different ways; Bottasso et al. (2013 & 2014) use the total port throughput without passenger data, while Danieles and Gregori (2013) and Kuipers (2018) also include business activity instead of only port activity in their analysis. The economic performance of a country or region has also been measured in a number of ways; Bottasso et al. (2013) and Ferrari et al. (2010) measure the economic performance of a region by the level of employment, while Bottasso et al. (2014) use the GDP of a region as an indicator for economic performance. In this thesis the port activity will be represented by the total throughput of a port in tonnes, thereby excluding passenger data, and by the throughput of the different categories of handled goods. The economic performance will be measured by the GDP of the NUTS 2 region surrounding the port.

The most important characteristics and findings of the different papers on the topic of economic impact of port throughput are displayed in table 1.

Table 1 Results of earlier literature

Paper	Economic indicator	Throughput indicator	Effect or conclusion
Bottasso et al., 2013	Employment	Total throughput without passengers	Port throughput is positively correlated with regional employment
Bottasso et al., 2014	GDP	Total throughput without passengers	Ports might have non negligible effect on local GDP
Danielis & Gregori, 2013	Performance of businesses	Business and port activity	The port system plays a relevant role in the region
Ferrari et al., 2010	Employment	Total throughput, including passengers	Positive, depends on the sector being considered
Kuipers, 2018	Added value and employment	Business and port activity	There is an effect also beyond the boundaries of the region, more research is needed.
Warf & Cox, 1989	Jobs, personal and business incomes	Difference in total throughput between 1977 and 1987	Positive, The type of transhipment is more important than the number of tons.
Jung, 2011	Local GDP as a percentage of the GDP of the whole country (1985-2009) and the unemployment rate of the city or region(2000-2009).	Whether a city houses a port or not.	A negative effect; ''Local economies may no longer benefit much from nearby ports.''

2.2 Direct and indirect economic effects

A number of things underlie the relationship between a seaport and the economy of the region. The effects of economic activity in a seaport on the region are multiple, the two most important economic effects are the added value of a port and the employment the port creates. In this thesis the effect of a port on GDP will be studied, hence one of the effects that will be important is the effect of the added value of the goods handled in the port. The added value of the activity of a seaport can be divided in a number of categories, as is shown by Kuipers (2018). For the added value of a port these categories are; the direct added value, the indirect added value, the added value of re-exports and the added value of maritime business services.

The direct added value is a result of all the activities that are directly related to the port. The categories in which the direct added value can be divided are: industrial activities, services to transport, transport, wholesale and business services (van der Lugt et al., 2018).

The indirect or backward added value consists of all the added value resulting from purchases by port companies in the economy of the region or country that is being examined. The indirect added value per sector roughly follows the same pattern as the direct added value, since companies purchase more raw material or half products when they produce more (van der Lugt et al., 2018).

The added value of re-exports consists of the benefits from the importing and exporting of goods, since businesses gain often from re-exporting imported goods, while the practice of importing and exporting also has a spill over effect on other types of businesses such as transport firms. Re-exporting takes place in ports located on crossroads of trade routes (Kuipers, 2018).

The added value of maritime business services consist of business activities that are needed for the functioning of businesses within a port, for the im- and export and for the functioning of ships, some of these activities are banking, consulting, insurance, IT service providers, law, training, ship brokers and ship registrations (Kuipers, 2018).

When all of the effects of the added value and employment of businesses and activities in a port are taken into account it can be made clear what the effect of a specific port is on the economy of the surrounding country or region. In this thesis these effects will be aggregated and the effect of the activity of ports in the European Union on the economy of the regions they are located it will be measured.

2.3 Ports as clusters

The effect of the activity of businesses within ports on the economic environment can be measured by the added value of the goods handled and the employment that is created by the businesses present in the port. However the total effect of all the activity in a port on the regional economic environment also consists of the multiple advantages that the presence of the port induces. These advantages range from cultural advantages to technological or competitive advantages. When taking into account the geographical concentration of businesses in a port and the advantages associated with benefits of the geographical concentration, a port can be referred to as a cluster of economic activity.

Ports are often referred to as clusters of economic activity, this cluster thinking started in the 1990s (Kuipers, 2018) with the adoption of the theories of Porter. Other authors who have regarded ports as clusters are Fujita & Mori (1996) and De Langen (2004). Seeing a port as a cluster can only be regarded as logical when looking at the definition of a cluster:

"A population of geographically concentrated and mutually related business units, associations and public(-private) organizations concentrated around a distinctive economic specialization." (Porter, 1990)

A port can be seen as an example of a cluster, since all the business units are geographically concentrated because of the infrastructure, there are public and private organizations interacting and there is a distinctive economic specialization, being transport. When looking at a port as a cluster the different businesses will impact one another through different interactions. These interactions can result in externalities. Earlier literature on externalities in a cluster categorized these externalities as static and dynamic, where static externalities impact the productivity of firms and dynamic externalities result from the geographical concentration of competitors and suppliers in a cluster (Pessoa, 2011). These externalities partly explain the efficiency and the formation of clusters.

There are a number of different theories discussing clusters and the efficiency of clusters, the first one being the diamond theory of Porter (1990). The second theory is the new economic geography by Krugman (1991) and Fujita, Krugman and Venables (1999), this theory focuses on explaining the spatial concentration of economic activities. The third theory was formed by the industrial district school by Piore and Sabel (1984) and Staber (1998) the theory was developed to explain the success of clusters of small and medium sized firms in Italy. The last theory is population ecology by Metcalfe (1998) and Hannan and Freeman (1989). This school analyses the evolution of populations of firms in an industry. These different theories regarding the efficiency and the performance of clusters are combined by De Langen (2004) in his work regarding the performance of seaport clusters. According to De Langen (2004) the added value created in a cluster is the best performance indicator. And hence it can be argued that the best way to determine the economic impact of seaport clusters is by examining the added value or impact on GDP.

A cluster forms because of a number of firms are in proximity of each other in of geographical, cultural or institutional terms. This results in special access, special relationships, better information, powerful incentives, and other advantages in productivity and productivity growth that are difficult to tap from a distance. As a result, in a cluster, the whole is greater than the sum of the parts (Porter, 2000). Clusters show the importance of the role of location in competitive advantage (Porter, 2000) and clusters are geographic concentrations of interconnected companies, specialized suppliers, service providers, firms in related industries, and associated institutions (e.g. universities, standards agencies, trade associations) in a particular field that compete but also cooperate (Porter, 2000). Since in a port almost all industries are related to or depend on transport a port can also be seen as a cluster.

Apart from the way clusters form, they also differ in size, there are clusters on a city level, while some clusters comprise entire regions or countries and even parts of different countries (Porter, 2000). When looking at a cluster in the way Porter did a port can also be a regarded as a cluster, since a port houses companies on a limited geographical area. So it can be argued that also in a port the whole is great is greater than the sum of parts, because of the earlier mentioned special access, relationships, information and incentives.

A cluster depends on positive externalities or spill overs between firms, since otherwise the statement of Porter regarding the whole being greater than the sum of parts, could not be true. As mentioned earlier, when looking at a cluster as a whole and examining the externalities of the cluster on the region, literature concludes that there are different forms of externalities from cluster, static and dynamic externalities (Pessoa, 2011).

Agglomeration externalities apart from Jacobs externalities can be regarded as static externalities. Where Jacobs externalities are strongly related to knowledge spill overs (van der Panne, 2004). Agglomeration externalities are static in the sense that they affect the total factor productivity of firms through an increase in the efficiency of the technologies in use. This increase in efficiency usually comes from a reduction of costs caused by concentration, such as reduced transportation and transaction costs for intra-organisational exchange and access to external markets (Pessoa, 2011). Agglomeration externalities can be divided in localization and urbanization externalities. Localization externalities can be summarized as agglomeration advantages that result from a spatial concentration of companies operating in the same industry or conducting similar types of activities. Companies in similar industries benefit from co-location due to the creation of a regional pool of specialised inputs (Pessoa, 2011). Urbanization externalities can be summarized as the agglomeration advantages that arise in large cities as a consequence of their rich economic environment, or simply because of their size (Pessoa, 2011).

Dynamic externalities arise mainly through the relationships between people and organisations that increase knowledge flows and, consequently, enhance knowledge formation, innovation and diffusion. So, dynamic externalities are strongly associated with knowledge spill overs (Pessoa, 2011).

The different benefits for companies within a cluster and the externalities of a cluster on the surrounding region can be viewed as forces that promote clustering, these cluster promoting forces are also called agglomeration economies (Fujita, Krugman and Venables, 1999). The first agglomeration economy, a shared labour market, was already discussed by Marshall (1890) the concept is that in a cluster labour is widely available because of the presence of different firms with the same, or similar labour demand (De Langen, 2004). The presence of customers and suppliers in a clusters is the second agglomeration economy. This makes the cluster attractive for firms lower in the value chain (De Langen, 2004). The concept of knowledge spill overs is the third agglomeration theory, an idea also discussed by Marshall and Krugman. Knowledge spill overs can be explained as knowledge and information are cheaper and earlier available inside clusters than outside, because it flows more easily locally (De Langen, 2004). However there are also agglomeration diseconomies, these forces are opposed to agglomeration economies. Agglomeration diseconomies are forces that oppose concentration, such as congestion and high land prices, when agglomeration economies dominate, clusters will develop.

The existing theories regarding economic effects of clusters and direct and indirect economic effects of ports show that there are several aspects of a port that can possibly positively impact the economy of the country or the region surrounding the port. Taking both the direct as well as the indirect effects of a European port on the economic performance of the surrounding region into account, the first hypothesis is:

H_1: For the regions of the European Union, there is a positive effect of port throughput on the economic performance of the surrounding region.

2.4 Port activity and types of goods

Ports differ among each other in a lot of ways, for instance in size, their geographical location, the businesses that are present in and around the port, but also in terms of trade activity. These different trade activities of the businesses in a port all have different effects on the added value of the port. These trade activities can be categorized as transit goods, re-exports and exports of produced goods. The presence of a lot of re-exports in a port or in a country is sometimes referred to as the Rotterdam effect (Kuipers, 2018). This is important to acknowledge since these different kinds of trade activities all have a different levels of added value, with the transit activity having the lowest impact with 1,4 cents of added value per euro of value, followed by re-exports with 10 cents per euro and exports of in the country produced goods, representing 60 cents of added value per euro of value (Kuipers, 2018). In a port or country where we can observe a type of Rotterdam effect the total value of the goods has a relatively lower impact on the economic environment of the respective country than a port that handles a lot of goods that are produced within the country. This shows that not only the size of the different activities within a port is important to include in an analysis regarding port impact but also the proportion or value of the different kinds of transport through the port, since a euro of exported goods that is produced in the country has a far greater effect on the GDP of the region than a euro of transported transit good.

The different activities businesses within a port perform are related to different kind of goods. The transport of these goods all have different profitability and added value levels, since different types of goods are for instance more often handled by a more or less profitable activity. These goods can be categorized as liquid bulk, dry bulk, roll-on-roll-off goods and containerized cargo. These are the categories used in this thesis to express the different goods that form the total throughput of a port, according to Jara-Díaz et al. (2002) these measures are consistent with literature on multi-output cost functions for ports.

Liquid bulk consist of all goods transferred as bulk through a port that are in a liquid state, e.g. crude oil, gasoline, diesel and biofuels to liquid chemicals and edible oils and fats. Liquid bulk is measured in tonnes. Dry bulk consist of all dry cargo that is transferred through a port as bulk, e.g. agricultural commodities, biomass, coal, iron ore and scrap metal. Dry bulk is measured in tonnes. Roll-on-roll-off (RORO) goods consists of cargo that is self-propelled when loading and unloading the ship or is non-self-propelled but mobile. RORO is measured in tonnes. Containerized cargo is cargo that is transported in a container. Containerized cargo is measured in twenty foot equivalent units (TEU).

The differences between these different types of goods has led to the specialisation of different ports in certain types of goods. Ports do not only differ in terms of throughput and size, but also in the different types of cargo transported through the port. There are for instance highly specialised ports that only handle one type of good because it serves a specific industry or business. While there are also ports that handle the full range of types goods. This specialisation could possibly also lead to a different effect on the economic activity of the surrounding region.

The different types of throughput are all in itself associated with different kinds of activities within the port and the surrounding region. If a port handles a lot of liquid bulk there are for instance often a lot of petrochemical companies active within the surrounding region of the port, something that is seen around the port of Rotterdam and the port of Antwerp, both part of the petrochemical ARRA (Antwerp-Rotterdam-Rhine-Ruhr Area) cluster. (*Centre for Petrochemical and Biobased Industries*, 2015)

In a situation where a port handles a lot of dry bulk there is often a lot of iron and coal handled in the port, both needed for the steel industry, which is often present near a port with high dry bulk volumes, an example of a port region with an active steel industry and high volumes of dry bulk is the port of Amsterdam, with the nearby steel plant of Tata Steel in IJmuiden.

However regions that house ports that handle a lot of iron, coal and other raw materials for industries like the steel industries, do not always house these industries themselves, the processing of the dry bulk materials could also take place in another region or even another country, something that can be witnessed in and around the port of Rotterdam, where a lot of raw materials are handled for and transported to the regions of North Rhine Westphalia in western Germany. While high dry bulk throughput could also be related to the agricultural industry, an example of such a region is the region around Constanta in eastern romaine, which is an agribulk hub for central and eastern Europe (ESPO, 2018).

The types of businesses that arise in and around a port with high RORO volumes are twofold, the first type of business is the ferry business, where people transit through a port together with their car or truck, while the second industry is the transport, and manufacturing, of new cars. An example of a port that has high RORO throughput due to ferry activity is the port of Calais in Northern France. While an example of a port with high RORO volumes due to new car transport is the region surrounding the port of Goteborg in Sweden, where the Swedish Volvo manufacturing plant is located.

The most diverse type of throughput is container throughput, since there are almost infinite possibilities in what can be transported in a container. The most important and most common type of business within a port that handles high container volumes are businesses active in the transport industry, such as container terminals, transport businesses and sometimes shipping companies. The diversity in activities of businesses that handle high volumes of containers can be seen in all of the regions of the ports in the Hamburg-Le Havre range.

The differences in specialisation in a certain type of port activity, but also the earlier mentioned other possible differences between ports in Europe can best be with an example of three ports. The regions that will be described in a small case study are; the Italian region of Calabria which houses the port of Gioia Tauro, the Spanish region of Catalonia with the port of Barcelona and finally the Dutch region South-Holland that houses the port of Rotterdam. These three region differ in a number of ways, the first thing is the population of each of the regions, Calabria had a population of 2 million people in 2018, Catalonia of 7,5 million and South-Holland housed 3,7 million people in 2018. Another difference between these regions is the location of the port; in Calabria the port of Gioia Tauro is located in a sparsely populated part of the region, without a city with more than 250.000 inhabitants nearby. In Catalonia the port of Barcelona is located near the city of Barcelona, the second largest city of the country with over 1,6 million inhabitants. While in the region of South-Holland the port of Rotterdam is located near the city of Rotterdam with over 550 thousand inhabitants, at the same time the region of South-Holland is one of the most densely populated regions of the Netherlands. The last important difference between these regions is level the specialisation of the ports in the different categories of port activities. The region of Calabria with port of Gioia Tauro for instance is specialised in container handling, making it the biggest container port in Italy with over four million TEU handled in 2018 (approximately 87% of the total port throughput of the region), while it is a relatively small port in terms of liquid bulk, dry bulk and RORO transport. The region of Catalonia also depends on container handling, with of 3,5 million TEU handled in 2018 (contributing about 32% to the total throughput), while at the same time it also handles over 34 million tons of liquid bulk (about 45%) and over 15 million tons of dry bulk (almost 20%). While South Holland with the port of Rotterdam is an example of a port region that handles all of the categories of goods, although the port region depends on liquid bulk, with over 210 million tonnes handled in 2018 (almost 47% of the throughput), for a big part of the total activity, dry bulk (approximately 17% of the throughput) and container handling (over 13 million TEU in 2018, representing over 30% of the total throughput) also contribute a lot to the total activity in the port, while RORO throughput, with a contribution of about 4%, is the smallest category in terms of throughput. The differences between these regions and ports will illustrate the results later on.

When it is taken into account that the different types of port throughput are related to different kinds of businesses in and around the port, it can be seen that some types of goods might be transported more often as transit goods than others. This would imply that there is a difference in levels of added value between the different types of throughput of a port, since the difference in profitability between types of transport, being transit, re-export and export, would also lead to a different direct effect on the economic performance of the surrounding region for ports that are specialised in a certain good. However there is no literature or data available on whether certain types of throughput are transported more often as for instance a transit good than others, hence at this point it cannot be confirmed whether there are different kinds of added value levels associated with the different kinds of port throughput. On the other hand the different types of industries that can be linked to the different categories of throughput could also differ in their added value to the national or regional economy. For the 1000 largest companies of the united states it was for instance found that there are large differences in financial performance between industries (Jay et al., 2014). This thesis tries to connect the concept of the difference in financial performance between industries with the levels of different categories of throughput of different European ports. This will be done by determining whether there is a difference in added value of the different throughput categories.

All of the different businesses in a port rely on different kinds of transport activities for their, production, processing or handling activities. These different businesses and activities can have different positive or negative economic effects on the surrounding regions. Some activities might be more polluting or cause more congestion than others, which is one of the negative effects a port can have on the economic environment of the region, according to Bottasso et al. (2014). While at the same time the nature of these different kinds of goods also has an effect on the impact of the throughput of the respective good on the local economy, Bottasso et al. (2013) mentioned that the potential employment effect of liquid bulk traffic is usually considered not very important because of both the reduced labour force needed to handle it and the low value produced for the region where the ports are located. Implying that liquid bulk throughput has a smaller effect on the local economy than throughput of other types of goods. However not only liquid bulk exerts negative effects of the surrounding region, depending on the nature of the transport, transhipment, unloading, processing and storage of each of the different types of throughput, each type of throughput has its own possible negative economic effects, apart from the earlier mentioned direct and indirect positive effects of port throughput. A port with large dry bulk activity, because of coal imports for a coal plant, could for instance have large externalities (Galetovic & Muñoz, 2013) on other businesses and the local environment, while there could also be differences in added value between the different activities because some goods might be a transit good more often than other goods, resulting in a different effect on regional economic performance.

The possible difference in economic impact between the different types of handled goods in a port has not been included in earlier academic literature. Earlier papers did not make a subdivision in the types of goods handled by seaports. The studies on a European level by Bottasso et al. in 2013 and 2014 for instance used aggregated data of the activities. *This thesis will try to establish the relationship between the level of different kinds of transport activities , as mentioned above, and the economic performance of a region.*

Hence the second hypothesis:

H_2: For European ports, the different types of port throughput have a different effect on the economic performance of the surrounding region.

2.5 Externalities of a seaport

Apart from the direct and indirect economic effects a seaport can have on a region, a seaport can also exert positive and negative externalities onto the surrounding living environment. Some of these externalities might coincide with the earlier mentioned effects of clusters, such as higher land prices resulting in higher rents (De Langen, 2004). So it might be said that these agglomeration economies and diseconomies not only help form a cluster or prevent a cluster from forming, but also have an effect on the living environment. And because it is often mentioned that ports can be viewed as clusters (De Langen, 2004) ports also impose these economies and diseconomies, being congestion of roads in the region and higher land prices. Other externalities that might not have a direct effect on local economic indicators, but do influence the welfare or living conditions of the region are the air pollution of ships within the port (Tzannatos, 2010) and possible pollution by producing companies within the port area. The different producing or energy companies within a port can exert a number of large externalities, especially the externalities of coal plants (Galetovic & Muñoz, 2013) get special attention in the current political debate (Geels, 2014).

2.6 Welfare relationship between ports and the region

European regions not only differ in terms of GDP, but also in other determinants of welfare, in the report regarding the regional quality of living index in Europe (Lagas, van Dongen, van Rijn & Visser, 2015) there are a lot of factors mentioned that influence the welfare in a region. The different attributes of European regions are placed in a number of categories. Being public services, purchasing power and employment, housing, social environment, natural environment, recreation, health, education and governance (Lagas et al., 2015). However one of the characteristics that is not mentioned is the presence of a port, while ports influence a variety of indicators of welfare in a region.

Guisán and Frías (1997) discuss a number of regional characteristics that influence social welfare, being: domestic economic wellbeing, employment opportunities, education and research, health assistance, public services and infrastructure and female participation. Their research also shows the differences for the different indicators between different European countries and regions.

The effect ports and businesses within the port transmit on the surrounding region is not solely economic. As mentioned the externalities of a port or the activities in a port could also indirectly effect the living conditions and therefore the welfare in a region, when taking into account negative externalities Jung (2011) found a negative relationship between the presence of a port and the local economic environment in South Korea. While Bottasso et al. (2014) also mention the possible negative influence ports can have. From all of these studies it can be concluded that the effect a port has on a region can be categorized in two categories, being the economic effect, discussed earlier, and the non-economic effect ports have on the surrounding region.

The effect these two categories can have on adjacent cities or regions can be seen from the analysis of Hoyle (1989), this study proves that cities have become less dependent on the adjacent port. A port however enables a city to be a part of the global maritime transport and trading system, which is argued to be a major facilitator of economic life of most countries and a focus of regional activity (Hoyle, 2001), this effect can however also boost the different attributes of regions in Europe, while this is not included by either Lagas et al. (2015) or Guisán & Frías (1997). Being part of the global maritime transport and trading system can also give impact the quality of life or welfare in these regions. This thesis will try to incorporate the activity of ports in the welfare analysis of European regions by taking both the economic as well as the non-economic externalities into account. Hence the third hypothesis:

H_3: For European regions there is a positive effect of port throughput on the welfare of the surrounding region.

The conceptual framework has covered and introduced a number of subjects in order to establish a basis on which this thesis will further elaborate. The most important findings are that the earlier work on the effect port throughput has on the economic performance of the region, found almost all positive effects, only included parts of Europe or separate countries, did only include total port throughput and did not include broader measurements of the situation in the region such as quality of life. It was also made clear that this thesis will include the regions of the whole European Union, will not only look at total port throughput but will also include different categories of throughput and will also include the effect port throughput has on the welfare of the surrounding region.

3. Data

Each of the three different hypotheses demand different data. The economic performance of a region, that is needed for 2 of the three hypotheses, can be measured by several indicators. The indicator that will be used in this thesis is the GDP per capita (GDPC) on a NUTS 2 level. The data for this variable is retrieved from the Eurostat database, which includes the GDP per capita in purchasing power standards (PPS) of all regions in the European Union on a NUTS 2 level. The GDP per capita in PPS is chosen to eliminate the differences in price levels and purchasing power between the regions in the data set. Because the GDP per capita is measured in PPS every effect on the GDP per capita is depicted in PPS instead of euro. Since the data includes the Nuts 2 regions of the countries of the European Union there would otherwise be a difference in price levels between the regions but also over time because there are also different inflation rates in the different countries of the European Union (Égert, 2007). The data is available for the years 2007-2018.

3.1 Hypothesis 1

For the first hypothesis, regarding the relationship between port activity and the economic performance of the region a number of variables and definitions are used. The total activity of a port is represented by the total throughput in tonnes of the port, this does not include passenger data, the decision not to include passenger data is based on the claim of Bottasso et al. (2014) that empirical evidence has shown that the economic impact of passenger traffic is not particularly relevant. The variable that represents the total port activity will be the total throughput in tonnes (TON). This variable is not available for all ports in the European Union, that is why this variable is constructed by adding the different types of goods for each individual port for the different years. For the variables liquid bulk, dry bulk and RORO this can be done instantly, while the variable TEU has to be transformed from a measurement of volume, being the number of containers, into a weight measurement, being the total tonnage of the containerised goods. This can be done by multiplying the TEU by a factor 10.6, which is the average loading weight in tonnes of a container in the ports of the Hamburg Le-Havre range (*Feiten en Cijfers 2019 Port of Antwerp*, 2019). The data that was used to construct this variable is retrieved from the ESPO database for the years 2007-2018, which includes data for all of these variables for all ports in the European Union. In order to account for the different effects of the different kinds of trading activities, being transit goods, re-export and exports by the home country of the port, on the GDP of the surrounding region, it would be favourable to include data on the total value of the throughput and the ratio's between the different kinds of trading activity for each port, but at this point in time this data is not available.

In Table 2 the descriptive statistics for both the total throughput in tonnes (TON) and the GDP per capita in PPS (GDPC) are shown.

Table 2 Descriptive statistics GDP per capita and port throughput

VARIABLES	N	mean	Sd	min	max
TON	3,768	13,056	75,086	0	448,706
GDPC	2,938	27,010	13,291	6,891	193,821
Number of Regions	223	223	223	223	223

The table above highlights a number of things. First it can be seen that the minimum throughput (TON) in all of the European regions is zero, coming from the fact that not every region includes a port. While the maximum value for the total throughput is over 448 million tons for the Dutch region of South Holland home of the port of Rotterdam, the data in the data set is included in thousands of tons. While the minimum value of the GDP per capita in PPS is 6.891, for the Bulgarian region of Severozapaden, and the maximum value for GDP per capita is 193.821, for the British region of west inner London. The magnitude of the difference between the lowest and highest GDP per capita directly shows the difference in economic performance between European regions.

3.2 Hypothesis 2

For the second hypothesis the same definition for economic performance is used, but the indicator of port throughput is divided into a number of categories, being liquid bulk, dry bulk, RORO and container (TEU) throughput. The different types of goods are represented by the tonnes of liquid (LBULK) and dry (DBULK) bulk handled, the tonnes of Roll-on-Roll-off goods (RORO) and the number of containers (TEU) handled. These measures of output are consistent with the literature on the multi-output cost function for ports (Jara-Díaz et al., 2002). The data for these variable is collected from the ESPO database for the years 2007-2018, which includes data for all of these variables for all ports in the European Union. When examining these different categories one could also argue why breakbulk is not included as a separate category, although this is not included as a separate category by Jara-Díaz et al. (2002) breakbulk could possibly impose effects on the local economic performance, because of the connection it can have with different types of industries. However the reason it is not included as a separate category is that ESPO does not recognize it as a separate category and hence we do not have throughput data on the subject of Breakbulk.

In table 3 the descriptive statistics of the variables that are included to estimate the effect of the different indicators of port activity on the economic performance of the surrounding region.

Table 3 Descriptive statistics GDP per capita and categories of port throughput

VARIABLES	N	Mean	Sd	min	Max
LBULK	3,768	4,448	15,072	0	219,670
DBULK	3,768	4,666	68,434	0	95,035
RORO	3,768	1,497	4,269	0	53,420
TEU	3,768	230,647	1.093e+06	0	1.360e+07
GDPC	2,938	27,010	13,291	6,891	193,821
Number of Regions	223	223	223	223	223

From the table above a number of interesting things emerge. First it can be seen that the minimum throughput for all of the different indicators of port activity in all of the European regions is zero, arising again from the fact that not every region includes a port. The values of liquid bulk, dry bulk and RORO are all included in thousands of tons while the value of the number of containers is included as number of twenty foot equivalent units. The maximum value of liquid bulk is over 219 million tons, while the highest throughput of dry bulk in an EU region was over 95 million tons, both of these were in the Dutch region of South-Holland, home of the port of Rotterdam. At the same time the maximum value of RORO throughput was over 53 million tons, transported through the French region of Nord-Pas-de-Calais, home of the port of Calais. Finally the maximum value of the number of containers is over 13 million TEU, again transported through the region of South-Holland in the Netherlands.

3.3 Hypothesis 3

This thesis does not only focus on the relationship between port throughput and economic performance, but also on the possible relationship between port activity and the welfare or quality of life of the region. This relationship is the subject of the third hypothesis, for the third hypothesis both the total throughput and the throughput of the different categories is used. To measure the effect on welfare a welfare indicator is included. The welfare or quality of life variable is taken from the paper by Peiró-Palomino & Picazo-Tadeo (2018) on well-being and government quality. In this paper a quality of life variable is constructed by combining ten different well-being indicators from the OECD regional well-being dataset. The techniques used by Peiró-Palomino & Picazo-Tadeo to combine these indicators are the Data Envelopment Analysis and Multi-Criteria-Decision-Making technique. The indicators that are used to compose the well-being variable are: income, jobs, education, safety, health, environment, civic engagement, accessibility to services, community and housing. The quality of life variable is available for 168 European regions, on both the nuts 1 and nuts 2 level. The selection of these regions is entirely determined by the availability of data (Peiró-Palomino & Picazo-Tadeo, 2018). The OECD regional well-being dataset that was used consisted of data from 2014, because of this the analysis of quality of life in this thesis will be made with data from the year 2014. Although other authors studying well-being in European regions argue when examining the welfare of a region it is also important to include variables that have an impact on welfare, in their paper on ''Economic growth and social welfare in economic regions'' Guisán and Frías (1997) discuss a number of characteristics of a region that influence social welfare, being: domestic economic wellbeing, employment opportunities, education and research, health assistance, public services and infrastructure and female participation, when using the quality of life variable form the paper by Peiró-Palomino & Picazo-Tadeo (2018), including welfare related control variables could create problems of its own, because the discussed regional characteristics are already included in the quality of life variable, since many of the subjects mentioned by Guisán & Frías (1997) are also included in the OECD data, used to construct the variable. These variables combined result in a dataset of 143 data points, while there is one time period being the year 2014.

In table 4 the descriptive statistics of the variables that are included to analyse the effect on welfare are shown.

Table 4 Descriptive statistics quality of life and port throughput

VARIABLES	N	Mean	sd	min	Max
QoL	168	868.5	108.7	480	1,000
LBULK	163	7,270	19,446	0	199,112
DBULK	163	20,798	210,964	0	82,520
RORO	163	2,805	6,778	0	42,005
TEU	163	403,289	1.665e+06	0	1.230e+07
TON	168	34,101	211,864	0	425,906

In the table above one thing is obvious, being that the minimum for all of the throughput variables is, as we saw before, zero because not every EU region houses a port. A first thing that is different than in the data of the other hypotheses is the quality of life, or QoL, variable. This variable depicts the quality of life in each of the included region on a scale of 1 to 1000. And as can be seen from the table above the region with the worst living conditions scores 480, while the region with the best living conditions scores the maximum of 1000. The maximum values of the different throughput variables are a bit different than for the other hypotheses, since for the analysis of this hypothesis only the year 2014 is included. However the maximum value of liquid bulk, over 199 million tons, dry bulk, over 82 million tons and container throughput, over 12 million TEU are again transported through the Dutch region of South Holland, home of the port of Rotterdam. While the maximum value of RORO throughput, over 42 million tons, was transported through the region of Schleswig-Holstein is northern Germany.

3.4 Control variables

Apart from the data that is directly needed to establish the different relationships of the three hypotheses there is also need for a set of control variables. The control variables that are used are all collected from the Eurostat database and consist of data on the Nuts 2 level. The control variables consist of variables regarding the demography of the NUTS 2 regions and a number of variables regarding the accessibility of the NUTS 2 region. The demography variables are included to control for extreme variations in economic performance of a region, the controls included for this purpose are total population (Population), the percentage of the population aged 65 or over 65 (Population over 65) and the percentage of the population with an educational degree over level 5 (High Educ), these variables are all retrieved from Eurostat and are reported on a NUTS 2 level. The rationale for including these variables was retrieved from the paper of Ferrari et al. (2010) who stated that the older the population, the lower is economic development, owing to the existence of a demographic dividend. While a region with a lower educated population would also have lower economic development. Another demography related control variable that is included is the population density, this variable is included to account for the distinction between core and periphery regions, since there are differences between these two types of regions in terms of well-being, in the European Union it is observed that core regions have a higher level of well-being (Peiró-Palomino & Picazo-Tadeo, 2018). It is also important to control for the accessibility of the port, as shown by Ferrari et al. (2010) who controlled for accessibility by including an index of road and railway provision in their regressions, while other authors included motorway length (e.g. Bottasso et al., 2013, 2014). Bottasso et al. (2013) has also mentioned the importance to include a variable to account for a motorway network, since the existence of a well-developed motorways network can be necessary for a port to display its positive effect on the economic development of the host region (Bottasso et al., 2013). In this thesis the densities of the highway and railway networks will be included to control for the accessibility of the port. The density of highways (DensHighway) and the density of railways (DensRailway) are retrieved from Eurostat and are reported on a NUTS 2 level. For both density of highways and density of railways the density is on a scale of kilometre per thousand square kilometres.

3.5 case study

To indicate what the differences for all these variables across the regions of the European union are, the data of these variables of the earlier introduced ports of the regions of Calabria, Catalonia and South-Holland are shown in Table 5 for the year 2018.

Table 5 2018 values for the ports in the case study

VARIABLES	Calabria	Catalonia	South-Holland
LBULK	924.000	34.096.000	210.623.000
DBULK	95.000	15.083.000	75.631.000
RORO	4.934.000	1.396.000	18.314.000
TEU	4.017.992	3.521.350	13.597.929
TON	48.543.715	87.901.310	448.706.050
Population	1.956.687	7.488.718	3.681.044
Popover65	0,212	0,19	0.178
Higheduc	0,151	0,408	0,389
DensHighways	19	46	127
DensRailways	56	58	169
PopDens	128,6	235,5	1281,2
GDPC	17.285,98	33.369,24	39.544,30

The table above highlights a number of interesting differences between the three regions. First of all there is of course the difference in GDP per capita in PPS, where Calabria has the lowest GDP per capita, followed by Catalonia, with almost double the GDP per capita of Calabria, while South-Holland has the highest GDP per capita. Another difference is the earlier discussed level of specialisation in a certain type of good. The region of Calabria for instance handles only a small amount of dry and liquid bulk, while there were more than 4 million TEU in containers transported through the region in 2018, the relatively high number of RORO throughput comes from the port of reggio Calabria, the second port of this region after Gioia Tauro, this is the port where the ferry's to Sicily set sail. Another thing to acknowledge is that the region of Catalonia has a relatively small throughput of RORO, taking the size of the total throughput in mind, compared to the other regions. The differences between the regions in terms of control variables is also striking, the population of Calabria is for instance relatively less highly educated than the other regions, while it also has a less dense highway network than the other regions. Catalonia has percentage wise the highest educated population of the three regions, while both its highway and railway network, although not being the smallest of the three, is much less dense than those of the region of South-Holland. Finally the most obvious difference between the three regions is the population density, where we see that South-Holland, although not having the largest population is much denser populated than the other two regions. The differences between the three regions in all of the different included variables highlight the diversity across all of the European NUTS2 regions that are included in this thesis.

The most important findings of the data chapter are that this thesis includes the GDP per capita in PPS as a measure of welfare, uses total port throughput in tonnes as a measurement of total port throughput, uses the throughput in tonnes of the throughput categories liquid bulk, dry bulk and RORO and uses the number of TEU as a measurement of the number of containers. While the control variables that are included can be divided into a demography and a accessibility component. The variable to account for the welfare of the regions is a quality of life variable, constructed by Peiró-Palomino & Picazo-Tadeo (2018). Furthermore it is important to acknowledge for the next parts of this thesis that the data shows a large diversity in all of the variables across the regions, the GDP per capita varies enormously across the regions in Europe, while also the quality of life differs between countries and separate region. At the same time it has to be acknowledged that, because the port data is also measured on a regional scale a lot of regions do not show any port throughput, simply because those regions are inland regions or do not house a seaport.

4. Methodology

The effect port activity has on the economic performance of a European region can be measured by a panel data regression model, including regional and time fixed effects. The GDP per capita (GDPC) is included as the dependent variable and the throughput in tonnes (TON) as the independent variable. Including a number of control variables this model would be:

(1) $$GDPC_{it} = \beta_0 + \beta_1 TON_{it} + \Gamma X_{it} + \mu_i + \mu_t + \varepsilon_{it}$$

Where $GDPC_{it}$ denotes the level of GDP per capita in NUTS 2 region *i* in year *t* and TON_{it} the throughput in tonnes of the port of NUTS 2 region *i* in year *t*. X_{it} represents a vector of control variables, μ_i represents the regional fixed effects and μ_t the year fixed effects, while ε_{it} denotes the region specific error term for region *i* in year *t.* The included region specific fixed effects, potentially correlated with regressors, captures the effects of regional unobserved time invariant heterogeneity, such as institutions, levels of economic development and the structure and composition of the local economy (Bottasso et al., 2013). While the year fixed effects capture the effects of trends or shocks in both the

GDP per capita and the total port throughput, caused by for instance an economic recession or cyclical effects of macroeconomic processes. (Bottasso et al., 2014a)

The effect the different activities; liquid bulk, dry bulk, roll on roll of goods and containers, have on the economic performance in a region can be measured by a number of panel data regression models, including regional and year fixed effects, this model includes the GDP per capita (GDPC) as the dependent variable, a number of control variables and the different indicators for the respective activities as the independent variable. These models are:

(2) $$GDPC_{it} = \beta_0 + \beta_1 LBULK_{it} + \Gamma X_{it} + \mu_i + \mu_t + \varepsilon_{it}$$

(3) $$GDPC_{it} = \beta_0 + \beta_1 DBULK_{it} + \Gamma X_{it} + \mu_i + \mu_t + \varepsilon_{it}$$

(4) $$GDPC_{it} = \beta_0 + \beta_1 RORO_{it} + \Gamma X_{it} + \mu_i + \mu_t + \varepsilon_{it}$$

(5) $$GDPC_{it} = \beta_0 + \beta_1 TEU_{it} + \Gamma X_{it} + \mu_i + \mu_t + \varepsilon_{it}$$

(6) $$GDPC_{it} = \beta_0 + \beta_1 LBULK_{it} + \beta_2 DBULK_{it} + \beta_3 TEU_{it} + \beta_4 RORO_{it} + \Gamma X_{it} + \mu_i + \mu_t + \varepsilon_{it}$$

Where $GDPC_{it}$ denotes the level of GDP per capita in NUTS 2 region *i* in year *t*, $LBULK_{it}$ the tonnes of liquid bulk transferred through the port of NUTS 2 region *i* in year *t*, $DBULK_{it}$ the tonnes of dry bulk transferred through the port of NUTS 2 region *i* in year *t*, $RORO_{it}$ the tonnes of roll on roll off goods transferred through the port of NUTS 2 region *i* in year *t and* TEU_{it} the number of containers in TEU transferred through the port of NUTS 2 region *i* in year *t*. X_{it} represents a vector of control variables, μ_i represents the regional fixed effects and μ_t the year fixed effects. ε_{it} denotes the region specific error term for region *i* in year *t.* First all of the indicators of port activity are included as independent variables in separate regressions in models 2 to 5 after which all of the variables of the indicators of port activity are included together in model 6.

In all models regional fixed effects are included to account for regional heterogeneity. The time invariant characteristics of the different European regions that affect both GDP and port throughput are accounted for by including regional fixed effects (Bottasso et al., 2014a). The estimation of a fixed effects model is also important because the presence of ports within a region is mainly associated either to geography or to historical reasons, which in turn could also explain GDP levels (Bottasso et al., 2014a), including fixed effects would eliminate the possible bias resulting from these effects. Time fixed effects are included for the same purpose as in the model including total port throughput as the independent variable, being to capture the effects of trends and shocks in both the GDP per capita or the indicators of port activity, caused by (cyclical) variation in macroeconomic processes. (Bottasso et al., 2014a)

Apart from the fixed effects, it is also important to include the right control variables in the respective regression equations. To examine the impact of port activity on the regional economic activity a number of variables that are regional specific and impact the activity in the port will be included. As mentioned in the data section these control variables can be divided in a demographic and a accessibility component. The demographic control variables include the percentage of the population over 65 and the part of the population that is highly educated, these are included to account for differences in economic performance between regions due to the demography and the education of the population. The accessibility control variables, as mentioned in the data section; the density of the highway network and the density of the railway network, are included to account for differences in economic performance between regions due to smaller transport time and hence lower transport cost. The choice on whether to include more control variables was based on the trade-off between more control variables and less observations or a smaller set of control variables but more regions and hence more observations in the dataset. Since including more control variables resulted in a loss of observations due to the lack of availability of data for all European NUTS2 regions. For example the inclusion of the railway density variable results in a loss of 451 observations, as will be discussed in the results section. In an ideal situation where data would be available for all NUTS2 regions this thesis would also have included control variables such as the distance to the nearest large city, to control for port-city interface effects, the size of the hinterland in economic terms or the number of businesses within the region to account for agglomeration effects. In the models 1 to 6 the control variables that are eventually included are the percentage of the population over 65, the percentage of the population that is higher educated and the density of the highway network.

The welfare of the different European NUTS 2 regions will be represented by the welfare (WEL) variable, which is, as mentioned earlier taken from and constructed by Peiró-Palomino & Picazo-Tadeo (2018).

The possible effect the port activity has on the welfare of the associated region can be estimated by an OLS model. In the model the total throughput in tonnes (TON) for the year 2014 is included as the independent variable, the welfare (WEL) as the dependent variable and a number of control variables.

(7) $$WEL_i = \beta_0 + \beta_1 TON_i + \Gamma X_{it} + \varepsilon_i$$

Where WEL_i denotes the level of welfare in NUTS 2 region *i* and TON_i the throughput in tonnes of the port of NUTS 2 region *i*, X_{it} represents a vector of control variables and ε_i denotes the region specific error term for region *i.* The welfare data is not available for a sufficient number of years to include the variables in a panel dataset, since the data is based on the study by Peiró-Palomino & Picazo-Tadeo

(2018) and only holds for 2014. The analysis for the effect of throughput on welfare will be executed with data from the year 2014 for both dependent, independent and control variables.

To estimate the correct effect on the welfare of the region surrounding the port it is also important to include the right control variables in this model. The control variables that will be used for this model are the same as door the models 1 to 6, but in this model the population density is also included, as was already mentioned in the data section it is important to include this variable to account for differences in quality of life between core regions and periphery regions, since the reported value of the welfare variable is higher for core regions, as was concluded by Peiró-Palomino and Picazo-Tadeo (2018).

The most important findings of the methodology chapter are that there will be a number of different models used in order test the three different hypotheses. For the first and second hypothesis the models that will be used contain the GDP per capita as the dependent variable and respectively the total throughput and the throughput of the different categories as independent variables. In the model both regional and year fixed effects are included. To test the third hypothesis a quality of life variable is included as a dependent variable to account for the welfare of the region, while the total port throughput is included as the independent variable in this OLS model. In all of the models a number of control variables are included, these control variables can be divided into two groups, being demography control variables and accessibility control variables.

5. Results

The result section is divided into a number of subsections. This division is based on the different hypotheses as stated in the conceptual framework.

At first it will be determined whether there is indeed a positive relationship between port throughput and the economic performance of the surrounding region, after which the models including the different categories of port activity will be executed, the third section includes the model that measures the effect of port throughput on the welfare of the surrounding region.

The results of the models measuring the effect of total port throughput on GDP per capita are shown in Table 6, while the results of the models measuring the effect of the different categories of port throughput are shown in tables 7 to 11. The control variables in these tables do not include Railway density, in tables A1 to A6 in the appendix Railway density is included. When railway density is included the number of included regions drop from 223 to 178, resulting in a drop in observations from 1911 to 1460, as can be seen when comparing both tables. Including the railway density of the regions results in non-significant outcomes for all models that include both the regional as well as the year fixed effects, as can be seen in tables A1 to A6 in the appendix.

5.1 Economic performance and port throughput

Table 6 GDP per capita and port throughput

VARIABLES	(1) OLS	(2) Regional FE	(3) Regional and Year FE
TON	-0.000560	-0.000230	-0.000196***
	(0.00101)	(0.000288)	(5.37e-05)
Popover65	7,167	66,362***	-29,956*
	(5,067)	(9,910)	(17,730)
Higheduc	51,124***	29,323***	11,795***
	(2,152)	(4,081)	(3,552)
DensHighways	128.3***	64.58***	56.42***
	(5.800)	(18.93)	(18.56)
Observations	1,911	1,911	1,911
R-squared	0.476	0.533	0.671
Number of Regions		223	223
Regional FE		YES	YES
Time FE			YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The regressions in Table 6 show the relationship between the total port throughput of the NUTS2 regions and the GDP per capita of those NUTS2 regions. The first model is the ordinary least squares model, included as a robustness check. The model shows a negative, but not significant, effect of the total throughput in the NUTS2 region on the GDP per capita in those NUTS2 regions. The second and third model are both panel data regression including regional fixed effects, however for the third regression time fixed effects are also included. The test on whether to include time fixed effects rejects the null hypothesis that all of the time fixed effects are equal to zero and hence time fixed effects have to be included. The first fixed effects model shows a significant effect of all the included control variables while the effect of the port throughput itself is not significant. The fixed effects model including both regional as well as year fixed effects shows a significant and negative effect of the total port throughput on GDP per capita. The regressions shows an effect of a drop in GDP per capita of 0,000196 PPS per thousand tons of port throughput. Implying that since there is a significant and negative effect observed in the third model in table 6, it can be concluded that there is no positive effect of total port throughput on the GDP per Capita of the surrounding region. This implies that the first hypothesis is rejected, it cannot be stated that for the European Union the total port throughput has a positive effect on economic performance, measured by the GDP per capita, of the surrounding region.

To show what this result means in reality, the case study that was introduced in the theoretical framework will be used. For the three regions in this example the effect of throughput on GDP per capita would result in the following. For Calabria in southern Italy, a region where in 2018 48.543.715 tons of goods were handled through ports, the GDP per capita was negatively influenced by 9,51 PPS, whereas the total GDP per capita was 17.285,98 PPS. In Catalonia the total port throughput was 87.901.310 tonnes, the GDP per capita was 33.369,24 PPS, which was negatively influenced with 17,23 by the throughput. In South-Holland the total throughput was 448.706.050 tonnes in 2018, while the GDP per capita was 39.544,30 PPS, this was negatively influenced by the port throughput by 87,95.

The effect of port throughput on the GDP per capita in PPS, although being significant, can be regarded as small when one looks at the effects of the ports discussed above. This result is not only surprising because it contradicts the first hypothesis, but also because it contradicts with the results of the existing literature. The existing literature, although sometimes including different kinds of variables to account for economic and port activity, almost all have in common that the effect they found was positive, as was already stated in table 1 in the theoretical framework. Taking everything into account the negative effect of total port throughput on GDP per capita is surprising because it is negative and the effect is rather small.

5.2 Economic performance and different categories of throughput

In the next section the effect of the various indicators of port activity on the GDP per capita of the surrounding region will be determined. The following tables are compared in order to determine whether for European ports the different port activities do have a different effect on the economic performance of the surrounding region. The control variables in the models in these tables do not include the variable railway density, since, as was also the case for the model including total port throughput, the adoption of this variables reduces both the number of ID variables, being the included NUTS2 regions as well as the total number of observations. The models with the variable railway density are included in tables A2 to A6 in the appendix.

Table 7 GDP per capita and liquid bulk throughput

	(1)	(2)	(3)
VARIABLES	OLS	Regional FE	Regional and Year FE
LBULK	-0.0284***	0.0430	0.0273
	(0.00536)	(0.0387)	(0.0337)
Popover65	7,028	65,956***	-30,031*
	(5,067)	(9,921)	(17,635)
Higheduc	51,059***	29,224***	11,739***
	(2,147)	(4,078)	(3,536)
DensHighways	132.9***	66.01***	57.32***
	(6.281)	(18.42)	(18.17)
Observations	1,911	1,911	1,911
R-squared	0.478	0.534	0.672
Number of Regions		223	223
Regional FE		YES	YES
Time FE			YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The regressions in table 7 show the relationship between the total port throughput of liquid bulk in the different NUTS2 regions and the GDP per capita of those regions. The first model is an ordinary least squares model, included as a robustness check. The second and third model are panel data regressions, both including regional fixed effects, while the third model also includes time fixed effects. The OLS model shows a significant and negative effect of port throughput of liquid bulk, while the second and third model do not show a significant effect. The test regarding the necessity of including time fixed effects rejected the null hypothesis that all of the time fixed effects are equal to zero, meaning that time fixed effects have to be included. Taking these results into account it can be stated that there is no significant effect of the port throughput of liquid bulk on the GDP per capita of the surrounding region.

Table 8 GDP per capita and dry bulk throughput

VARIABLES	(1) OLS	(2) Regional FE	(3) Regional and Year FE
DBULK	0.000401	-0.000278	-0.000196***
	(0.000472)	(0.000245)	(4.24e-05)
Popover65	7,214	66,334***	-29,951*
	(5,066)	(9,913)	(17,730)
Higheduc	51,107***	29,324***	11,795***
	(2,153)	(4,081)	(3,552)
DensHighways	128.0***	64.60***	56.44***
	(5.762)	(18.93)	(18.56)
Observations	1,911	1,911	1,911
R-squared	0.476	0.533	0.671
Number of Regions		223	223
Regional FE		YES	YES
Time FE			YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The results of the regressions in table 8 show the relationship between the total port throughput of dry bulk of the NUTS2 regions and the GDP per capita of those NUTS2 regions. The first regression is an ordinary least squares model, including the different discussed control variables, since this model is potentially biased it serves the purpose of a robustness check. The results of the OLS model show a negative, significant effects of the port throughput of dry bulk on the GDP per capita. The second model shows a panel data regression including regional fixed effects, this model does not show a significant effect of the port throughput of dry bulk on GDP per capita. The third and last model is a panel data regression including both regional and time fixed effects. This model shows a significant and negative effect of the port throughput of dry bulk on the GDP per capita of the surrounding region. The test on whether to include time fixed effects indicates a rejection of the null hypothesis that all of the time fixed effects are equal to zero, implying that time fixed effects have to be included. The model including time fixed effects shows an effect of a drop in GDP per capita of 0.000196 PPS per thousand tons of port throughput of dry bulk.

Table 9 GDP per capita and roll-on-roll-off throughput

VARIABLES	(1) OLS	(2) Regional FE	(3) Regional and Year FE
RORO	-0.0141	-0.0213	-0.0524
	(0.0251)	(0.0277)	(0.0396)
Popover65	7,425	66,668***	-29,990*
	(5,048)	(9,907)	(17,692)
Higheduc	51,165***	29,311***	11,629***
	(2,158)	(4,079)	(3,485)
DensHighways	128.2***	64.46***	55.95***
	(5.827)	(18.91)	(18.63)
Observations	1,911	1,911	1,911
R-squared	0.476	0.533	0.672
Number of Regions		223	223
Regional FE		YES	YES
Time FE			YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The results of the regressions in table 9 show the effect of the port throughput of roll on roll off goods on the GDP per capita for the included NUTS2 regions. As was also the case in the previous models, the first model is the ordinary least squares model, included as a robustness check, while the second and third model are panel data regressions, with the second model including regional fixed effects and the third model including both regional and time fixed effects. The test on whether to include time fixed effects rejects the null hypothesis, implying that the second model is biased and time fixed effects have to be included. The OLS model shows a negative, although not significant, effect of Roll on Roll of goods on the GDP per capita. The first fixed effects model, with only regional fixed effects, also shows a negative, not significant effect. While the model of interest, the model with both regional as well as year fixed effects, shows a negative and not significant effect of Roll-on-Roll-off goods on GDP per capita.

Table 10 GDP per capita and container throughput

VARIABLES	(1) OLS	(2) Regional FE	(3) Regional and Year FE
TEU	-2.61e-05	0.000182	-2.04e-05
	(0.000146)	(0.000179)	(0.000111)
Popover65	7,196	66,187***	-29,868*
	(5,055)	(9,950)	(17,676)
Higheduc	51,085***	29,177***	11,796***
	(2,139)	(4,062)	(3,550)
DensHighways	128.6***	65.32***	56.36***
	(6.170)	(18.98)	(18.57)
Observations	1,911	1,911	1,911
R-squared	0.476	0.534	0.671
Number of Regions		223	223
Regional FE		YES	YES
Time FE			YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The results of table 10 show the effect of the last remaining category of port throughput, being the port throughput of containers, measured in TEU on the GDP per capita, both reported on a NUTS2 level. The first regression in table 10 shows the result of an ordinary least squares model, again included as a robustness check. While the second and third model are panel data regressions including regional fixed effects, for both models and time fixed effects for the third model. The test on whether to include time fixed effects indicates that also for this independent variable time fixed effects have to be included. The OLS model and the first fixed effects model, without time fixed effects, both do not show a significant effect of container throughput on the GDP per capita of the surrounding region. The model of interest, being the fixed effects model with both regional as well as time fixed effects does not show a significant effect of container throughput on the GDP per capita of the surrounding region.

The results of tables 7 to 10 can be summarized as follows: the only category of port throughput that has a significant effect on GDP per capita is the port throughput of dry bulk. The regressions in table 11 are included as a robustness check to test whether this conclusion also holds when all of the categories of throughput are included in a regression.

Table 11 GDP per capita and different categories of port throughput

VARIABLES	(1) OLS	(2) Regional FE	(3) Regional and Year FE
LBULK	-0.0497***	0.0401	0.0252
	(0.0115)	(0.0355)	(0.0328)
DBULK	0.000524	-0.000272	-0.000182***
	(0.000392)	(0.000242)	(4.36e-05)
RORO	0.0320	-0.0196	-0.0491
	(0.0266)	(0.0272)	(0.0381)
TEU	0.000376*	0.000172	-1.58e-05
	(0.000201)	(0.000147)	(0.000103)
Popover65	6,346	65,835***	-30,358*
	(5,109)	(9,962)	(17,635)
Higheduc	51,347***	29,135***	11,586***
	(2,158)	(4,065)	(3,481)
DensHighways	128.0***	66.49***	56.73***
	(6.361)	(18.62)	(18.30)
Observations	1,911	1,911	1,911
R-squared	0.479	0.535	0.673
Number of Regions		223	223
Regional FE		YES	YES
Time FE			YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The regression output, shown in table 11, includes all of the earlier included port throughput activity variables, being liquid bulk, dry bulk, roll on roll off goods and containers. The regressions in this table include an ordinary least squares model, being the first model, a panel data regression including regional fixed effects and a panel data regression including both regional and time fixed effects. The test on whether to include time fixed effects rejects the null hypothesis that all of the time fixed effects are equal to zero, implying that time fixed effects have to be included, making the third model the model of interest. The only category of port throughput that has a significant effect on GDP per capita is the port throughput of dry bulk. The effect of the port throughput of dry bulk on GDP per capita is negative, the GDP per capita drops with 0,000182 euro per thousand tons of dry bulk throughput. The results of this table confirm the stated effect of the results of tables 7 to 10, being that only the port throughput has a significant effect on GDP per capita. These results do not directly result in a clear interpretation of the second hypothesis, since only one of the categories of port throughput has a significant effect, while for the other categories of port throughput it cannot be concluded whether there is an effect on the GDP per capita of the surrounding region.

To place these results into perspective the case study of the three different ports will be resumed. The only category of port throughput that has a significant effect on GDP per capita is dry bulk. The throughput of dry bulk in the Italian region of Calabria was 95000 tonnes, resulting in a loss of GDP per capita of 0,02 according to the model in table 8, while the model with all the different activities included in table 11 concludes a loss of 0,02 in GDP per capita. Whereas the throughput of dry bulk in Catalonia was 15.083.000 tonnes, creating a loss in GDP per capita of 2,96 according to table 8, whereas the model in table 11 concludes a loss of 2,75. Lastly South-Holland had a throughput of dry bulk of 75.631.000 tonnes in 2018, resulting in a loss of GDP per capita of 14,82 according to table 8, while the loss is 13,76 PPS according to table 11. As was also the case for the effect of total throughput on the GDP per capita in PPS, also the effect of dry bulk can be regarded as small when looking at the effects in the above discussed port regions.

It is hard to put the result of this section into the perspective of earlier literature because of two reasons. First the existing literature has not made a distinction in the effect of the different kinds of port activity, secondly most of the categories of port throughput do not have a significant effect on the economic situation of the region. However taking the fact into account that almost all earlier literature found a positive effect of port throughput it is at least surprising that there is a negative effect of dry bulk throughput on the economic situation of the surrounding region. As for the magnitude of the effect it is also hard to place this into perspective since the effect dry bulk has on the GDP per capita has not been a separate subject in earlier literature. Although as was illustrated with the case study of the three different ports the effect on the GDP per capita of those regions can be regarded as rather small.

5.3 Welfare and port throughput

The last section covers the relationship between port throughput and the welfare of the region. The following models are included to determine whether there is an effect of port throughput on the welfare of the region. The different models of table 12 are ordinary least squares models and describe the effect of the total port throughput, as well as the port throughput of the different activities, on the welfare on different NUTS levels.

Table 12 Quality of life and port throughput

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	OLS	OLS	OLS	OLS	OLS	OLS
TON	1.64e-05***					
	(4.93e-06)					
LBULK		-0.000258				-0.000440
		(0.000262)				(0.000423)
DBULK			1.91e-05***			1.98e-05***
			(3.25e-06)			(3.52e-06)
RORO				0.000855		0.00136**
				(0.000524)		(0.000587)
TEU					-1.95e-06	-3.02e-07
					(2.41e-06)	(3.71e-06)
PopDens	-0.0169**	-0.0176**	-0.0169**	-0.0168**	-0.0173**	-0.0173**
	(0.00754)	(0.00768)	(0.00755)	(0.00740)	(0.00762)	(0.00761)
Popover65	737.8***	729.3***	738.4***	723.8***	732.4***	716.9***
	(232.2)	(231.4)	(232.0)	(231.4)	(231.4)	(233.5)
Higheduc	555.8***	563.7***	555.7***	547.6***	557.0***	545.8***
	(75.08)	(75.01)	(75.05)	(76.05)	(75.06)	(77.25)
DensHighways	0.437**	0.491**	0.446**	0.434**	0.496**	0.524**
	(0.187)	(0.209)	(0.188)	(0.185)	(0.205)	(0.214)
Observations	143	143	143	143	143	143
R-squared	0.305	0.307	0.306	0.308	0.305	0.318

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

The first model of table 12 describes the relationship between the total port throughput of the regions and the welfare of those regions. The regression coefficient indicates a significant, positive effect of total port throughput on welfare. The model indicates a rise in welfare of 0,00164 per million tons of port throughput, while the welfare indicator is on a scale of 0 to 1000. The model indicates that all of the control variables have a positive and significant effect.

The second model describes the effect of regional port throughput of liquid bulk on the regional welfare indicator. Although the model indicates a negative effect, as was expected, the coefficient is not significant and hence it cannot be determined from this model whether there is an effect of regional port throughput of liquid bulk on regional welfare.

The third model shows the effect of regional port throughput of dry bulk on the regional welfare. The regression coefficient indicates a significant and positive effect of throughput of dry bulk on the welfare indicator. The regression indicates a rise of welfare of 0.00191 per million tons of port throughput of dry bulk.

The fourth and the fifth model show the effects of the regional throughput of roll-on-roll-off goods and containers. The coefficient of both regressions are both not significant, hence it cannot be determined from these models whether there is an effect on welfare of roll on roll of or container throughput.

The last model combines all of the indicators of port throughput and shows significant and positive effects of both dry bulk and roll on roll of throughput. The regression indicates an effect of dry bulk on welfare of 0.00198 per million tons of dry bulk throughput. While the effect of roll on roll of goods is 1.36 per million tons of port throughput. The effect of the other indicators of throughput do not show a significant coefficient, suggesting there is no effect of the port throughput of both liquid bulk and container throughput on the welfare of the region, as was also observed in the other models of table 11.

The models included in table 12 give a clear view of the effects of the different indicators of port activity on the welfare of the region and answer the third hypothesis; there is indeed a positive relationship between the total port throughput and the welfare of the surrounding region, however the different indicators of port activity do differ in their effect on welfare and do not all have significant effects on the welfare of the surrounding region.

The results of the last section also have different consequences for the three different ports of the case study. The throughput in tonnes has a positive effects on welfare, that varies across the regions, with the amount of throughput in dry bulk and total throughput. For Calabria the total throughput was 38.908.830 tonnes in 2014, while the throughput of dry bulk was 150.000 tonnes. Resulting in a positive effect in welfare of respectively 0,0638 for total port throughput and 0,0003 for dry bulk, while the level of welfare was 875. In Catalonia the total port throughput in 2014 was 75.671.511 tonnes, of which 14.920.000 tonnes were dry bulk. Resulting in a positive effect in welfare of respectively 0,1241 for total port throughput and 0,0285 for dry bulk, while the level of welfare was 870. In South-Holland the total port throughput was 425.906.240 tonnes, whereas dry bulk throughput contributed 82.520.000 to this total. Resulting in a positive effect in welfare of respectively 0,6985 for total port throughput and 0,1576 for dry bulk, while the level of welfare was 939. The effects on welfare of these three different regions illustrate that, although the effect is significant in the model shown in table 12, the effect is rather small.

The results of this last section, regarding the effect of port throughput on welfare, can be regarded as expected, not only because of the fact that the found relationship was indeed positive, as was suggested by the third hypothesis, but also when set off against results of earlier literature, since as was mentioned before, almost all literature found a positive relationship between port throughput and the economic situation of the region. The magnitude of the effect however is quite surprising since as was illustrated by the case study above the effect can be regarded as small. However one cannot simply compare this result directly with the results of earlier literature, because of the fact that earlier literature only took the economic situation into account, instead of a broader measurement of welfare, as was done in this section.

6. Conclusion

In this thesis it was the objective to establish a relationship between port activity and the economic performance of the region of the port for the regions of the European Union. At first the concept of port activity was established as the total port throughput or as the total throughput of the separate throughput categories. After which a distinction was made between the economic performance of the region measured as GDP per capita and the economic performance in a broader perspective measured as quality of life in the region. These different measurements resulted in the different subsections of this thesis and were established to answer the question:

What is the effect of the activity of a port on the economic performance of the surrounding region?

The answer to this question depends on how the economic performance is measured, since as could be concluded from the results when economic performance is measured as GDP per capita there is a negative effect of total port throughput on the economic performance of the region, while when the quality of life variable is included the effect of total port throughput is positive.

The first hypothesis, stating that there is a positive effect of port throughput on the economic performance of the surrounding region, resulted in a model with total port throughput as a measurement of port activity and GDP per capita as an indicator of economic performance. The model suggested a negative relationship between port activity and the economic performance of the region surrounding the port. Hence the first hypothesis is rejected.

The model to test the second hypothesis, stating that there are different effects of the different categories of throughput on the economic performance of the surrounding region to be witnessed, included the separate categories of throughput as a measurement of port activity in order to test whether there is a different effect to be witnessed for the different categories. While the economic performance of the region was again measured by the GDP per capita. The model did not provide enough significant results to conclude whether there are different effects for the different categories, since only the throughput of dry bulk provided a significant results, being a negative effect on GDP per capita.

In order to account for the effects of port activity on the welfare of the region the third hypothesis, that stated that there is a positive effect of port throughput on welfare, the last section was included. This resulted in a model that included total port throughput as a measurement for activity and a quality of life indicator as a measurement for the welfare in a region. The different indicators of port throughput were included in a different model to determine their effect on welfare as well. From the results of these models it can be concluded that total port throughput has a positive effect on the welfare of the surrounding region for the European union. Hence the third hypothesis is accepted. However when looking at the effects of the different categories of throughput only the throughput of dry bulk had a significant, and positive, effect, hence it cannot be concluded whether the effect is different for the different categories of throughput.

When taking all of the conclusions of the different hypotheses into account the answer to the research question is ambiguous. When port activity is seen as the total throughput there is a negative effect on the economic performance to be observed. However, when the activity of a port is seen as the different categories of port activity this thesis does not provide a definitive answer. And when the economic performance is measured in a broader sense, also including welfare effects, the effect of total port throughput is positive.

7. Discussion

After taking the results of the different subsections into account a number of things can be concluded regarding the impact of this thesis on both the scientific as well as the social debate regarding the impact of port throughput on the economic performance and welfare of the surrounding region. First the result of the first section of this thesis suggests a negative relationship between port throughput and the economic performance of the surrounding region for all ports in the European Union. This contradicts most of the results on the subject that included single countries or only parts of Europe. Since this negative effects suggests that the negative economic externalities of the port are larger than the positive economic externalities of the businesses of a port, this result not only contradicts earlier reports on this topic but also the view of ports as clusters (e.g. De Langen, 2004; Fujita & Mori, 1996) with a positive economic effect on the surrounding region. This has direct implications for government policy regarding public investments in ports, such as for the ‘’mainportpolicy’’ in the Netherlands, where important transport nodes, such as ports, are incorporated in a public investment plan (Kuipers, 2018). The results of this thesis contradict the effect the investments of such a policy, for the ports among the transport nodes. The results of these thesis however do not conclude anything about the effects on different parts of the regional economy like some impact studies have done (e.g. Kuipers, 2018). These policy and scientific implications state the relevance of more studies on this subject including all EU ports, or even larger areas.

The aim of this thesis to state the different effects of the different kinds of port throughput did not result in achieving a definite result, making more research essential in order to include this subject in future scientific debate. Hence, at this point in time it is not possible to act upon possible differences in effects with different public policies. Although the category dry bulk did show a significant and negative effect, this effect is so small that this would probably not directly lead to any differences in public or port investment strategies.

The third section of this thesis, that was included to introduce a broader measurement of welfare to the debate of the impact of port throughput, did give a significant result stating a positive effect of port throughput on the welfare of the surrounding region. Since this result contradicts the result of port throughput on the economic performance of the surrounding region it would be interesting for future research to include more welfare data in impact studies of ports and port throughput. Because including more welfare data or variables could possibly lead to different outcomes, while at the same time this would lead to more information for policy makers, since this also takes the effect on other life conditions apart from employment or spendable income into account. The result of the welfare section also confirms the idea behind public investments in ports and policy plans such as the earlier mentioned ‘’mainportpolicy’’.

Apart from the impact the three different subsection have on both the scientific debate and what kind of policy implications they impose, this thesis also shows a number of issues that could be solved by future research. As was described above a first suggestion for future research could be to include more welfare or quality of life data, since the subsection that included the effect on welfare had contradicting results to the section stating the effect on local economic performance. A second extension for future research is to include the value of the throughput, in this way the difference in efficiency between ports and the ratios of the different types and value of goods can be accounted for. This could possibly be combined with data of the different types of trading activity, being transit goods, re-export and export from the home country of the port. At this point in time there is no data available data for the value of the throughput on a EU level or the different kinds of trading activities in European ports, that is why it was not possible to account for the value of the throughput or the different kinds of trading activities in this thesis.

8. Limitations

A first thing that is important to acknowledge when looking at the results of the different subsections of this thesis is that, as was also stated in the theoretical framework, the relationship between port activity and regional economic performance can be a two way relationship instead of just an effect of port throughput or the different categories of port throughput on regional economic performance or quality of life.

The actual limitations of this thesis are twofold, since the thesis can also be divided into two parts. On the one hand there is the relationship between throughput and GDP and on the other throughput and welfare, with both its own shortcomings. The data that is used to study both relationships, being the throughput data, depends on reported data by the port authorities to the ESPO, implying that when for a year an authority does not report its throughput there is either a lower value for throughput for that NUTS region, in the case when the NUTS region housed multiple ports, or no value at all, when there is only one port in the NUTS region. This could lead to a situation for the regions where ports did not report the throughput data to the ESPO the result of the impact on GDP is possibly overestimated, due to a lower reported throughput value for that region for a specific year. A limitation that is solely seen in the relationship between GDP and throughput is the missing GDP data of some regions, resulting from missing values in the Eurostat database. This creates a situation where the results do not hold for these regions, since they could not be included in the study. The regions with the most missing GDP data are the French NUTS regions.

Another case of missing data was already mentioned in the results section, being the large loss in observations when including the variable, this was solved by not including this variable in the final model. However not including this variable does impose other limitations, being that the accessibility of ports and regions, as was suggested to include by Ferrari et al. (2010), is only accounted for by the density of the highway network. Possibly resulting in different results because regions that depend more on their railway network for accessibility see their value for accessibility be much lower in the used data. However only using a variable depicting the accessibility by highway or motorway length has been done by other authors, such as (Bottasso et al., 2013, 2014a).

Another limitation of the study arises from the results of the second hypothesis, since the analysis of the effects of the different indicators of port activity, being the throughput of liquid bulk, dry bulk, roll on roll off goods and containerized goods, shows only a significant effect for the throughput of dry bulk. Hence there is not enough evidence to either accept or reject the second hypothesis and a clear conclusion on whether there are different effects on the economic performance of the region for the different indicators of port throughput cannot be drawn.

The section on the impact of port throughput on the welfare of the surrounding region also imposes a number of limitations. The welfare or quality of life variable was retrieved from the paper by Peiró-Palomino & Picazo-Tadeo (2018). In this paper the authors constructed a quality of life variable with data on 10 well-being domains retrieved from the OECD well-being Dataset. The variable was constructed with data from 168 NUTS regions, on both the NUTS 1 and NUTS 2 level. The limitations of this approach include two things, first the number of included regions is relatively small, coming from the fact that for a lot of countries only the NUTS 1 regions are included, this could impose a biased result since the regions are larger, making it more likely that a region includes a port, resulting in less distinction in throughput data between the regions. The second problem resulting from using this data is that the quality of life variable is constructed using data from 2014, hence the variable only holds for 2014 meaning only one time period can be included in the study.

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10. Appendix

Table A1 GDP per capita and total port throughput

VARIABLES	(1) OLS	(2) Fixed effects	(3) Fixed effects
TON	-0.0106***	0.00610***	0.000374
	(0.00342)	(0.00173)	(0.00134)
Popover65	12,815**	67,277***	-24,986
	(5,562)	(14,804)	(24,492)
Higheduc	57,630***	24,899***	10,243*
	(2,505)	(7,258)	(5,650)
DensHighways	126.4***	67.85***	60.70***
	(9.183)	(18.41)	(18.72)
DensRailways	10.77**	-8.889***	-5.328**
	(4.190)	(2.757)	(2.631)
Observations	1,460	1,460	1,460
R-squared	0.533	0.510	0.644
Number of Regions		178	178
Regional FE		YES	YES
Time FE			YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A2 GDP per capita and liquid bulk throughput

VARIABLES	(1) OLS	(2) Fixed effects	(3) Fixed effects
LBULK	-0.0266***	0.00582	0.00585
	(0.00626)	(0.0341)	(0.0389)
Popover65	12,305**	66,919***	-25,316
	(5,616)	(14,836)	(24,177)
Higheduc	57,740***	25,143***	10,191*
	(2,512)	(7,257)	(5,625)
DensHighways	125.8***	70.87***	61.01***
	(9.071)	(18.21)	(18.20)
DensRailways	10.20**	-9.092***	-5.322**
	(4.162)	(2.899)	(2.636)
Observations	1,460	1,460	1,460
R-squared	0.533	0.507	0.644
Number of Regions		178	178
Regional FE		YES	YES
Time FE			YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A3 GDP per capita and dry bulk throughput

VARIABLES	(1) OLS	(2) Fixed effects	(3) Fixed effects
DBULK	-0.0196**	0.00557***	0.000648
	(0.00998)	(0.00146)	(0.00134)
Popover65	12,891**	67,379***	-24,885
	(5,551)	(14,812)	(24,488)
Higheduc	57,730***	25,033***	10,261*
	(2,514)	(7,256)	(5,652)
DensHighways	122.8***	67.59***	60.53***
	(8.462)	(18.54)	(18.80)
DensRailways	11.04***	-8.883***	-5.320**
	(4.136)	(2.782)	(2.626)
Observations	1,460	1,460	1,460
R-squared	0.533	0.510	0.644
Number of Regions		178	178
Regional FE		YES	YES
Time FE			YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A4 GDP per capita and roll-on-roll-off throughput

VARIABLES	(1) OLS	(2) Fixed effects	(3) Fixed effects
RORO	0.0392	0.00168	-0.0528
	(0.0299)	(0.0346)	(0.0528)
Popover65	12,117**	66,971***	-25,870
	(5,573)	(14,822)	(24,182)
Higheduc	57,729***	25,141***	10,070*
	(2,523)	(7,262)	(5,528)
DensHighways	118.4***	70.72***	60.21***
	(8.138)	(18.46)	(18.47)
DensRailways	11.36***	-9.097***	-5.260**
	(4.105)	(2.906)	(2.653)
Observations	1,460	1,460	1,460
R-squared	0.532	0.507	0.645
Number of Regions		178	178
Regional FE		YES	YES
Time FE			YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A5 GDP per capita and container throughput

VARIABLES	(1) OLS	(2) Fixed effects	(3) Fixed effects
TEU	-0.000162	0.000195	-7.26e-06
	(0.000167)	(0.000163)	(0.000101)
Popover65	12,740**	66,912***	-25,180
	(5,576)	(14,832)	(24,145)
Higheduc	57,642***	24,844***	10,239*
	(2,502)	(7,222)	(5,661)
DensHighways	122.6***	71.68***	60.82***
	(8.927)	(18.52)	(18.40)
DensRailways	11.34***	-9.185***	-5.330**
	(4.162)	(2.856)	(2.634)
Observations	1,460	1,460	1,460
R-squared	0.532	0.509	0.644
Number of Regions		178	178
Regional FE		YES	YES
Time FE			YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A6 GDP per capita and categories of throughput

VARIABLES	(1) OLS	(2) Fixed effects	(3) Fixed effects
LBULK	-0.0392***	0.00621	0.00306
	(0.0122)	(0.0331)	(0.0373)
DBULK	-0.0141***	0.00553***	0.000687
	(0.00457)	(0.00146)	(0.00131)
RORO	0.0986***	-0.00284	-0.0527
	(0.0332)	(0.0326)	(0.0520)
TEU	0.000188	0.000195	4.22e-06
	(0.000235)	(0.000162)	(0.000102)
Popover65	10,627*	67,257***	-25,656
	(5,643)	(14,821)	(24,514)
Higheduc	57,532***	24,734***	10,075*
	(2,506)	(7,238)	(5,535)
DensHighways	125.9***	68.74***	59.97***
	(9.310)	(18.44)	(18.72)
DensRailways	9.889**	-8.967***	-5.240**
	(4.180)	(2.730)	(2.618)
Observations	1,460	1,460	1,460
R-squared	0.535	0.511	0.645
Number of Regions		178	178
Regional FE		YES	YES
Time FE			YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1