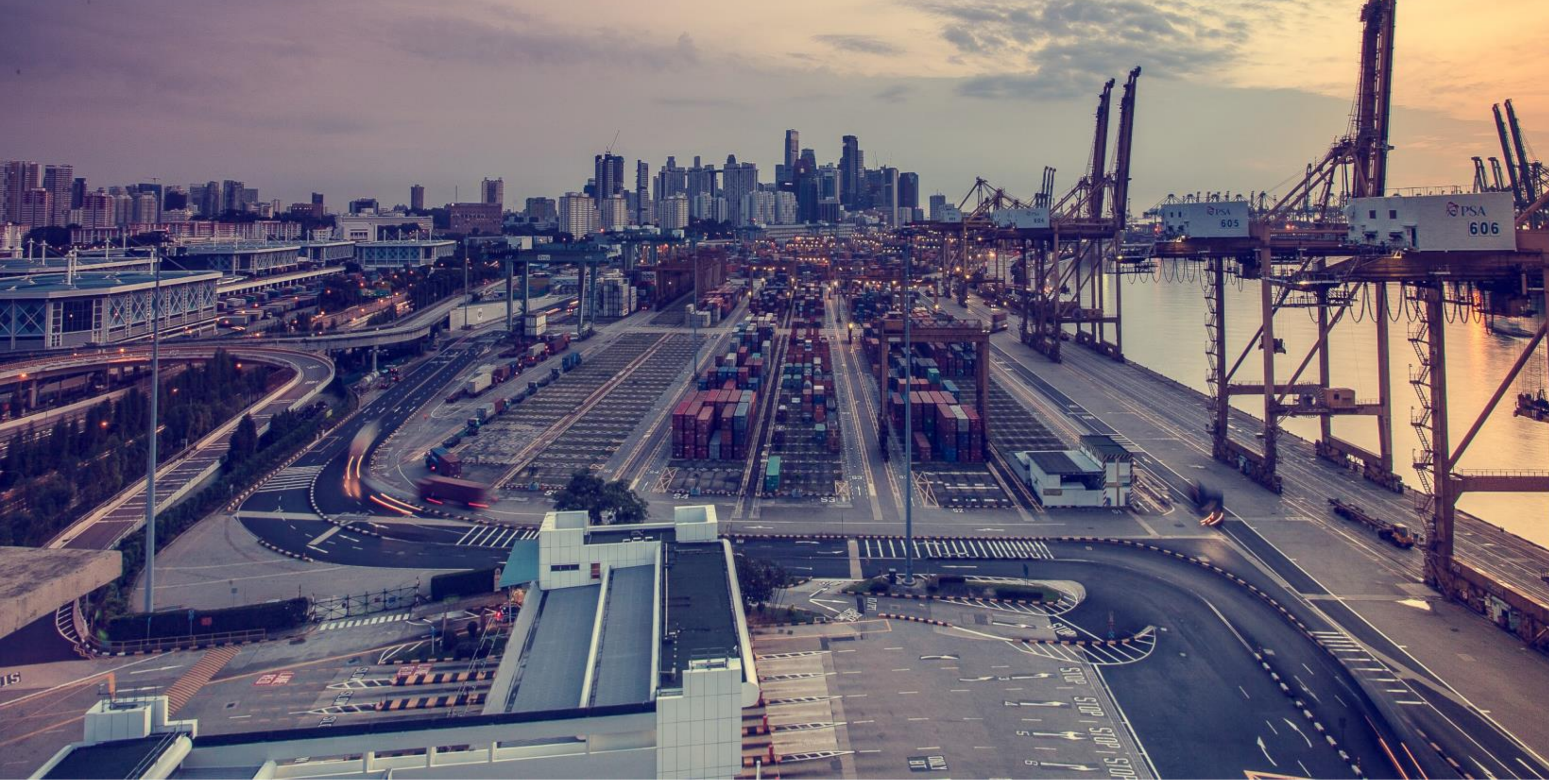
Determinants of seaports container throughput between the Hamburg-Le-Havre range and the Mediterranean ports:

Infrastructure investments and their returns on TEU



Master Thesis

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Acronyms

OECD : Organization of Economic Cooperation and Development
GDP : Gross Domestic Product
FTZ : Free Trade Zone
TEN-T : Trans-European Transport
TEU : Twenty-foot Equivalent Units
ITF : International Transport Forum
AFD : Augmented Dickey-Fuller
ECM : Error Correction Model
IPS : Im-Pesaran-Shin

Acknowledgements

"And if you find her poor, Ithaca will not have fooled you. Wise as you will have become, so full of experience, you will have understood by then what these Ithacas mean." Constantine P. Cavafy.

The present study constitutes my final effort towards completing my master studies at the Urban, Port and Transport Economics at the Erasmus University Rotterdam. As every journey comes to an end, a new chapter in the course of life opens, rich in adventures and challenges. I would like to take advantage of the opportunity of this short section to express my gratitude to the people who supported me fulfilling this objective.

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Abstract

The present paper investigates the effect of the infrastructure investments on the port container throughput between two port ranges: The Hamburg - Le Havre range versus the Mediterranean range. The Hamburg - Le Havre range includes Germany, Netherlands, Belgium and France. The Mediterranean range includes Portugal, Spain, Italy, Croatia, Slovenia and Greece. The infrastructure investments include infrastructure investments in the four modes of transport, namely Air, Rail, Road and Sea and investments in superstructures, namely Transport Equipment. Panel data analysis has been made, with depended variable the TEU (port container throughput) and independent variables the investments in infrastructures and superstructures. The results show that both infrastructure and superstructure investments have a positive and significant effect on the port container throughput. There are also sizable differences in the returns of investments between the Hamburg - Le Havre and the Mediterranean range. Policy recommendations under the prism of the findings of this paper are made: the container throughput as a Special Purpose Vehicle for financing transport infrastructure projects and its potential use for a balanced regional policy are discussed.

Key words: TEU, port container throughput, maritime port infrastructure investments, road transport infrastructure investments, rail transport infrastructure investments, air transport infrastructure investments, transport equipment investments.

1. Introduction

Container throughput is the most important and direct factor for evaluating the competitive strength of a port (Lechao Liu & Gyei-Kark PARK, 2011). Additionally, port container throughput figures are of utmost importance for the policy making of the port and regional authorities. The current port container throughput explanatory models make little or no use of the infrastructure investments' influence on the port performance.

1.1 Problem Definition

The existing models are based on figures which generate trade demand, such as population, income, GDP, inflation, trade volume and transport costs. The attention paid on the investments in port infrastructures is poor and the investments in hinterland infrastructure are absent from the current literature.

However, there are several papers which underline the decisive effect of infrastructure investments on port performance. For example, Grossmann et al. (2006) state that, except for port infrastructure, highly significant for the competitiveness of ports are the infrastructure links from the port to the hinterland market by pipelines, rail, waterways, road and air.

Furthermore, even though infrastructure investments in the other modes of transport (air, road, rail) play a critical role in the competitiveness of a port, they have not been tested for improving the predictive performance of the container throughput forecasting models yet. Therefore the current forecasting models are of limited power and the significance of the infrastructure investments, since not en-modeled and measured, as a result are underestimated by the port authorities and the relevant parties (liners, shippers, regional authorities, terminal operators etc).

1.2 Research Approach

The missing gap from the previous literature is to be filled with variables found in the OECD database. It is assumed, that the following elements cover the vast majority of the infrastructure investments which can potentially influence port efficiency:

Infrastructure Investments

- Maritime Port Infrastructure Investments
- Road Transport Infrastructure Investments
- Rail Transport Infrastructure Investments
- Air Transport Infrastructure Investments

Superstructure Investments

- Transport Equipment Investments

1.3 Thesis Contribution

As aforementioned, there is a gap in the current forecasting literature: researchers have been exploring ways to improve the explanatory power of the port models on the one hand, and on the other hand, the evident influence of the infrastructure and superstructure investments on the port container throughput, which has not been investigated yet.

****The objective of the present paper, is to connect the infrastructure and superstructure investments with the ports container throughput, quantify and highlight its significance for the performance of the ports.****

As a result of this connection, the accuracy of the current container forecasting models is expected to be improved. Container forecasting is of utmost importance for the long term policy making of the port authorities, liners, shippers and terminal operators. Therefore, except for its academic contribution, the present paper might as well assist the strategic decision making of the aforementioned agents.

Finally, the presented models can be used by the governmental organizations and port authorities, in order to predict the returns of infrastructure investments in terms of TEU. With an estimation of the average transported goods' value per container, the amount of revenues in taxes, custom duties, clearance et cetera can be calculated. This could be an interesting insight for governments, local authorities and investment funds which could monetarize the returns of infrastructure investments as well, in order to assess the attractiveness of infrastructure investments.

2. Literature Review

In this section, the literature review will be presented, for both studies that have not included the infrastructure investments effect on the port container throughput, and a recent study which has included the investments in maritime port infrastructure. Additionally, the effect of the infrastructure investments on the ports' performance as per the current studies will be reviewed.

2.1 Determinants of Port Container Throughput

One of the most popular explanatory variables of the port container throughput is trade. Seabrooke et al (2003), predicted the container throughput of the port of Hong Kong. They used the value of raw materials, fast moving consumer goods and chemicals. In their study for the import and exports for Spanish ports [1], Coto-Millán, Baños-Pino & Castro (2005) found of significant explanatory power the prices of imports and exports, the prices of maritime transport services and the world and national income.

Chou, Chub and Liang (2008) used the variables of GDP, world GDP, exchange rate, population, inflation rate, interest rate and fuel price for predicting the import and exports of container throughput of Bangkok Port. Lechao LIU, Gyei-Kark PARK (2011) found that port tariffs, terminal storage capacity, berth length, direct call liner, transshipment, hinterland's GDP, hinterland's import-export volume, FTZ (Free Trade Zone) area and government investment influence significantly the container throughput of the Korean and Chinese ports.

Yasmine Rashed (2015) concluded that, the EU18 industrial confidence indicator and the index of industrial production are leading the container throughput at the port of Antwerp. At a Hawa M. (2015) study, Foreign Direct Investment, Population and GDP were chosen as the principle components to analyze the port's container throughput.

Pitinoot Kotcharat (2016) developed a forecasting model, predicting the container throughput in the Chabang Port. He used as explanatory variables the employment, private investment index and the bunker price in Singapore.

Last but not least, as mentioned in the introduction, only one study was found to employ maritime port infrastructure investment for predicting the port container throughput. Arjun Makhecha (2016), used among others Sea Infrastructure Investments for explaining the container throughput of the Hamburg-Le Havre range. However, for some of the ports of the region, the specific variable was found either insignificant or with negative coefficient. According to the author, these results indicate that the investments in port infrastructure in the region are not optimal.

2.2 Effect of Infrastructure Investments on Ports' Performance

Except for the aforementioned variables, and as mentioned in the introduction, even though there is a plethora of studies stressing the critical effect of infrastructure investments on the performance of a port, little research has been made in order to verify and quantify their significance in determining port container throughput.

According to Oosterhaven & Knaap (2003), investments in the hinterland infrastructure can improve the competitiveness of a port. Meersman et al. (2008) emphasize that successful ports belong to successful supply chains. Jose L. Tongzon (2009) investigated the forwarders' port choice criteria and found that adequate infrastructure (roads and railways) play a crucial role to forwarders' decisions choosing a port. Adequate infrastructure, decreases port congestion and ship waiting time, allows for a quicker and safer freight movement and enables the ships to achieve economies of scale, resulting in reduced maritime transport costs.

Bart W. Wiegmans et al. (2008), mentions port physical and technical infrastructure as a port choice criteria by shipping lines. This includes nautical accessibility, terminal infrastructure and equipment and hinterland accessibility (intermodal interface for trucks, rail, barge and short-sea).

Lusthaku (2017), mentions that the determinant of efficiency of port operations is connected with the factors of costs and time, which are correlated with the hinterland infrastructure such as inland waterway connections, road and rail lines. Lustaku concludes that both hinterland and port infrastructure influence the port performance and container throughput.

Lustaku's analysis is qualitative and the effects of hinterland infrastructure on port performance are rather blurred. Even thought that generally admitted, the investments in infrastructure positively impact the competitiveness of ports, many times their return on investments is questioned (Tshepo Kgare et al, 2011).

In Table 1, the Literature Synopsis is presented, together with the sign of the Effect of the Variable(s) on the TEU.

Table 1: Literature Synopsis

Author(s)	Variables	Effect
Coto-Millán, Baños-Pino & Castro, 2005	*Import Prices, Cost of Maritime Transport Services*	-
Coto-Millán, Baños-Pino & Castro, 2005	*National Income, World Income*	+
Seabrooke et al., 2003	*Trade Value, Population*	+
Gosasang et al., 2010	*Exchange Rates, Interest Rates, Inflation Rates*	-
Hui, Seabrooke & Wong, 2004	*Trade with the biggest partner*	+
Yasmine Rashed et al., 2015	*Business Confidence Indicator, Economic Sentiment Indicator, Industrial Confidence Indicator, Index of Industrial Production, Total Export Volume Index, Total Import Volume Index*	+
Lechao LIU, Gyei-Kark PARK, 2011	*Port Tariff*	-
Lechao LIU, Gyei-Kark PARK, 2011	*Terminal Storage Capacity, Berth Length, Direct Call Liner, Transshipment, Hinterland's GDP, Hinterland's Import Export Volume, FTZ Area, Government Investment*	+
Pitinoot Kotcharat, 2016	*Employment, Private Investment Index*	+
Pitinoot Kotcharat, 2016	*Bunker price*	-
Chou, Chub and Liang, 2008	*GNP, GNP per capita, wholesale GDP, agricultural GDP, industrial GDP and service GDP*	+
Arjun Makhecha, 2016	*Quay length*	-

Table 1: Literature Synopsis

Author(s)	Variables	Effect
Arjun Makhecha, 2016	*Terminal area, Labor productivity index, GDP, Import, Export, Sea Infrastructure Investments, Container Traffic (calling)*	+
Hawa Mohamed Ismael, 2015	*FDI, Population, GDP*	+

In the following section, the various infrastructure investments will be analyzed and their expected effect on the port container throughput. Finally, relevant hypothesis will be made.

2.3 Theoretical Framework

Port efficiency varies widely from country to country and specifically from region to region (T. Rajasekar & Malabika Deo, 2014). Therefore, it is crucial to test the infrastructure investments returns on ports' TEU between geographically and culturally different regions. As per the current study, the chosen port regions are within the European Union, namely the Hamburg-Le Havre and the Mediterranean region. The Hamburg-Le Havre region includes Germany, Netherlands, Belgium and France. The Mediterranean region Includes Portugal, Spain, Italy, Slovenia, Croatia and Greece. The two regions, compete each other not only for the market of the European hinterland, but also for infrastructure investment funding from the European Union (TEN-T network), which makes the analysis even more interesting.

The variables which will be used are assumed to cover the majority of a country's infrastructure investments. Two groups of infrastructure investments have been distinguished: Infrastructure investments and superstructure investments, a distinction that has been made by The World Bank Group (2000). On their report for the private sector and the infrastructure network, docks and storage yards are defined a port's infrastructure and sheds, fuel tanks, canes and van carriers as superstructure.

2.4 Infrastructure Investments

In the Infrastructure Investments the following elements have been included:

- Maritime Ports Infrastructure
- Road Transport Infrastructure
- Rail Transport Infrastructure
- Air Transport Infrastructure

2.4.1 Maritime Port Infrastructure Investments

Kazutomo Abe and John S. Wilson (2009) stressed the importance of trade costs and their negative effect on the international trade flows. Their regression analysis recommends that the expansion of port infrastructure would ceteris paribus reduce the import charges and trade costs paid by the importers, which would in turn reduce the transport costs and lead to a trade expansion through the ports.

According to Tshepo Kgare et al. (2011), the obsolete trade infrastructure of South Africa resulted in port and terminal congestion which in turn gained the reputation of an inefficient port. Long port and terminal waiting hours increase the lead time and pipeline costs of a supply chain, therefore limit the chances of the port to be used and finally restrict its potential container throughput.

Nil Güler (2003), suggested that the benefits of port development projects are transport saving costs and reduced turn-round time. "A port investment may, depending on the situation, ease congestion, increase productivity, reduce ship waiting time cost, cargo-handling cost and finally reduce overall transport costs." Therefore, port infrastructure investments increase the competitiveness of a port and its ability to attract container flows.

Hypothesis 1: Maritime Port Infrastructure Investment has a positive and significant effect on the TEU for both port ranges.

2.4.2 Road Transport Infrastructure Investments

Road transport represents the largest share, or 75%, of the total inland freight transported within the EU (Eurostat, 2017). Road transport in this study refers to the transportation of containers through trucks. According to a research conducted by Charles K. et al. (2012), 98% of the questionnaires responded that road transport inefficiencies affect port performance. Poor road network is found to result in a slow uptake of cargo into the hinterland. As a result, higher truck turn-round time and therefore high cargo dwell time at the port occurs. The study suggests that investments in road infrastructures should be mobilized for a more efficient road network.

Another study, one conducted by Stephen G. et al. (2012) found that road transport improvements have direct effects related to transport cost savings, which are correlated with the accessibility changes. Intuitively, road transport infrastructure (such as street widening, longer road network, tunnels and bridges) can well result in shorter transport times between the port and the hinterland and increase the flexibility of the supply chain.

Concluding, the effect of road transport infrastructure on the performance of a supply chain is positive and sizable. The effect on the performance of ports is expected to be similar.

Hypothesis 2: Road Transport Infrastructure Investments have a positive and significant effect on the TEU for both port ranges.

2.4.3 Rail Transport Infrastructure Investments

Comparing with road, the share of rail in transporting freight has remained stable at around 18.5% since 2011 (Eurostat, 2017). Railway transport has advantages of high carrying capacity, lower influence by weather conditions, and lower energy consumption (M. Sreenivas & T. Srinivas, 2008). Ambwene Mwakibete's (2015) study, revealed that rail transport plays a superb role in the port performance of Dar es Salaam. Reduction of port congestion, increase of cargo traffic and lower logistics costs are among the contributions of rail infrastructure on port performance.

Erick L. et al. (2012), in their study for the benefits of rail and port integration, argue that port connectivity with the hinterland is of utmost importance for the competitiveness of a port and rail connections play this role. In order the competitive strength of the Latin America's port to be improved, they suggest investments in track, rolling stock and equipment.

Infrastructure investments in rail can be mobilized for high speed rail as well. According to OECD/ITF (2014), the benefits of high speed rail are congestion relief and faster services. Therefore, investing in improving the speed of rail, results in decreased transit time. Each day in transit is estimated to cost between 0.6 % and 2.6 % of the value of traded goods (Hummels & Schaur, 2012).

Concluding, Rail Transport Infrastructure Investments are expected to have a positive and significant effect on the ability of a port to attract container flows.

Hypothesis 3: Rail Transport Infrastructure Investments have a positive and significant effect on the TEU for both port ranges.

2.4.4 Air Transport Infrastructure Investments

Moving cargo via airlines is times faster than by rail, road or sea. However, air is usually used for very high added value commodities, such as technological advancements, which are time sensitive, and goods of strategic importance. Additionally, containers as the ones loaded on the ships, are not carried via airplanes. Finally, airlines are used mainly to transfer passengers, rather than goods.

From this perspective, unlikely with the Maritime Port, Road and Rail Transport Infrastructure, there is not an obvious effect of a potential Air Transport Infrastructure Investment on the performance of the sea ports. However, Air Transport Infrastructure Investments have a direct effect on a country's GDP. According to a survey conducted by Invervistas (2015), a consulting company with extensive expertise in aviation, transportation, and tourism, the European airports contribute to the employment of 12.3 million people earning € 356 billion in income annually, and generate € 675 billion in GDP each year, equal to 4.1% of GDP of Europe.

Therefore it is expected Air Transport Infrastructure Investments to strengthen the economic activity of the European Union and therefore, indirectly increasing the ports container throughput.

Hypothesis 4: Air Transport Infrastructure Investments have a positive and significant effect on the TEU for both port ranges.

Hypothesis 5: The Infrastructure Investments have jointly a positive and significant effect on the TEU for both port ranges.

2.5 Superstructure Investments

In the Superstructure Investments, the following elements have been included:

- Transport Equipment Investments

2.5.1 Transport Equipment Investments

Transport Equipment is the key element which makes the various infrastructures function internally and externally with each other. In the paper of Grossman et al. (2006), apart from the port infrastructure, superstructures (tractor units, container gantries, cranes, et cetera) are also a key factor influencing the competitive position of a port and thus the volume of cargo handled in that port. As per the OECD definition glossary, in the assets of the transport equipment, sea port, rail, road and airport transport equipment are included. Finally, the definitions of the infrastructure and superstructure elements will be further elaborated in the *Empirical Analysis* section.

Hypothesis 6: Transport Equipment Investments have a positive and significant effect on the TEU for both port ranges.

Hypothesis 7: Infrastructure Investments and Superstructure Investments have jointly a positive and significant effect on the TEU for both port ranges.

Table 2 provides a synopsis of the formulated hypothesis.

Table 2. Hypotheses Synopsis

Hypothesis 1	*Maritime Port Infrastructure Investment has a positive and significant effect on the TEU for both port ranges.*
Hypothesis 2	*Road Transport Infrastructure Investments have a positive and significant effect on the TEU for both port ranges.*
Hypothesis 3	*Rail Transport Infrastructure Investments have a positive and significant effect on the TEU for both port ranges.*
Hypothesis 4	*Air Transport Infrastructure Investments have a positive and significant effect on the TEU for both port ranges.*
Hypothesis 5	*Infrastructure Investments have jointly a positive and significant effect on the TEU for both port ranges.*
Hypothesis 6	*Transport Equipment Investments have a positive and significant effect on the TEU for both port ranges.*
Hypothesis 7	*Infrastructure Investments and Superstructure Investments have jointly a positive and significant effect on the TEU for both port ranges.*

In the following section, the various econometric models as per the port container throughput forecasting models available will be discussed and the choice of the most appropriate one for the needs of our analysis will be argued.

3. Methodology

What the present paper investigates is the relationship between the transport infrastructure investments and the port container throughput. Therefore we are looking for causes and their corresponding effects. The most popular method in the scientific literature in order to find if and to what extend does one (or a group) of variables-elements explain a phenomenon is the *cause and effect models.* In our case, the cause and effect model is to assist in the understanding of the relationship between the aforementioned transport infrastructure investments on the port container throughput of the defined port ranges.

According to M. Jansen (2014), this method is more specifically related to a particular port that can be seen as a zone. An instance of a cause and effect model is the regression analysis. A regression analysis helps to describe data, estimate parameters and verify relations that arise from economic logic.

There are several types of regression analysis: time series, cross sectional, panel data and the pooled data. The choice of the proper one is based on the structure of the collected data, which in turn is built and depends on the research questions. The aforementioned types of regression analysis will be elaborated in the following section, and the one which best describes our own research questions is to be chosen, in order to perform the empirical analysis part.

3.1 Time Series Data

Time series data is the observations of one variable, TEU, through the time (months, quarters, years). Time series data can be univariate and multivariate. A time series univariate model would attempt to explain the TEU variation of a single country through time, using previous observations of the given variable (TEU) of the given country (auto-regressive). The general formula can be described as:

$$TEU_t = \beta_0 + \beta\ TEU_{t-j} + \varepsilon_t \qquad (1)$$

t=time,
j=lagged time,
β_0=constant,
β=effect of previous years TEU on the following years,
ε_t=error term.

Alternatively, a multivariate time series model, would attempt to explain the TEU variation of multiple countries through time, using previous observations of the given variable (TEU) of multiple countries.

$$TEU_{it} = \beta_0 + \beta\ TEU_{i,t-j} + \varepsilon_{it} \qquad (2)$$

t=time,
j=lagged time,
i=country,
β_0 =constant,
β=effect of previous years TEU on the following years,
ε_t=error term.

Logically considering, TEU variation explanation, employing observations of the variable in question itself, does not provide cause and effects insights whatsoever. Time series model is not an appropriate model for our case.

3.2 Cross Sectional Data

On the other hand, cross sectional datasets, are observations at a single point in time, for several entities (countries). Cross sectional models are divided in univariate and multivariate models. An example of a cross sectional univariate model would have been the studying of the TEU variation at a single point in time, for multiple countries, employing a single variable other than TEU (for example the investments in maritime port infrastructure).

$$TEU_i = \beta_0 + \beta \text{ Investments in maritime port infrastructure}_i + \varepsilon_i \qquad (3)$$

i=country,
β_0=constant,
β=effect of Investments in maritime port infrastructure on TEU,
ε_i=error term.

Alternatively, a multivariate cross sectional model, would have been the studying of the TEU variation at a single point time, for multiple countries, employing multiple variables other than TEU (for example the Investments in maritime port infrastructure, GDP, etc).

$$TEU_i = \beta_0 + \beta \text{ Investments in maritime port infrastructure}_i + c\, GDP_i + \ldots + Variable_{n,i} + \varepsilon_i \qquad (4)$$

i=country,
β_0 =constant,
β=effect of Investments in maritime port infrastructure on TEU,
c=effect of GDP on TEU,
$Variable_n$=last explanatory variable,
ε_i=error term.

Even though cross sectional models are closer to a cause and effect analysis, the dimension of time is missing. Therefore, it might happen that a relationship which appears to be significant for one point in time, to be insignificant for a different point in time.

3.3 Panel Data

What differentiates panel data from cross sectional data, is that the same cross sectional units are followed over time. Panel datasets (or longitudinal data) are structured by observing in multiple points in time (months, quarters, years), multiple entities (countries). Therefore, panel data are characterized by two dimensions, time (t = 1,..., T) and entity (i = 1,..., N).

An advantage of the panel data comparing to the cross section, is that they allow the researcher to investigate the importance of the lag effects of the explanatory variables on the behavior of the depended variable (TEU). This information can be crucial, since many economic policies can be expected to have an impact only after a certain period of time has passed (Wooldridge, 2012).

Panel models are divided in univariate and multivariate models. An example of a univariate panel model would be the studying of the TEU variation at multiple points in time, for multiple countries, employing a single variable other than TEU (for example the investments in maritime port infrastructure).

$$TEU_{i,t} = \beta_0 + \beta \text{ Investments in maritime port infrastructure}_{i,t} + \alpha_i + u_{it} \quad (5)$$

t=time,
i=country,
β_0=constant,
β=effect of Investments in maritime port infrastructure on TEU,
α_i=unobserved, time constant factors that affect $TEU_{i,t}$,
$u_{i,t}$=time varying error which represents factors that change over time and affect $TEU_{i,t}$.

Alternatively, a multivariate panel model, would have been the studying of the TEU variation at multiple points in time, for multiple countries, employing multiple variables other than TEU (for example the Investments in maritime port infrastructure, GDP, etc).

$$TEU_{i,t} = \beta_0 + \beta \text{ Investments in maritime port infrastructure}_{i,t} + \\ + c\, GDP_{i,t} + \ldots + \text{Variable}_{n,i,t} + \alpha_i + u_{i,t} \quad (6)$$

t=time,
i=country,
β_0=constant,
β=effect of Investments in maritime port infrastructure on TEU,
Variable $_n$=last explanatory variable,
α_i=unobserved, time constant factors that affect $TEU_{i,t}$,
$u_{i,t}$ =time varying error which represents factors that change over time and affect $TEU_{i,t}$.

3.4 Pooled Data

Pooled data are mostly used in surveys, where random people or specialists (depending on the short of the study) are asked (interviews or questionnaires) about their intuition, regarding the effect of various factors on the behavior of a certain phenomenon. An example of a pooled model would have been asking specialists, such as forwarders, liners, shipping lines et cetera, regarding the potential effects of Investments in maritime port infrastructure, GDP etc on the TEU variation.

Pooled modeling is time and resources demanding. Additionally, the reliability of the analysis results are vulnerable to the extent the intuition of the specialists is correct. Concluding, pooled data are not a proper method to answer our research questions.

3.5 Model Choice

As mentioned before, time series models do not provide cause and effects insights. According to Yasmine R. (2016), time series methodology does not allow measuring the dynamics between different ports and actors and suggests the panel data model to be of value added to her container throughput modeling study for the port of Antwerp.

Additionally, Peter F. et al (2011), having analyzed the determinants of efficiency of Brazilian ports, suggest the superiority of the panel data approach in comparison to the one single-period or cross-sectional models.

Finally, Vonck Indra et al. (2015), in their study for developing a port forecasting tool, conclude that, among the various regression models, panel data regression model emerges as an available solution for forecasting complex phenomena. Therefore, the most appropriate model for the needs of the current paper is the panel data analysis.

In the following section, a discussion regarding the aspects to be concerned before executing the regression models follows.

3.6 Estimation Concerns

3.6.1 Lag Effects

Infrastructure investments, be it the sea, air, road or rail, consume a significant period of time until they are complete. The design, planning, construction, completion and beginning of function of an infrastructure object might last from months to years. Furthermore, it might require some additional time even to see their effect on the economy overall.

As mentioned in the literature review, Arjun Makhecha (2016) found the investments in port infrastructure insignificant in explaining the port container throughput. However, Arjun Makhecha did not test his regression models for lag effects, in case the investments in port infrastructure happens to significantly affect the port container throughput only after some years.

For example, the Channel Tunnel, which connects Folkestone, Kent (UK), with Coquelles, Pas-de-Calais (France) via rail, took 20 years in order the returns of investments to make the project profitable (OECD/ITF, 2014). Engineering-wise, according to OECD (2011), major infrastructure can take 10-20 years to plan and develop. O. Pokorná and D. Mocková (2001), mention of a construction period between 2-7 years of a transport infrastructure project to complete.

An infrastructure development might take some years in order to be officially delivered for function. However, real life examples (Egnatia Odos/ Egnatia Motorway, Greece) show that projects are partially delivered for use, unofficially, as soon as that part of the project is safe and functional. Therefore, it is expected that infrastructure investments might well begin impacting the economy and the competitiveness of a port, not necessarily the very first year and as well as before 10 years.

3.6.2 Unit Root Test

A unit root test, tests whether a time series variable is stationary (no unit root) or not. If a time series is stationary, that means that its statistical properties (mean, variance, covariance) do not vary with time. If a time series is described as a stationary (rejecting the presence of a unit root), then economic shocks would have transitory effects. Alternatively, if a time series is described as non-stationary, shocks have permanent effects (Verbeek, 2008). The implications of non-stationarity are the following:

- Invalid regression results
- Existence of spurious regression
- OLS assumption of no serial-autocorrelation violated

Chou et al. (2007), presented the importance of the non-stationary relationship between the volumes of containers and the macroeconomic variables. They conclude that, not taking care of the non-stationary relationship between the TEU (depended variable) and the explanatory variables (investments in infrastructure) leads to an overestimation of the forecasted container throughput volumes.

Various statistical tests exist in order data stationarity to be diagnosed. The most popular one in the container throughput forecasting literature is the Augmented Dickey-Fuller (ADF) test. After applying the test, if any variables are non-stationary on their level but stationary on their 1st difference, have to be turned into logarithms before used in the equation (Yasmine Rashed, 2015). This methodology has been applied for the majority of the port container throughput forecasting, with the most recent examples Dragan D. et al. (2014) and Yasmine Rashed et al. (2015) and Pitinoot Kotcharat (2016). In the present paper, for practical issues the Im–Pesaran–Shin test will be performed[2].

[2] Both tests have been performed yielding the same results. However the AFD test is harder to present in a simple output table.

A major drawback of the first differencing is that, the model only considers the short-run adjustments related to how the difference in one variable correlates with the changes in the other (M. Jansen, 2014). Hence, it ignores the long-term relationship between variables (Hui et al., 2004).

3.6.3 Co-Integration and Error Correction Model

Co-integration is a necessary property in a model in order the relationships within an equilibrium to have long lasting meaning. In a general description of co-integration we consider the following regression model of two I(1) (stationary in the first difference) variables, Yt and Xt:

$$Y_t = \alpha + b X_t + u_t \qquad (7)$$

u_t=the error term,
Y_t=the depended variable,
X_t=the explanatory variable.

If Yt and Xt co-integrate, then the:

$$u_t = Y_t - \alpha - b X_t \qquad (8)$$

is a stationary process with mean zero.

In the co-integration the residuals are stationary with mean zero and there is a long run equilibrium relationship between Yt and Xt. The null hypothesis is the existence of no co-integration. In the no co-integration, the relationship between the depended and the explanatory variables is valid in the short run and not in the long run.

To avoid this issue, the error correction model (ECM) can be performed. The error correction model is a differenced model that contains an error correction term, which predicts short-term adjustments of the dependent variable. The main idea of ECM is that, a possible disequilibrium in the short run corrects itself over time, creating a path that fluctuates around the long-run equilibrium (Hui et al., 2004). Therefore, the ECM is only valid if there is a true relationship between the variables in the long-run (Van Dorsser et al., 2011). A co-integration test can be used to test whether such a relationship exists (Hui et al., 2004).

In the following section, two approaches of the panel data analysis, the fixed effects and the random effects will be discussed.

3.6.4 Fixed Effects

In the fixed effects model (or within estimator), the relationship between the depended variable (TEU) and the explanatory variables (infrastructure investments) **within** an entity (Hamburg - Le Havre and Mediterranean range) is investigated. Each entity (range) has its own unique characteristics which influence the depended variables (TEU). In the fixed effects model it is assumed that something within an entity may bias the results of the regression analysis. In this model, the time invariant characteristics (α_i) of the entities (such as location for example), are differenced away, and therefore it is possible to estimate the net effect of the explanatory variables on the depended variable.

3.6.5 Random Effects

Alternatively, in the random effects models, it is assumed that the variation **between** the entities is random and not systematically related with the explanatory variables which are included in the model, are they fixed or not. A benefit of the random effects model comparatively with the fixed effects is that one can include time invariant characteristics (for example location). Therefore, the α_i term is not difference away but estimated.

3.6.6 Hausman test

The Hausman test is a specification test which assists choosing between the Fixed and Random Effects. The Hausman test assesses if the time-invariant effects (α_i) are correlated with the independent variables. The null hypothesis states that the difference between the coefficients is not systematic and that the Random Effects is consistent and more efficient and should be preferred. If we reject that null, the Random Effects is inappropriate and the Fixed Effects should be used instead.

4. Empirical Analysis

In this section, the assumptions necessary for simplifying our analysis and the limitations which do not harm the generalization of the results are discussed. Additionally, the way the collected data have been measured as per the OECD glossary[3] will be described, data description will follow and basic trends observed will be discussed.

4.1 Assumptions and Limitations

Firstly, the port container throughput in terms of TEU has been chosen as a depended variable. The reason is that, the majority of the transported goods are transferred within containers. As of 2009, approximately 90% of non - bulk cargo worldwide is moved by containers stacked on transport ships and this trend is being constantly increased (Ebeling, 2009). It is assumed that in the future, more and more commodities will be containerized (Havenga & Van Eeden, 2011) causing the container shipping industry to expand even more. Havenga & Van Eeden (2011) also predict a maturing in the containerization trend, simply because on a given point in time every commodity that can be shipped in containers shall be shipped in containers. Therefore, it is assumed that containers are the most representative measurement for the evaluation of the busyness of a port.

Secondly, inland waterways are not included in the analysis. Inland waterways, especially long rivers, are present only in the Hamburg-Le-Have range. Therefore the analysis between the two regions would have been unequal. After all, inland waterways represent only a 6% of the total inland transport freight (Eurostat, 2017).

What is more, we assume port efficiency, competitiveness and performance to have interchangeable meaning, and it is estimated as the annual number of TEUs per port. Throughout the analysis, the terms of container or cargo throughput and TEU are used interchangeably.

Additionally, TEU figures account for both loaded and empty containers. The empty containers on average represent a less than 5% of the total container throughput (loaded and empty) of the chosen countries, as per the Eurostat data and are not expected to influence the analysis outcomes.

Furthermore, the available data series of the infrastructure investments refer to the period 1987-2015. It is assumed that this period is sufficient in order to apply a reliable panel analysis. Time-wise, this paper incorporates the 2008 economic crisis in the modeling process, which has the benefit of providing insight into the impact of the crisis.

Moreover, the two major ports of France are Le Havre in North and Marseille in South. Since there is not a clear geographical perspective of the ports of this country, we assume that culturally, France is closer to the Western European countries. Therefore, France is classified in the Hamburg-Le Havre range of ports and not in the Mediterranean range of ports.

Except for the assumptions, limitations are present in the present study as well. Two main limitations are considered: Firstly, it is recognized that there are more variables that explain the port container throughput (such as GDP, Imports-Exports, Income, Population etc) as per the relevant literature. However they have not been included in the present paper, since this paper investigates solely the effects of the infrastructure and superstructure investments on the port container throughput. As a result, our model is expected to suffer from omitted variable bias.

[3] According to the OECD glossary of statistical terms, the terminology source comes from the Glossary for Transport Statistics, prepared by the Intersecretariat Working Group on Transport Statistics – Eurostat, European Conference of Ministers of Transport (ECMT), United Nations Economic Commission for Europe (UNECE).

Finally, infrastructure maintenance has not been accounted for, since there have been incomplete data in the OECD database. Therefore, the infrastructure investments of the current paper refer to the construction of new infrastructures.

4.2 Data Definitions

In this section, the depended and independent variables will be discussed in order to define which physical infrastructure elements does each variable include. This is an important part of the analysis, since it provides with visibility of the constitutes of the employed variables.

4.2.1 Depended Variable

The depended variable, port container throughput, is measured in TEU (Twenty-foot Equivalent Units). One TEU refers to one intermodal container, a standard-sized metal box, which can be readily transported among different transport modes, such as trains, trucks and ships. There are different sizes of containers, with the most popular alternative of the 20 feet, being the 40 feet long container.

4.2.2 Explanatory Variables

The explanatory variables are the variables which are assumed to explain the variation of the depended variable. In the present paper, the explanatory variables consist of the transport infrastructure and transport superstructure. The transport infrastructures include the Maritime Port Infrastructure, Road Transport Infrastructure, Rail Transport Infrastructure and Air Transport Infrastructure. The transport superstructure includes the Transport Equipment.

According to the OECD glossary, expenditure on new construction, extension of existing infrastructure, including reconstruction, renewal and major repairs are included in the following data series, except for the transport equipment.

4.2.2.1 Maritime Ports Infrastructure

In the Maritime Ports Infrastructure the following elements are considered:

- Maritime coastal area
- Total port land area
- Port storage areas
- Container stacking areas
- Roads
- Rail tracks
- Passenger terminals
- Quays
- Ro-Ro berth
- Port cranes
- Port repair facilities
- Lights and lighthouses
- Radars
- VTS (Vessel Traffic System)
- Bunkering facilities
- Port hinterland links

4.2.2.2 Road Transport Infrastructure

In the Road Transport Infrastructure the following elements are considered:

- Roads
- Paved roads
- Road networks
- Carriageways
- Lanes

4.2.2.3 Rail Transport Infrastructure

In the Rail Transport Infrastructure the following elements are considered:

- Tracks
- Sidings
- Lines
- Railway network
- Railway stations
- Halts
- Terminals

4.2.2.4 Air Transport Infrastructure

In the Air Transport Infrastructure the following elements are considered:

- Terminals
- Runways
- Taxiways
- Check-in facilities
- Gates
- Car parking
- Facilities provided within the airport for connection with: Rail, Metro, Bus.

4.2.2.5 Transport Equipment

In the Transport Equipment the following elements are considered by transport mode:

Maritime transport equipment:

- Seagoing vessels
- Dry cargo seagoing barges
- Ships (Boat)
- Merchant ships
- Dry bulk carriers
- Container ships
- Specialized carriers
- Passenger ships
- Cruise ships
- Automatic Identification Systems
- Containers

Road transport equipment:

- Trucks
- Trailers
- Lorries
- Cars
- Buses

Rail transport equipment:

- Railway vehicles
- High speed railway vehicles
- Locomotives
- Tractive vehicles
- Light rail motor tractors
- Railcars
- Passenger railway vehicle
- Freight wagons
- Reefers
- Containers
- Pallets
- Ro-Ros

Air transport equipment:

- Cargo aircrafts
- Passenger aircrafts
- Combo aircrafts

4.3 Data Analysis

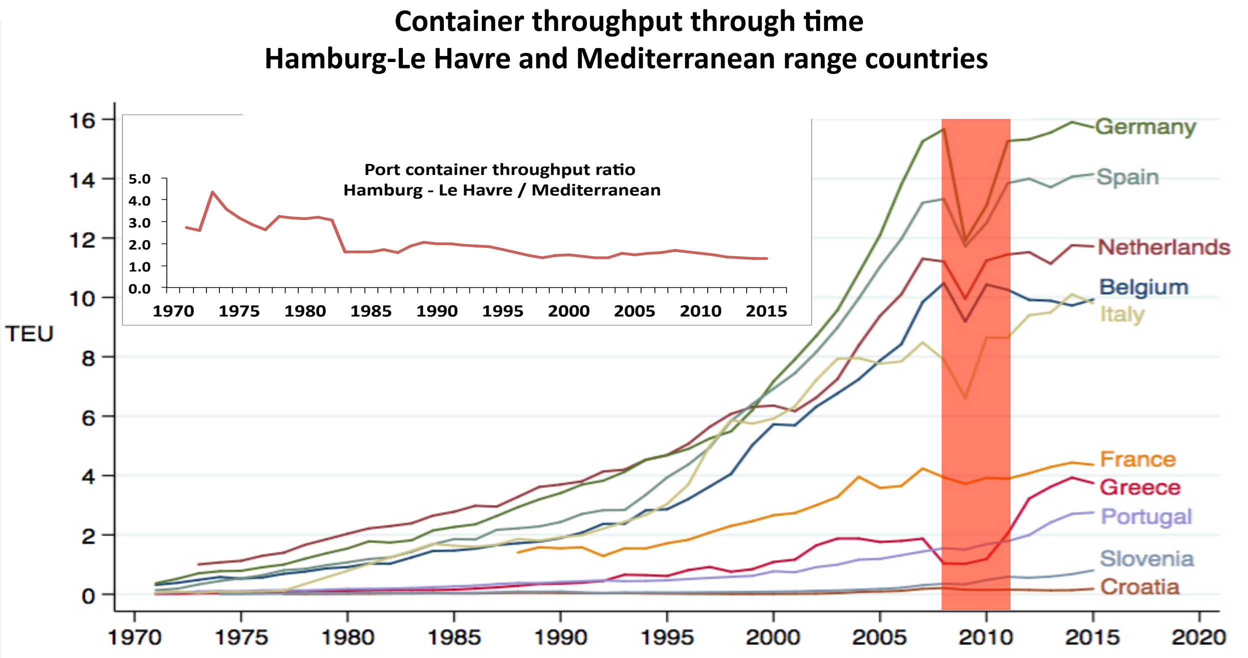
In the present section, our variables will be presented as per country and an overall picture will discussed. Additionally, as mentioned in the *Estimation Concerns* section, a unit root test will take place, as the Im–Pesaran–Shin test will be applied upon our variables.

4.3.1 Port Container Throughput (TEU)

As observed from Graph 1, from 1970 until 1995, the country with the highest number of containers circulation was the Netherlands. After that period, Germany became the country-champion in attracting containers, followed by the forever increasing growth the of the Spanish ports. Ever since, the Netherlands comes in the third position, followed by Belgium and Italy which have been interchanging positions through the time.

Another important notice is the fact that, after 1995, there is a widening gap between the top 5 countries (Germany, Spain, Netherlands, Belgium, Italy) versus the bottom 5 countries (France, Greece, Portugal, Slovenia, Croatia). Except for France, which is the only country from the Hamburg - Le Havre range in the bottom group, the rest of the countries belong in the Mediterranean range.

Interestingly, from a geographical perspective, the gap between the Hamburg - Le Havre range and the Mediterranean range in terms of container throughput is being steadily decreased after 1970. Whereas in the beginning of 1970 the port container throughput ratio was almost 5 for the Hamburg-Le Havre range countries to 1 for the Mediterranean range countries on average, in 2015 the ratio was almost 1 to 1 (sub-Graph 1).



Graph 1. Data source: OECD. Design: Author

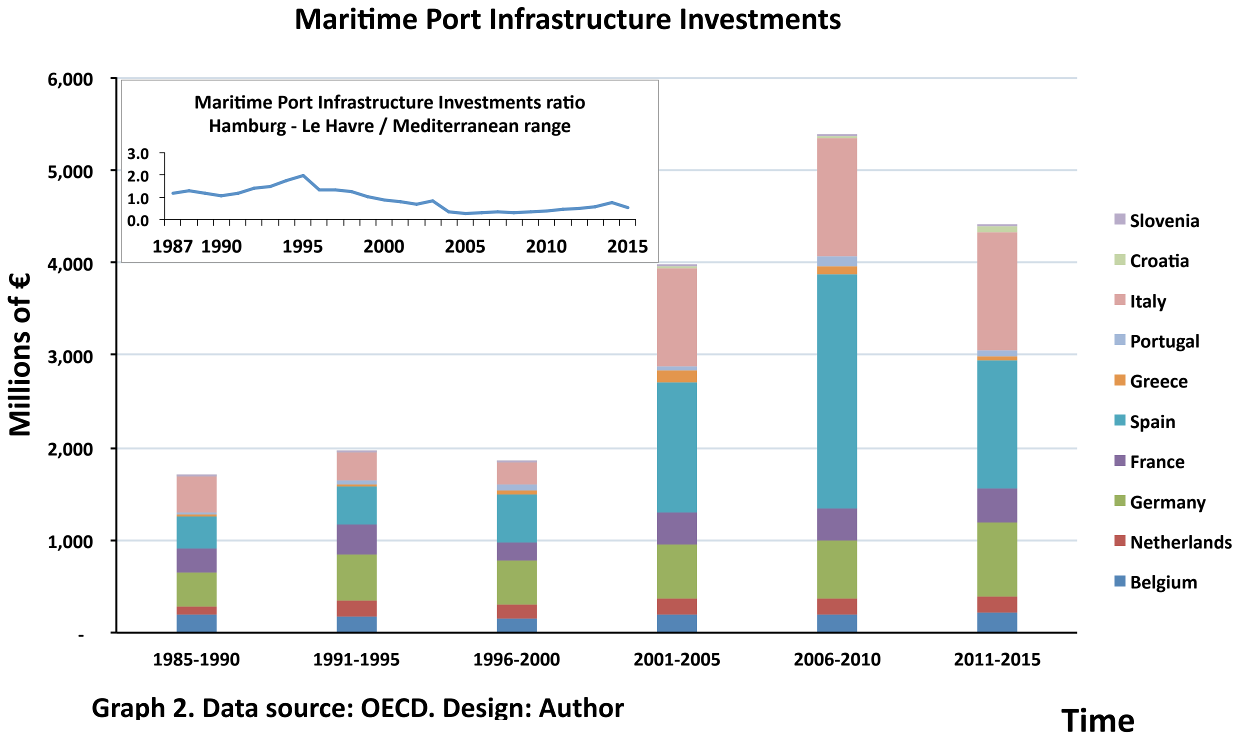
Finally, the economic crisis of 2008 is also depicted. As seen in the red rectangular inside Graph 1, the crisis influenced deeper the top 5 countries comparatively with the bottom 5 countries. The top 5 countries lost approximately 1-2 million TEUs per year, whereas the bottom 5 were almost unaffected, except for Greece. The countries of both ranges needed approximately 2 years to recover from the crisis, with all of the having fully recovered their container throughputs after 2011. Netherlands and Belgium were the countries which faster recovered, whereas Greece was the country where the impact of the crisis lasted for the longest period of time.

4.3.2 Maritime Port Infrastructure Investments

According to Graph 2, from 1985 until 2010, the maritime port infrastructure has been increasing. A small drop is observed after the 2010, which might be attributed to the 2008 economic crisis and the restrictive spending by each country.

Spain is the country with the highest spending in maritime port infrastructure investments, followed by Italy. Germany follows and after that Belgium and Netherlands. The rest of the countries barely appear in Graph 2. It is worth noticing that the Hamburg- Le Havre countries, that is Germany, Belgium, Netherlands and France, seem to follow a more steady spending policy for port infrastructure that in the Mediterranean range countries, especially Italy and Spain.

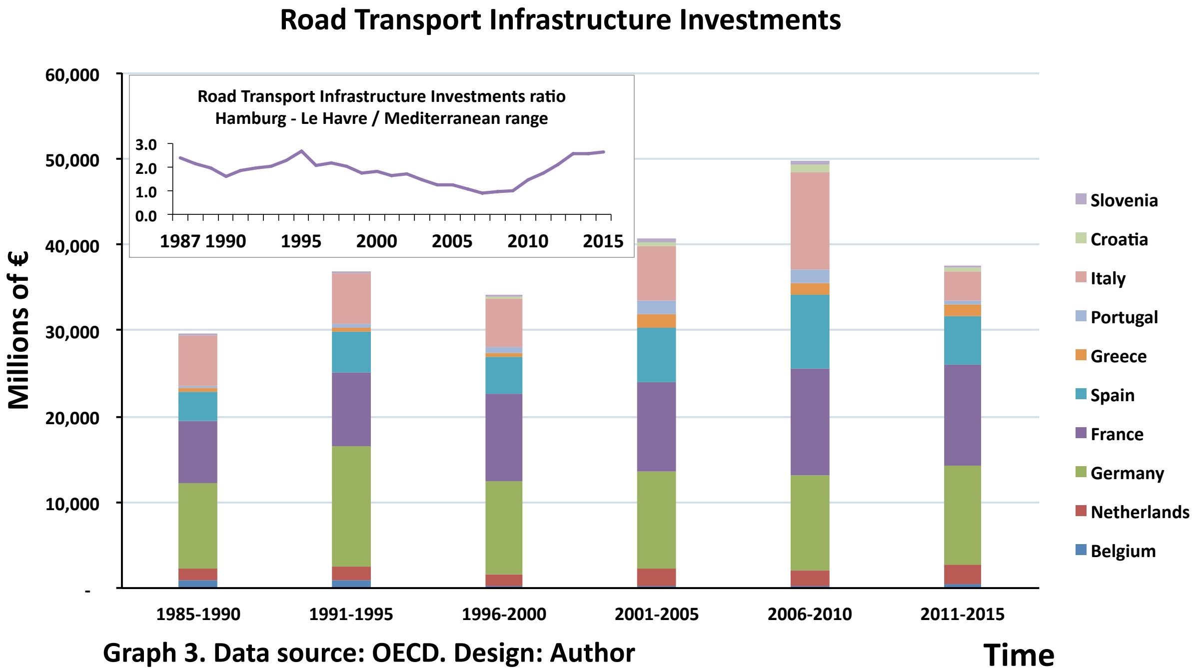
Finally, as it can be seen in the sub-Graph 2 the maritime port infrastructure investments ratio between Hamburg-Le Havre and the Mediterranean range has been fluctuating. In 1995 the Hamburg-Le Havre range spent almost twice as much on average than the Mediterranean range, whereas until 2000 the trend reversed and investments in port infrastructure in the Mediterranean range became significantly higher than in the Hamburg-Le Havre range.



Graph 2. Data source: OECD. Design: Author

4.3.3 Road Transport Infrastructure Investments

According to Graph 3, from 1985 until 2010, the road transport infrastructure has been increasing. A small drop is observed after the 2010, which might be attributed to the 2008 economic crisis and the restrictive spending by each country.



Graph 3. Data source: OECD. Design: Author

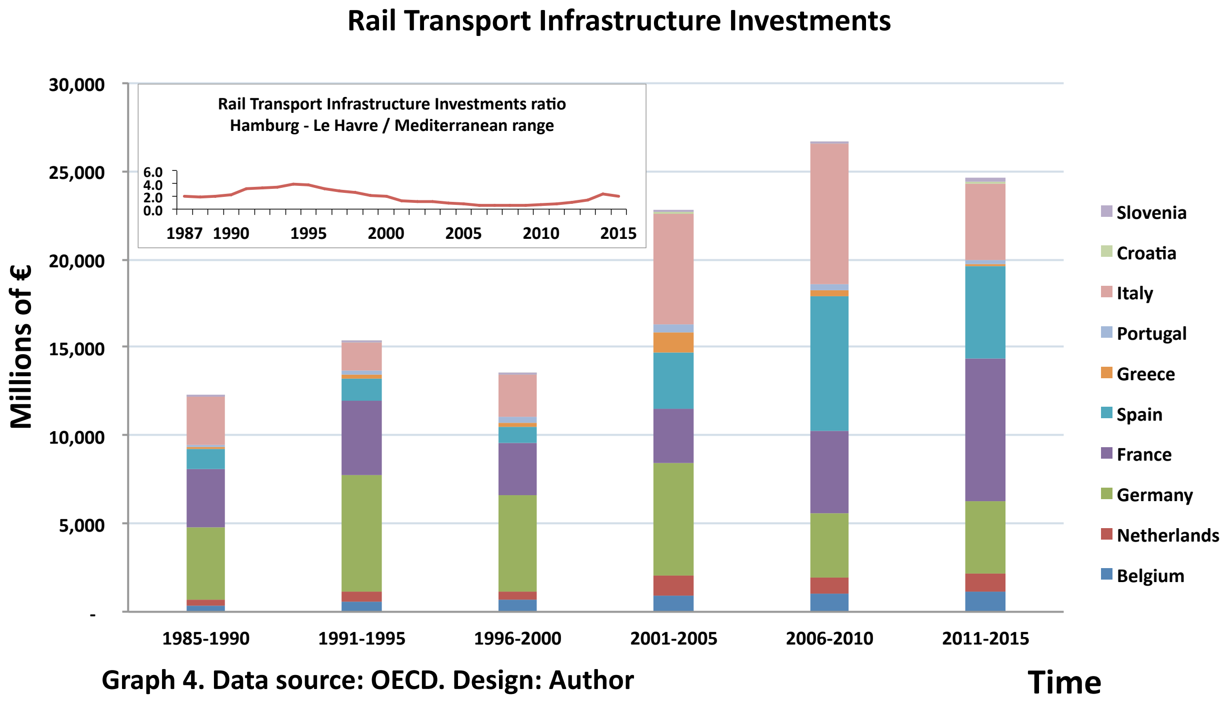
Contrary to maritime port infrastructure investments, Spain comes only forth in the road transport infrastructure. The first place is possessed by Germany, which is nevertheless renowned for the long highways (autobahn). The second and third countries are France and Italy correspondingly. The rest of the countries barely appear in Graph 3. It is worth noticing that, the biggest the continental size of a country (Germany, France, Spain, Italy), the higher the infrastructure investments in road transport.

Finally, as it can be seen in the sub-Graph 3, the road transport infrastructure investments ratio between Hamburg-Le Havre and the Mediterranean range has been fluctuating. In 1995 the Hamburg-Le Havre range spent almost three times as much on average than the Mediterranean range, whereas until 2007 the trend reversed and investments in road transport infrastructure in the Mediterranean range became slightly higher than in the Hamburg-Le Havre range. After 2010, the ratio turned back higher on the Hamburg-Le Havre range.

4.3.4 Rail Transport Infrastructure Investments

According to Graph 4, from 1985 until 2010, the rail transport infrastructure has been increasing. A small drop is observed after 2010, which might be attributed to the 2008 economic crisis and the restrictive spending by each country. This trend is consistent with the maritime port and road infrastructure as well.

France was the only country which did not decrease the spending in rail infrastructure during 2011-2015, but almost doubled it, comparatively with the previous period of 2006-2010. Following France, Germany comes second, followed by Italy and Spain. It is worth noticing that, Belgium and Netherlands have been constantly investing more in rail transport infrastructure. This might be reflecting the effort of the two countries, which accommodate two of the biggest European container ports (Rotterdam and Antwerp), to tackle road traffic congestion, better hinterland connectivity and less CO2 emissions.



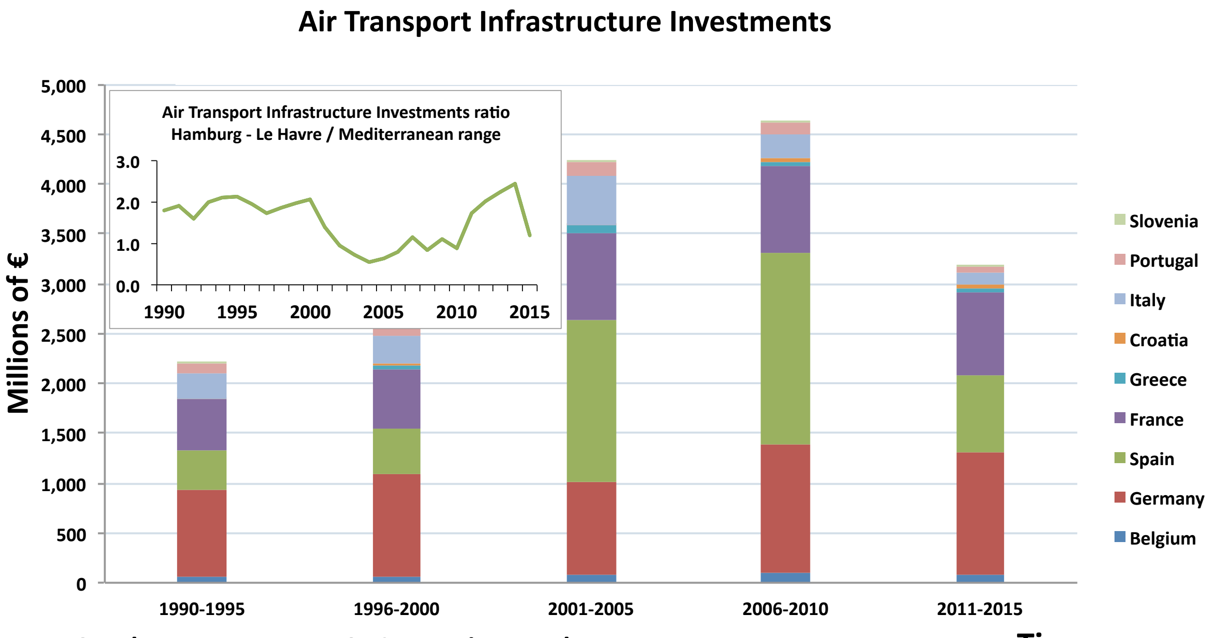
Graph 4. Data source: OECD. Design: Author

Finally, as it can be seen in the sub-Graph 4 the rail transport infrastructure investments ratio between Hamburg-Le Havre and the Mediterranean range has been fluctuating. In 1995 the Hamburg-Le Havre range spent almost four times as much on average than the Mediterranean range, whereas until 2007 the trend reversed and investments in rail transport infrastructure in the Mediterranean range became significantly higher than in the Hamburg-Le Havre range. After 2010, the ratio turned back higher on the Hamburg-Le Havre range.

4.3.5 Air Transport Infrastructure Investments

According to Graph 5, from 1990 until 2010, the air transport infrastructure has been increasing. A small drop is observed after the 2010, which might be attributed to the 2008 economic crisis and the restrictive spending by each country. This trend is consistent with the maritime port, road and rail infrastructure as well.

Spain is the country with the highest fluctuations when it comes to air transport infrastructure investments. Between either decade 2001 - 2005, or 2006 - 2010, Spain spent more than the rest of the other years combined. Germany on the other hand, is the country which spends almost equal amount of euros throughout the time. Similar to Germany in terms of the amount invested in air transport policies, is France.



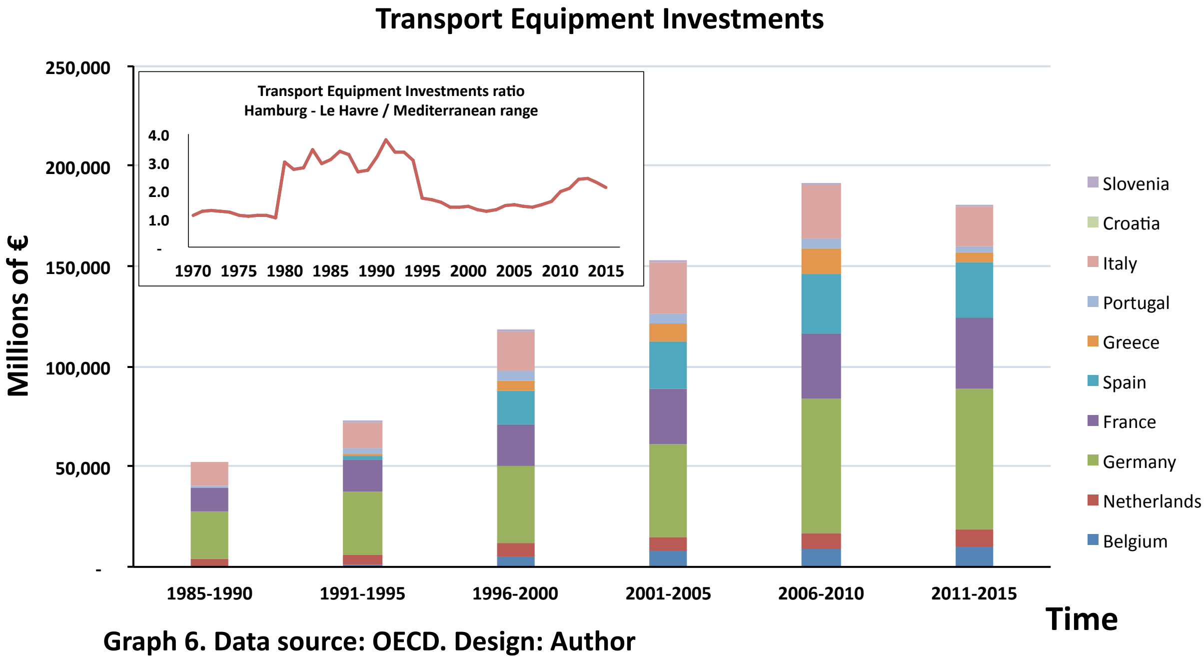
Graph 5. Data source: OECD. Design: Author

Finally, as it can be seen in the sub-Graph 5, the air transport infrastructure investments ratio between Hamburg-Le Havre and the Mediterranean range has a higher fluctuation comparing with maritime port, road and rail. Between 1990 and 2000, the Hamburg-Le Havre range spent almost twice times as much on average than the Mediterranean range, whereas until 2004 the trend reversed and investments in air transport infrastructure in the Mediterranean range became slightly higher than in the Hamburg-Le Havre range. After 2005, the ratio turned back higher on the Hamburg-Le Havre range.

4.3.6 Transport Equipment Investments

According to Graph 6, from 1985 until 2010, the transport equipment investments have been steadily increasing. A small drop is observed after the 2010, which might be attributed to the 2008 economic crisis and the restrictive spending by each country. This trend is consistent with the maritime port, road, rail and air infrastructure as well.

Germany is the country with the highest transport equipment investments, followed by France, Spain and Italy. Almost all the countries are observed to have been constantly increasing their spending in transport equipment assets in a steady rate.



Graph 6. Data source: OECD. Design: Author

Finally, as it can be seen in the sub-Graph 6 the transport equipment investments ratio between Hamburg-Le Havre and the Mediterranean range has a higher fluctuating comparing with maritime port, road and rail. Between 1980 and 1990, the Hamburg-Le Havre range spent almost four times as much on average than the Mediterranean range, whereas after 1993 this trend decreased. Unlike the transport infrastructure investments (sea, road, rail, air), superstructure investments (transport equipment investments) in the Mediterranean range never surpassed the transport equipment investments in the Hamburg - Le Havre range.

Overall, the majority of the investments are placed in the superstructure investments, namely the transport equipment. Between the two ranges, during 2006 - 2010 almost € 200 billion were spent on transport equipment. This amount should not be of a surprise, since, as mentioned in the *Data Definitions* section, it includes transport equipment elements from all the transport modes (sea, road, rail, air).

Regarding the infrastructure investments, road transport infrastructure investments reached € 50 billion, followed by rail with € 26 billion, € 5.5 billion maritime port and air with € 4.5 billion for the same period. Additionally, the last decade, the infrastructure investment gap between the two ranges has significantly decreased. Concluding the data description, the port container throughput (TEU) moves in the same direction as the transport infrastructure investments, showing a first positive relationship.

4.4 Stationarity Test

As mentioned in the *Estimation Concerns* section, our variables have to be examined for stationarity. One test which can be performed in order to test for stationarity is the Im-Pesaran-Shin (IPS) test. The zero hypothesis of the Im–Pesaran–Shin test is the existence of a unit-root meaning that our variables are non - stationary. The null hypothesis is rejected when the p-value is less than the 5% significance level. In Table 3, the IPS test results is presented for both the level and first difference of our variables.

As it can be observed from Table 3, all of our variables are non - stationary on the level, since all of their p-values are higher than 5% significance level and therefore the null hypothesis cannot be rejected. On the other hand, all of our variables are stationary on their first difference, since all of their p-values are lower than 5% significance level and therefore their null hypothesis is rejected. The methodological directions of the port container throughput literature have so-far been confirmed.

Table 3: IPS test

Variables	IPS (level)			IPS (first difference)		
	t-statistic	p-value	Result	t-statistic	p-value	Result
Port container throughput (TEU)	0.0130	0.5052	*non-stationary*	-9.1035	0.0000	*stationary*
Maritime Port Infrastructure Investments	1.2748	0.8988	*non-stationary*	-2.3514	0.0094	*stationary*
Road Transport Infrastructure Investments	0.7675	0.7786	*non-stationary*	-3.5395	0.0002	*stationary*
Rail Transport Infrastructure Investments	1.0352	0.8497	*non-stationary*	-4.4803	0.0000	*stationary*
Air Transport Infrastructure Investments	3.3094	0.9995	*non-stationary*	-3.0457	0.0012	*stationary*
Transport Equipment Investments	-0.9154	0.1800	*non-stationary*	-8.1623	0.0000	*stationary*

Therefore, the panel regressions are to be based on the first difference of the variables. As mentioned in the *Estimation Concerns* section, a major drawback of the first differencing is that, the model only considers the short-run adjustments related to how the difference in one variable correlates with the changes in the other (M. Jansen, 2014). Therefore, after running the regressions, it is necessary to perform co-integration test, in order to test if the equilibrium relationships between the depended (TEU) and the independent variables (infrastructure and superstructure investments) are valid only in the short run, but on the long run as well. The results of the co-integration tests are reported at the end of the regression results tables.

5. Regression Results

In the present section the regression results will be presented. It begins with the Fixed Effects regression results of the Hamburg - Le Havre range and continue with the Mediterranean range. Similarly, the Random Effects follow. Various combinations have been tried, regarding different lagged effects. The presented models are the ones where the combination of the lagged effects yield the highest R-squared.

In general, all the investments in transport infrastructure and superstructure have a positive and significant effect on the port container throughput of both ranges. However, in some examples (Road and Rail Transport Infrastructure Investments) the effect on the TEU is insignificant or the signs are negative. Yet, their behavior changes as the model is enriched (H5 or H7). As mentioned in the *Literature Review* section, important explanatory variables (kindly refer to Table 1) are not included in the model. This results in an omitted variables bias, leading to unexpected signs or significant variables to appear as insignificant.

In regression analysis it happens that, a variable that was not significant to become significant after adding relevant variables to the model. The originally not significant variable was significantly associated with the omitted variable and reflects the effect of the omitted variable in addition to its own effect (plus some other unobserved variables). When the omitted variables (Table 1) are added into the model, the originally not significant variable no longer captures the partial effect of the omitted variable but now reflects the "true" effect of that variable. It turns out to be statistically significantly associated with the port container throughput. Concluding, our independent variables do not present unexpected behavior in terms of signs or significance.

5.1 Fixed Effects

5.1.1 Hamburg - Le Havre Range

As per Table 4, in general, all the investments in transport infrastructure and superstructure have a positive and significant effect on the port container throughput of the Hamburg - Le Havre range of ports. Since model H7 is the most complete model among H1-H7, the H7 model will be interpreted. For practical reasons and in order to avoid repetition, the regression output of the models H1-H6 will be not be described. However, the models H1-H6 are interpreted in the same way.

More specifically, Maritime Port Infrastructure Investments have a positive and significant effect at the 1% level on the port container throughput of the Hamburg - Le Havre range as per the H7 model. If the Maritime Port Infrastructures in the Hamburg - Le Havre region increase by EUR 1 million, the port container throughput will increase by 3,620 TEU on average, after 5 years ceteris paribus.

Table 4: Regression Results: Hamburg - Le Havre range

Depended variable: TEU (port container throughput)							
Fixed Effects							
Explanatory Variables	**H1**	**H2**	**H3**	**H4**	**H5**	**H6**	**H7**
L5.Maritime Port Infrastructure Investments	.00293*** (.000659)				.00532*** (.000949)		.00362*** (.000998)
Road Transport Infrastructure Investments		-.00009 (.00009)					

Table 4: Regression Results: Hamburg - Le Havre range

Depended variable: TEU (port container throughput)							
Fixed Effects							
Explanatory Variables	**H1**	**H2**	**H3**	**H4**	**H5**	**H6**	**H7**
L3.Rail Transport Infrastructure Investments			.00029*** (.00009)				
L5.Air Transport Infrastructure Investments				.00105* (.00061)			
L7.Rail Transport Infrastructure Investments					.000685*** (.000181)		.000382** (.000187)
L6.Air Transport Infrastructure Investments					.00151** (.000649)		.00121** (.000585)
L4.Road Transport Infrastructure Investments					.000375* (.000195)		.000222 (.00018)
Transport Equipment Investments						.000096*** (.0000143)	.00008*** (.0000244)
R-squared	0.215	0.01	0.0942	0.066	0.488	0.286	0.607
Prob > F	0.0000	0.0000	0.0022	0.0953	0.0001	0.0000	0.0000
Cointegration test	0.2773	0.0001	0.0019	0.0777	0.4285	0.0000	0.3176

Standard errors in parentheses.

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

"L" stands for lag effects. For example L5.Maritime Port Infrastructure Investments accounts for the effect of the variable after 5 years.

H1 stands for Hypothesis 1 etc.

Rail Transport Infrastructure Investments have a positive and significant effect at the 5% level on the port container throughput of the Hamburg - Le Havre range as per the H7 model. If the Rail Transport Infrastructures in the Hamburg - Le Havre region increase by EUR 1 million, the port container throughput will increase by 382 TEU on average, after 7 years ceteris paribus.

Air Transport Infrastructure Investments have a positive and significant effect at the 5% level on the port container throughput of the Hamburg - Le Havre range as per the H7 model. If the Air Transport Infrastructures in the Hamburg - Le Havre region increase by EUR 1 million, the port container throughput will increase by 1,210 TEU on average, after 6 years ceteris paribus.

Road Transport Infrastructure Investments have a positive and insignificant effect on the port container throughput of the Hamburg - Le Havre range as per the H7 model. However, the Road Transport Infrastructure Investments have a positive and significant effect at the 10% level as per the H5 model. If the aforementioned investments in the Hamburg - Le Havre region increase by EUR 1 million, the port container throughput will increase by 375 TEU on average, after 4 years ceteris paribus.

Transport Equipment Investments have a positive and significant effect on the port container throughput of the Hamburg - Le Havre range at the 1% in the H7 model. If the Transport Equipment Investments in the Hamburg - Le Havre region increase by EUR 1 million, the port container throughput will increase by 80 TEU on average, effective the same year, ceteris paribus.

5.1.2 Mediterranean Range

As per Table 5, in general, all the investments in transport infrastructure and superstructure have a positive and significant effect on the port container throughput of the Mediterranean range ports. Since model H7 is the most complete model among H1-H7, the H7 model will be interpreted. For practical reasons and in order to avoid repetition, the regression output of the models H1-H6 will be not be described. However, the models H1-H6 are interpreted in the same way.

Table 5: Regression Results: Mediterranean range

Depended variable: TEU (port container throughput)

Fixed Effects

Explanatory Variables	H1	H2	H3	H4	H5	H6	H7
L2.Maritime Port Infrastructure Investments	.000707*** (.0001518)				.0007595*** (.0001707)		.0007246*** (.0001827)
Road Transport Infrastructure Investments		-.000089** (.0000315)					
L3.Rail Transport Infrastructure Investments			-.000146** (.0000685)		-.0003087*** (.000082)		-.0002841*** (.000088)
L5.Air Transport Infrastructure Investments				.000661** (.0002994)			
L4.Air Transport Infrastructure Investments					.0008314*** (.0002339)		.000706*** (.0002547)
L3.Road Transport Infrastructure Investments					.0001165** (.0000395)		.0001092*** (.0000424)
Transport Equipment Investments						.0000596*** (.0000168)	.0000474** (.0000192)
R-squared	0.1271	0.0477	0.0311	0.0590	0.3432	0.0956	0.4001
Prob > F	0.0000	0.0051	0.0338	0.0300	0.0000	0.0006	0.0000
Cointegration test	0.0003	0.0000	0.0000	0.0885	0.0006	0.0944	0.1018

Standard errors in parentheses.

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

“L” stands for lag effects. For example L5.Maritime Port Infrastructure Investments accounts for the effect of the variable after 5 years.

H1 stands for Hypothesis 1 etc.

To begin with, Maritime Port Infrastructure Investments have a positive and significant effect at the 1% level on the port container throughput of the Mediterranean range as per the H7 model. If the Maritime Port Infrastructures in the Mediterranean region increase by EUR 1 million, the port container throughput will increase by 725 TEU on average, after 2 years ceteris paribus.

Rail Transport Infrastructure Investments have a negative and significant effect at the 1% level on the port container throughput of the Mediterranean range as per the H7 model. If the Rail Transport Infrastructures Investments in the Mediterranean region increase by EUR 1 million, the port container throughput will decrease by 284 TEU on average, after 3 years ceteris paribus.

Air Transport Infrastructure Investments have a positive and significant effect at the 1% level on the port container throughput of the Mediterranean range as per the H7 model. If the Air Transport Infrastructures in the Mediterranean region increase by EUR 1 million, the port container throughput will increase by 706 TEU on average, after 4 years ceteris paribus.

Road Transport Infrastructure Investments have a positive and significant effect at the 1% level on the port container throughput of the Mediterranean range as per the H7 model. If the aforementioned investments in the Mediterranean region increase by EUR 1 million, the port container throughput will increase by 110 TEU on average, after 3 years ceteris paribus.

Transport Equipment Investments have a positive and significant effect on the port container throughput of the Mediterranean range at the 5% in the H7 model. If the Transport Equipment Investments in the Mediterranean region increase by EUR 1 million, the port container throughput will increase by 47 TEU on average, effective the same year, ceteris paribus.

5.2 Random Effects

5.2.1 Hamburg - Le Havre Range

As per Table 6, in general, all the investments in transport infrastructure and superstructure have a positive and significant effect on the port container throughput of the Hamburg - Le Havre range ports. Since model H7 is the most complete model among H1-H7, the H7 model will be interpreted. For practical reasons and in order to avoid repetition, the regression output of the models H1-H6 will be not be described. However, the models H1-H6 are interpreted in the same way.

To begin with, Maritime Port Infrastructure Investments have a positive and significant effect at the 1% level on the port container throughput of the Hamburg - Le Havre range as per the H7 model. If the Maritime Port Infrastructures in the Hamburg - Le Havre region increase by EUR 1 million, the port container throughput will increase by 3,040 TEU on average, after 5 years ceteris paribus.

Rail Transport Infrastructure Investments have a positive and insignificant effect on the port container throughput of the Hamburg - Le Havre range as per the H7 model. However, the Rail Transport Infrastructure Investments have a positive and significant effect at the 1% level as per the H5 model. If the aforementioned investments in the Hamburg - Le Havre region increase by EUR 1 million, the port container throughput will increase by 565 TEU on average, after 7 years ceteris paribus.

Air Transport Infrastructure Investments have a positive and significant effect at the 10% level on the port container throughput of the Hamburg - Le Havre range as per the H7 model. If the Air Transport Infrastructures in the Hamburg - Le Havre region increase by EUR 1 million, the port container throughput will increase by 1,000 TEU on average, after 6 years ceteris paribus.

Table 6: Regression Results: Hamburg - Le Havre range

Depended variable: TEU (port container throughput) Random Effects							
Explanatory Variables	**H1**	**H2**	**H3**	**H4**	**H5**	**H6**	**H7**
L5.Maritime Port Infrastructure Investments	0.00291*** (0.000656)				0.00490*** (-0.00101)		0.00304*** (0.000990)
Road Transport Infrastructure Investments		-0.0000874 (0.0000851)					
L3.Rail Transport Infrastructure Investments			0.000269*** (0.0000938)				
L5.Air Transport Infrastructure Investments				0.0010628* (0.0006095)			
L7.Rail Transport Infrastructure Investments					0.000565*** (0.000189)		0.0002547 (0.0001813)
L6.Air Transport Infrastructure Investments					0.00127* (0.000693)		0.00100* (0.000597)
L4.Road Transport Infrastructure Investments					0.000244 (0.000203)		0.000104 (0.000178)
Transport Equipment Investments						0.0000953*** (0.0000142)	0.0000913*** (0.0000239)
R-squared within	0.0099	0.0099	0.0942	0.0664	0.4811	0.2864	0.5986
R-squared between	0.0335	0.0335	0.9522	0.2384	0.8908	0.0227	0.0117
R-squared overall	0.0092	0.0092	0.0775	0.0658	0.3981	0.2779	0.5714
Wald - chi2	19.69	1.05	8.23	3.04	24.47	45.21	47.99
Cointegration test	0.2750	0.0001	0.0019	0.0776	0.4051	0.0000	0.2276

Standard errors in parentheses.

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

"L" stands for lag effects. For example L5.Maritime Port Infrastructure Investments accounts for the effect of the variable after 5 years.

H1 stands for Hypothesis 1 etc.

Road Transport Infrastructure Investments have a positive yet insignificant effect on the port container throughput of the Hamburg - Le Havre range. However, this variable has yielded significant correlation with the TEU in the rest of the regressions.

Transport Equipment Investments have a positive and significant effect on the port container throughput of the Hamburg - Le Havre range at the 1% in the H7 model. If the Transport Equipment Investments in the Hamburg - Le Havre region increase by EUR 1 million, the port container throughput will increase by 91 TEU on average, effective the same year, ceteris paribus.

5.2.2 Mediterranean Range

As per Table 7, in general, all the investments in transport infrastructure and superstructure have a positive and significant effect on the port container throughput of the Mediterranean range ports. Since model H7 is the most complete model among H1-H7, the H7 model will be interpreted. For practical reasons and in order to avoid repetition, the regression output of the models H1-H6 will be not be described. However, the models H1-H6 are interpreted in the same way.

Table 7: Regression Results: Mediterranean range

Depended variable: TEU (port container throughput)

Random Effects

Explanatory Variables	H1	H2	H3	H4	H5	H6	H7
L2.Maritime Port Infrastructure Investments	.0007669*** (.0001607)				.0007936*** (.0001797)		.0007483*** (.0001883)
Road Transport Infrastructure Investments		-.000089** (.0000314)					
L3.Rail Transport Infrastructure Investments			-.0000967 (.0000712)		-.0002328** (.0000839)		-.0002181** (.0000879)
L5.Air Transport Infrastructure Investments				.000789** (.0002989)			
L4.Air Transport Infrastructure Investments					.0008422*** (.000247)		.0006975** (.0002636)
L3.Road Transport Infrastructure Investments					.0001065** (.0000417)		.0001007*** (.0000438)
Transport Equipment Investments						.0000693*** (.0000171)	.0000549*** (.0000196)
R-squared within	0.1271	0.0477	0.0311	0.0590	0.3349	0.0956	0.3932
R-squared between	0.8619	0.0431	0.7946	0.8261	0.2408	0.9678	0.6704
R-squared overall	0.1290	0.0389	0.0072	0.0775	0.2931	0.1180	0.3749
Wald - chi2	22.77	8.06	1.84	6.97	36.36	16.46	41.38
Cointegration test	0.0004	0.0000	0.0000	0.1026	0.2440	0.0010	0.1723

Standard errors in parentheses.

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

"L" stands for lag effects. For example L5.Maritime Port Infrastructure Investments accounts for the effect of the variable after 5 years.

H1 stands for Hypothesis 1 etc.

To begin with, Maritime Port Infrastructure Investments have a positive and significant effect at the 1% level on the port container throughput of the Mediterranean range as per the H7 model. If the Maritime Port Infrastructures in the Mediterranean region increase by EUR 1 million, the port container throughput will increase by 748 TEU on average, after 2 years ceteris paribus.

Rail Transport Infrastructure Investments have a negative and significant effect at the 5% level on the port container throughput of the Mediterranean range as per the H7 model. If the Rail Transport Infrastructures in the Mediterranean region increase by EUR 1 million, the port container throughput will decrease by 290 TEU on average, after 3 years ceteris paribus.

Air Transport Infrastructure Investments have a positive and significant effect at the 1% level on the port container throughput of the Mediterranean range as per the H7 model. If the Air Transport Infrastructures in the Mediterranean region increase by EUR 1 million, the port container throughput will increase by 218 TEU on average, after 4 years ceteris paribus.

Road Transport Infrastructure Investments have a positive and significant effect at the 1% level on the port container throughput of the Mediterranean range as per the H7 model. If the aforementioned investments in the Mediterranean region increase by EUR 1 million, the port container throughput will increase by 101 TEU on average, after 3 years ceteris paribus.

Transport Equipment Investments have a positive and significant effect on the port container throughput of the Mediterranean range at the 1% in the H7 model. If the Transport Equipment Investments in the Mediterranean region increase by EUR 1 million, the port container throughput will increase by 55 TEU on average, effective the same year, ceteris paribus.

5.3 Fixed Effects or Random Effects

As mentioned in *Estimation Concerns* section, a Hausman test is to be applied, in order to decide if the Fixed Effects model should be chosen instead of the Random Effects model and vice versa.

Table 8: Hausman test

	Hamburg - Le Havre			Mediterranean		
Model	**Chi2**	**p-value**	**Result**	**t-statistic**	**p-value**	**Result**
H1	18.54	0.0000	*Fixed Effect*	18.54	0.0000	*Fixed Effect*
H2	0.01	0.9322	*Random Effect*	0.02	0.8938	*Random Effect*
H3	5.54	0.0186	*Fixed Effect*	16.16	0.0001	*Fixed Effect*
H4	0.02	0.8888	*Random Effect*	54.71	0.0000	*Fixed Effect*
H5	6.97	0.0335	*Fixed Effect*	12.87	0.0119	*Fixed Effect*
H6	0.10	0.7496	*Random Effect*	10.92	0.0010	*Fixed Effect*
H7	5.44	0.3643	*Random Effect*	22.45	0.0004	*Fixed Effect*

As it is observed in Table 8, the Hausman test has yielded mixed results. For the same model (for example H4), in the Hamburg - Le Havre range the Random Effects are suggested, whereas for the Mediterranean range the Fixed Effects. Furthermore, for the same range (for example the Mediterranean range), in some models the Fixed Effects estimators are recommended, in comparison with Random Effects estimators for the rest of the models. It is therefore unclear which of the two methods should be preferred.

Like many tests, the Hausman test is performed conditionally on proper specification of the underlying model. If we have omitted an important explanatory variable from both forms of the model (kindly refer to Table 1), then we are comparing two inconsistent estimators of the population model (Wooldridge, 2006). Therefore, the choice of the estimators should be guided by our objectives and data characteristics rather than only by means of a Hausman test, since the test is not accurate in all cases.

If the coefficients output of both models are systematically different from each other, a Fixed Effects model will be more suitable than a Random Effects model. However, if the coefficients output of both models are (nearly) similar ($E(\alpha i| xit)=0$), a Random Effects model will be more suitable than a Fixed Effects model. In this case, comparing Table 4 with Table 6 and Table 5 with Table 7, we observe that the coefficients as per the Fixed Effects and the Random Effects are very similar with each other. This is an indicator that under the Random Effects, the predicted models are more efficient.

In every case, be it Fixed Effects or Random Effects, the differences between the coefficients and their significances are very slight, without harming generalization.

6. Discussion of the Results

Except for the coefficients' interpretation, continuing the findings discussion, further points can be made. According to the R-squared in the most complete version, in the H7 model is around 50%. This means that approximately 50% of the port container throughput variation is explained by our model. Considering that there are more variables than infrastructure investments that potential influence port container throughput, the current models are significantly improving the predicting performance of the container forecasting models.

Additionally, as per the co-integration tests and considering the omitted variable bias weakening the robustness of the models, for the majority of them it seems that there is a long run equilibrium relationship between the port container throughput and the infrastructure and superstructure investments. Therefore, the interaction among them is causal.

6.1 Synopsis of Hypotheses Results

Regarding our hypotheses, they have all been confirmed, except for some cases for which it was reliably assumed that they are otherwise due to omitted variable bias. In Table 6 the Hypotheses Synopsis results are presented.

Table 9: Hypotheses Synopsis results

Hypothesis 1	*Maritime Port Infrastructure Investment has a positive and significant effect on the TEU for both port ranges.*	***Confirmed***
Hypothesis 2	*Road Transport Infrastructure Investments have a positive and significant effect on the TEU for both port ranges.*	***Confirmed***
Hypothesis 3	*Rail Transport Infrastructure Investments have a positive and significant effect on the TEU for both port ranges.*	***Confirmed***
Hypothesis 4	*Air Transport Infrastructure Investments have a positive and significant effect on the TEU for both port ranges.*	***Confirmed***
Hypothesis 5	*Infrastructure Investments have jointly a positive and significant effect on the TEU for both port ranges.*	***Confirmed***
Hypothesis 6	*Transport Equipment Investments have a positive and significant effect on the TEU for both port ranges.*	***Confirmed***
Hypothesis 7	*Infrastructure Investments and Superstructure Investments have jointly a positive and significant effect on the TEU for both port ranges.*	***Confirmed***

An interesting note is that, although transport infrastructure investments have a positive and significant effect on the port container throughput for both ranges, significant differences exist between them. Infrastructure and superstructure investments yield higher TEU returns in the Hamburg - Le Havre range than in the Mediterranean range, something that is well observed in Table 7, calculated based on the Random Effects estimations. **F**or example, EUR 1 million invested in Maritime Port Infrastructure, yields between 4 to 6 times more containers in the Hamburg - Le Havre range comparing with the Mediterranean range.

Table 10: Return of investments on TEU

Ratio of the Hamburg - Le Havre range returns to the Mediterranean range							
Explanatory Variables	**H1**	**H2**	**H3**	**H4**	**H5**	**H6**	**H7**
Maritime Port Infrastructure Investments	3.8				6.2		4.1
Road Transport Infrastructure Investments		1			2.3		1
Rail Transport Infrastructure Investments			2.8		2.4		1.2
Air Transport Infrastructure Investments				1.3	0.3		1.4
Transport Equipment Investments						1.4	1.7

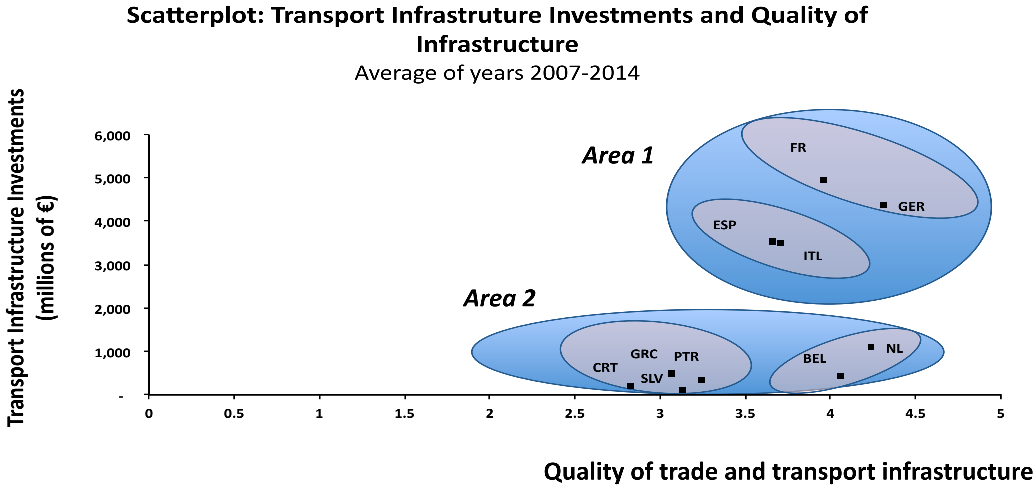
Comparing the impact of the investments with each other, according to the regression results, the largest impact of the infrastructure investments on the port container throughput comes from the Maritime Port Infrastructures. Even though the Maritime Port Infrastructure Investments make up almost a tenth of the Road Transport Infrastructure Investments, their impact on the port container throughput is much higher. Finally, the Air Transport Infrastructure Investments, yield more or less the same returns on TEU for the two ranges.

Overall, the transport infrastructure investments appear to systematically yield higher returns in the Hamburg - Le Havre range than in the Mediterranean range. This might be due to various reasons. One reason can be the higher levels of corruption in the Mediterranean countries. This means that, for each euro spend in infrastructure and superstructure investments in the Mediterranean countries, lesser part of it finally reaches an infrastructure project, than in Northern Europe where corruption rates are lower (Transparency International, 2017).

6.2 Quality of Transport Infrastructure and Spatial Synergies

In Graph 7, the scatterplot between the Transport Infrastructure Investments and the Quality of Trade and Transport Infrastructure is presented. Two main areas are distinguished: Area 1 and Area 2. In Area 1 France and Germany in the higher subgroup and Spain and Italy in the lower subgroup. In Area 2 there are two subgroups as well. The lower one with Croatia, Greece, Slovenia and Portugal and the higher one, with Belgium and Netherlands. In both areas, the Hamburg - Le Havre range countries yield higher quality of transport infrastructure for similar amount of investments.

The difference is more apparent in Area 2. The subgroup of Belgium and Netherlands spent almost 2 billion euros in transport infrastructure, which is almost equal to the amount spent in the Mediterranean range. Yet, in scale from 0 to 5 (5 as the top quality of infrastructure), Belgium and Netherlands yield more than 1 unit higher quality of infrastructures, which is very significant. Assuming that the technological advancements are similar between the two ranges, the underlying reasons for this difference could be attributed to the mismanagement of the funds headed to infrastructure investments.



Graph 7. Data source: The World Bank. Design: Author

Another possible reason for which transport infrastructure investments yield more containers in the Hamburg - Le Havre range, is the fact that the ports in this region are closer with each other, in comparison to the Mediterranean ports. Within a distance of about 850 kilometers, 11 ports are located with more than 1,224,300,000 tons throughput in 2015 (Port of Rotterdam Authority, 2016a). Therefore, this spatial proximity might lead to infrastructure synergetic effects (Theo Notteboom, 2012). On top of that, the Northern governmental authorities pay more attention to the economic development and planning of their countries, resulting in a more careful and aimed spending of the investments.

6.3 Comparison to the Literature

It is also interesting to make a few notes regarding the relevance of our results with the container forecasting literature. As mentioned in the literature, Makhecka (2016) is the only one who has used the Maritime Port Infrastructure Investments. Makhecka found insignificant effect of the Maritime Port Infrastructure Investments on the port container throughput of the Hamburg - Le Havre range ports and attributed this to a suboptimal level of investment.

As per the results of the current paper, Maritime Port Infrastructure Investments have a positive and significant effect on the port container throughput of both the Hamburg - Le Havre range and the Mediterranean range. However, the effect of the investments can be seen only after a couple of years.

Additionally, in the same paper, Makhecka found inland transport in length in kilometers (motorways, railways, waterways) to have an insignificant effect on the port container throughput. In order the inland transport network (in length) effect to be captured, the relevant variable needs to have a certain minimum degree of variation. Makhecka implies that for some port ranges these variables remained constant, making it hard for the econometric program to capture any significance. Makhecka suggests different measuring techniques to be used.

One thought supported by the findings of the present study, is to measure the amount of money invested in the extension of the inland network instead of its length, since the first has a higher degree of variation through time than the latter. In this way, the effect of the changes in the inland transport network can be captured by the econometric program.

6.4 Policy Implications and Further Considerations

According to OECD (2013) the cumulative investments in land transport infrastructure are predicted to reach US $ 45 trillion by 2050. In the European Union alone, the total cost of the transport infrastructure needs is estimated over EUR 1,5 trillion for the period 2010-2030. Only the European TEN T network requires EUR 500 billion until 2020 for its completion. The main sources of funding are public resources followed by EU grants and loans from the European Investments Bank (K. Bodewig & C. Secchy, 2014).

However, the anemic economic growth and the long lasting effects of the 2008 economic crisis, have constrained the governmental budgets. Simultaneously, the private sector participation in transport infrastructure projects is modest. Therefore, the pool of the EUR 1,5 trillion transport infrastructure investment needs, do not seem to be fulfilled up to 2030.

6.4.1 Infrastructure Investment Gaps

Evidently, there is a financing infrastructure issue. Under-financing of the transport infrastructures can harm economic activity and employment, competitiveness and increasing external costs such as accidents and environmental degradation. As a solution, a plethora of studies supports the idea the infrastructure investment financing will need to come increasingly from the private sector (Torsten Ehlers, 2014).

Complex legal arrangements in order to ensure fair distribution of the returns to investments and risks between the parties involved, creation of cash flows after many years and unattractive returns to investments are usually factors that discourage private participation in transport infrastructure projects (K. Bodewig & C. Secchy, 2014). Therefore, the potential financing deficit is rephrased as to, how to make infrastructure financing returns to investments more attractive to private investors. The current study contributes in answering this problem as follows.

6.4.2 Container Throughput as an Index of Returns to Infrastructure Financing

In the present study, the relationship between various transport infrastructure investments and their return to container throughput has been quantified. Under certain assumptions and within specific boundaries, one can predict the additional container throughput as per the additional infrastructure investments. The additional port revenues (from container handling charges, fees and port dues) and governmental taxes (collected from import tariffs and taxation) which occur due to the additional container throughput can be predicted as well.

Therefore, it can be agreed among the parties which are influenced and/or interested in transport infrastructure investments, a share from the created port and governmental revenues as per additional container generated. A container unit (TEU), is therefore a potential Special Purpose Vehicle, which connects the financial investments of the related infrastructure and their corresponding revenues, assisting into a fair distribution of the profits generated by the investments.

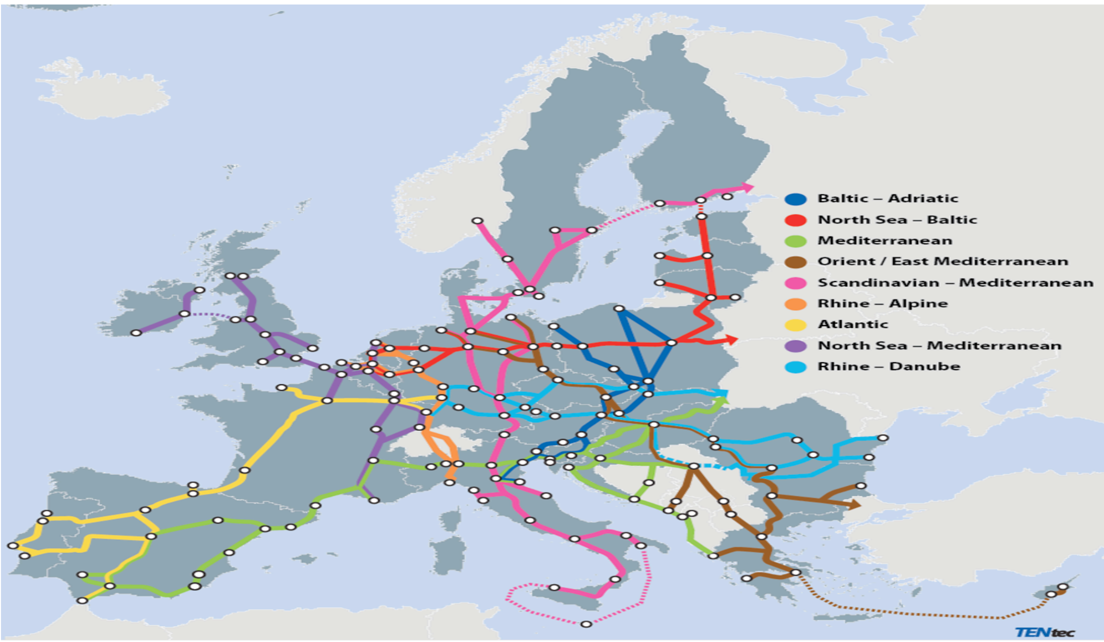
A container unit as a Special Purpose Vehicle has several potential benefits over the current transport infrastructure financing:

- Clear and simple way of predicting the returns to investment
- Stable stream of revenues and attractive returns
- Reduced risk levels (as seen in Graph 1, port container throughput is being increased since 1970, except for the 3 years of the financial crisis 2008-2011, therefore the returns to investments will be following similar trend)
- Reduced bureaucracy and room for crowdfunding (relieving tax payers)
- Improved transparency

Except for assisting in the transport infrastructure financing, predicting the container throughput based on the potential volume of the investments can assist in regional policies.

6.4.3 Contributing in a Balanced Regional Policy

As mentioned in the regression results, transport infrastructure investments in the Hamburg - Le Havre range yield higher container throughput returns than in the Mediterranean range. This implies that in the long run, congestion in the sea (vessel traffic), rail (train traffic), road (truck traffic) and air (aviation traffic) transport modes might become more acute in the North, than in the South of Europe. On the other hand infrastructures in the South might be functioning sub-optimally. Therefore, the present study sheds light into the distribution of the (at least on cross border infrastructure projects) European funds, in a way that balanced growth is easier monitored and achieved along the European periphery.



The TEN T Core Network Corridors. Source: European Commission

A pan-European project of such a concept is the TEN-T network, which builds towards closing infrastructure gaps, removing bottlenecks and eliminating technical barriers that exist between the transport networks of EU Member States. Additionally it aims into strengthening the social, economic and territorial cohesion of the Union and contributing to the creation of a single European transport area.

The New Silk Road Routes on land and sea. Source: Xinhua News

Another similar infrastructure initiative regarding mostly the Mediterranean Europe is the One Belt One Road initiative from the Chinese. Chinese envisage to "embrace" the European hinterland market by constructing a transcontinental railway from China to London and a sea motor way from China to Piraeus via the Suez Canal. As such, the present study is appropriate into deepening the understanding of the long-term effects on the transport system and the economic growth of similar mega-projects.

6.4.4 Macro-Constructing Requires Macro-Financing

Overall, observing the vision of world's biggest players, such as Russia, China, Middle East and Europe concerning the future of the world transport infrastructure, one observes that mega-projects are going to become the new reality. Mega infrastructural projects imply macro-constructing and the latter requires macro-financing. The present model shows that predicting the container throughput based on aggregate-macro figures is not only possible, but sufficiently precise as well.

Concluding the *Policy Implications* section, it is suggested that transport infrastructure investment planning to be implemented in a macro-scale (for example on regional scale), as it is not only more efficient to physically coordinate, but also monitoring its effects through time safer for a balanced regional growth.

7. Conclusions

The present study investigated the effect of transport infrastructure investments on port container throughput between Hamburg - Le Havre and the Mediterranean range. The regression results showed that indeed, as per the objective of the present paper, there is a sizable and quantifiable connection between the transport infrastructures and superstructure investments and the port container throughput. Maritime Port, Road, Rail, Air transport investments and Transport Equipment investments have a positive and significant effect on the port container throughput on both Hamburg - Le Havre and Mediterranean range.

As per the literature, the effect of the aforementioned infrastructure investments is significant only after a couple of years, since the construction period needs to be accounted for. On the contrary, the Transport Equipment superstructure investments have a positive and significant effect on the port container by the first year, since transport equipment is a buy-to-direct-use asset.

The presented models explain more than 50% of the port container throughput variation, even though critical explanatory variables such as GDP, population and inflation have been omitted. As per the co-integration tests and considering the omitted variable bias weakening the robustness of our models, for the majority of our variables, it seems that there is a long run equilibrium relationship between the port container throughput and the infrastructure and superstructure investments.

Comparatively between the two regions, infrastructure and superstructure investments yield higher number of TEUs in the Hamburg - Le Havre region than in the Mediterranean range. Corruption and synergetic effects due to spatial proximity might explain this variation.

Finally, the causal relationship between port container throughput and infrastructure funding and the ability of the latter to predict the volumes of the first, creates room for creative proposals. The idea of the container unit as a Special Purpose Vehicle serving the worldwide increasing infrastructure needs should be looked at deeper both in academia and the business world.

7.1 Recommendations for Further Research

Although the findings of the present paper are insightful regarding the forecasting of the port container throughput, several ideas should be researched at in the future. First and foremost, the two main limitations as per the section *Assumptions and Limitations* should be taken care of.

To begin with, the effect of the infrastructure maintenance on the port container throughput should be examined. On the one hand, properly maintaining the transport infrastructure allows for an efficient and long term life of the infrastructure. However, there are concerns whether the current infrastructures are properly maintained. “As the stock of infrastructure grows, and in many cases ages, more effort is required to maintain the quantity and the quality of the infrastructure. In spite of this shift, observers in many countries have raised concerns about underfunding of infrastructure maintenance. Road maintenance is often postponed on the expectation that it will be made up for in the future and there is no risk of immediate asset failure.” (OECD, 2017).

Yet, the share of infrastructure maintenance appears to be generally increasing at the expense of the new infrastructure projects in the developed countries. Therefore, there is a trade of between the maintenance and the new infrastructure projects, due to limited funding. Should the container transport related parties invest more funds in the maintenance of the current infrastructures or in new infrastructure projects?

Furthermore, forecasting the port container throughput involves more explanatory variables other than the infrastructure investments. In the present paper, the models include solely infrastructure investments and as expected suffer from omitted variable bias. It would be therefore interesting to examine the behavior of enriched models, including both transport infrastructure investments and the omitted variables which have previously been employed as per the literature, such as GDP, fuel price, interest rate, population etc.

A concluding room for further study could be the use of the container unit as a Special Purpose Vehicle in the financing of transport infrastructure projects. Next to it, it will be interesting to investigate to which extend can monetary revenue streams (port fees, tariffs, taxes, etc) per container be used in order to improve the assessment of transport infrastructure projects (freight related) returns on investments.

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