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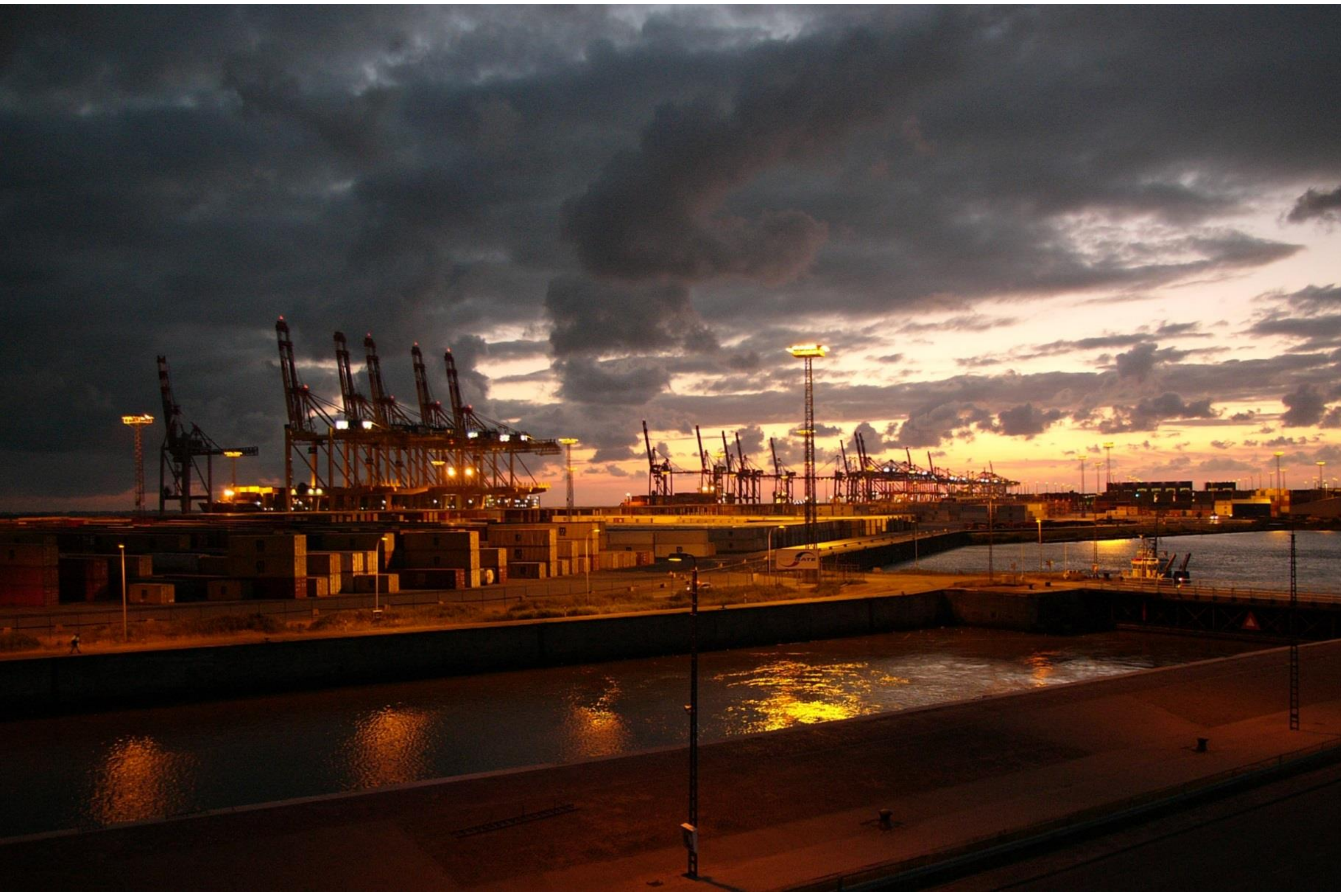

CONSTANZA - CONTAINER GATEWAY FOR SOUTH-EAST EUROPE

A MULTINOMIAL LOGIT MODEL ON PORT CHOICE

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PREFACE

Front page image source: Image retrieved 01 June 2015 from Wikipedia Website:
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ABSTRACT

The enlargement of the European Union together with the widespread adoption of containerization in international trade has allowed a number of ports in Europe to develop and grow. One such port is Constanza. Our aim is to identify the competitve position of Constanza in Europe's containerized trade and to evaluate the port's potential to become a gateway port for goods destined for the South-East European hinterland.

The port's competitive position is evaluated from two perspectives. First, Southern Europe's competitive advantages and disadvantages are compared with the Northern European range, the dominant range in Europe. Second, Constanza is evaluated in the South-East European setting against its closest rivals.

The potential of the port to become a gateway for South-East Europe was investigated by means of a multinomial logit model. The model used identifies the factors influencing the market share of Constanza and quantifies their effect. The hinterland containerized flows are constructed from commodity flow data. We also consider infrastructure differences between countries. Variables include transport cost, transit time, maritime deviation and port infrastructure indicators. By means of the estimated function we examine a number of transport cost evolution scenarios and determine their impact on Constanza's market share.

Keywords: Multinomial logit model; Port choice; Container port competition; Shipment routing; Constanza; Black Sea; South-East Europe

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1. INTRODUCTION

The past 50 years have represented a half century of unprecedented growth in international trade. Containerisation, one of the main elements of this growth, has facilitated goods flow by providing an easy, efficient and cost effective way of transportation. The ability to load goods in a container at a considerable distance from the point of shipping and then load the container on a truck or train for delivery to the port means that factories could be located further away from the main ports. Furthermore, loading times for the ships were seriously reduced with the introduction of the container as goods were not handled individually but by quay and gantry cranes. These factors allowed for global supply chain developments that integrate velocity of freight delivery within production and distribution functions (Notteboom & Rodrique, 2008).

This unprecedented growth led to the appearance of bigger ships on the market with larger transport capacities that ensure lower slot costs for container transport. Harbours have now to deal with mammoth ships that have to load and unload in a limited timeframe. Furthermore, the industry practice known as “slow steaming”, effectively defining slowing down of ships to allow for lower fuel consumption (Rosenthal, 2010), has impacted the schedule integrity of shipping lines. Ports are unable to accurately and effectively plan operations resulting in delays in berthing operations. Congestion at multiple port terminals cascades onwards to the inland distribution system causing further delays in the supply chain (Drewry , 2014).

The ports within the northern European range (Hamburg – Le Havre) supply close to half of the containers coming in to Europe (Notteboom, 2012). This means that it is not uncommon for containers to enter Europe in a northern European port and find their way to a destination in South-East Europe. This entails high costs for the shippers and also represents a great environmental and planning challenge which raises the question as to why this situation occurs in the first place.

The focus on increasingly larger ships has meant that the concentration of cargo to the northern range was natural due to the capabilities of ports to handle large ships into good times and the economies of scale provided by the large ships. Furthermore, their natural geographical position, serving the most developed European economic region meant that their development path was assured.

So far, many of the South-East European countries have not been considered as potential suppliers for global supply chains. Some of the countries have been closed economies for decades and lacked the investments and economic development that have characterised Western economies. This also means that the opportunities arose from these countries joining the European Union, opening their borders and sharing the same legal framework as the rest of the member states.

The large degree of freedom advocated and facilitated by the European Union in terms of cargo flows provides the foundation needed for container flows to shift their long voyage to the northern ports towards the closer southern ports. However this change has yet to occur. Why are containers still making a trip over 2500 nautical miles longer to reach the same destination as they would when discharged to a closer port? Why are cargo flows so concentrated and, can this situation be changed?

1.1 PROBLEM STATEMENT

This thesis aims to investigate the position of one of the ports in South-East Europe, namely Constanza, with respect to its current position in the regional containerised goods flow and the future that the port can play in supplying the region with goods.

The idea that the northern range ports could face increasing competition from west and east Mediterranean ports has been investigated so far by several authors such as Polyzos (2008), Cazzaniga (2002). However, to the author's knowledge, the possibility that Constanza could become more important actor in supplying their adjacent regions has not been investigated so far.

The port of Constanza enjoys the advantage of deep waters and geographical proximity to the countries considered in this study. Constanza also has access to the Danube, one of Europe's largest navigable waterways.

The main research question this thesis will attempt to answer is: *Can Constanza play a central role in serving the South-East European hinterland?*

The resulting sub-questions are:

1. What are the main regional competitors for the port of Constanza?

2. How can container cargo flows be improved at a port level and implicitly on a country level?

3. Does Constanza have the potential to become a hub in container transport?

1.2 GEOGRAPHICAL SCOPE

The geographical scope defines the borders of the study which are in this case the countries situated in South-East Europe. The countries considered in this study are: Bulgaria, Croatia, Greece, Hungary, Macedonia, Romania, Serbia and Slovenia. These countries are either members of the European Union, European Free Trade Association or candidates to join the European Union.

The South East European region is bordered by three seas, the Adriatic, the Aegean and the Black sea at which five of the eight considered countries have direct access. There are 79 ports on these coastlines (Searates World Ports, n.d.), however we have selected eight ports for our study: Burgas, Varna, Constanza, Thessaloniki, Piraeus, Rijeka, Koper and Trieste.

1.3 STRUTCURE OF RESEARCH

The structure of the thesis is as follows. The second chapter presents a literature review on port choice and port competition factors. The third chapter describes the competitive status of the port of Constanza in 2013 including the reasons for the current situation, the port's hinterland, its main competitors and some recommendations on improving containerised cargo flows. The fourth chapter includes the research approach, the methodology and the elaboration of a multinomial logit model for containerised goods flow in the South-East European region in order to investigate what the role Constanza could play in supplying South-East Europe with containerised goods. Finally, the concluding remarks of the study are presented along with its limitations and recommendations.

2. LITERATURE REVIEW

This chapter will provide an overview of the literature that evaluates port choice. The first section is centred on the search results and the key words used.

The next section presents the literature on region or range of discharge issues and aims to identify the array of hinterland factors affecting shippers choice that are not captured in port level analyses. This meant searching for literature that described the current situation in the South Mediterranean or Black Sea.

The third section presents papers that evaluate the factors that influence port choice for the different actors involved in the transport chain. The approach of these studies can be divided into two categories: those which evaluate stated preferences with the help of surveys and those which evaluate revealed preferences by analysing observed throughput volumes between different ports and the differences in factor endowments of the respective ports.

2.1 SEARCH RESULTS

The search was made using Google Scholar search engine. The search engine provides results ranked accordingly to the author's ranking, number of references that are linked to it, their relevance in the searched literature and the ranking of the journal the publication appears in (Google Scholar, n.d.). The key words used in performing this search were "port competition in the Black sea" for the first section of the literature review and "port choice multinomial logit", "port choice survey" for the second section of the literature review.

The search for port competition in the Black sea yielded approximately 130 search results. Not all of them covered the issue at hand and thus could not be used in developing this literature review. The port choice searches yielded approximately 600 search results related to port choice. From these, 95 were related to the multinomial logit and the rest regarding the survey approach.

It is interesting to also observe the evolution of the research topics over time. In this respect, the survey approach in port choice is the most represented section, with almost 500 search results. This research approach has seen a strong growth. Whereas between 1985 and 2000 only 37 papers related to be topic were published, between 2010 and 2014 more than 200 papers were published covering this topic. One explanation can be that this technique, as opposed to the modelling approach is less technical. As far as our search took us, none of the papers investigated the port choice in South-Eastern Europe. Our literature review contains 10 papers that use the survey approach. These papers were chosen as they are frequently quoted and also present a large variety of factors that affect port choice.

Research centred on port choice modelled by a multinomial logit function is relatively less developed than the survey approach. This field has also seen growth, with only one paper published between 1985 and 2000 and more than 40 published from 2011. Some of the reasons why the topic is less represented in the literature can be that modelling requires a higher degree of expertise and results cannot always provide very definite answers as this approach is based on a number of assumptions. The literature review contains 10 papers that use the modelling approach. As the literature related to port choice modelling is not particularly extensive, we attempted to cover the most used approaches. Thus, papers vary in aggregation levels of cargo flows, on the involved actor's perspective and factors considered.

The reason behind the broad coverage of the literature subjects is that we believe that factors that have an influence on the choice of ports lie within the ranges where the ports are located but also within the countries hosting the ports. The first part of the literature review elaborates on the issues that can be important for a specific port form a macroeconomic perspective. The second part of the literature review provides evidence related to the quantitative and qualitative factors that influence port choices. The factors that will be included in the multinomial logit estimation in Chapter 4 are extracted from the papers included in our literature review.

2.2 PORT COMPETITION IN THE BLACK SEA

Globalization has had an impact on the role of ports in the freight transport business. The days when ports were seen as nodes in a shipping network are behind us. The new paradigm, elaborated by Robinson (2002) states that ports are integrated elements in value driven chain and that they deliver added value to shippers and third party services providers. The perspective adopted by Robinson underlines that, even though ports are still links in a shipping network, on a broader level, they represent links able to provide competitive advantage for companies that want to deliver cargo between two destinations. The internal strengths of ports are no longer the only ones that determine the competitive position of a port but also the affected links in a given supply chain (Carbone & De Martino, 2003) .

Countries in the Black sea and South-East European region started raising standards of living and developing functional market economies much later than many Western countries. It is of no surprise that the literature centred on port competition in the Black Sea region is not of great richness. In order to point out the regional aspects that can have an impact on port choice, aspects that cannot be easily incorporated into a model, we have considered papers that discuss the differences between the South and North European ports. These papers shed light on the factors that differentiate the ports and highlight the issues where the South European ports are lagging behind. We believe that many of the issues identified below also apply to South-East European ports, even if these ports are not directly mentioned in the papers investigated.

A number of authors investigate the paradox of the South European ports which is that although Southern Mediterranean ports have a distance and time advantage over North European ports, the ports in the Hamburg – Le Havre range still handle about half of the European bound cargo (Notttebom, 2013). Virtually all the literature investigated mentions the travel time savings that can be achieved by calling at South European ports. Cazzania et al. (2002), Medda & Carbonaro (2007), Ferarri et al. (2006)and Notteboom (2010), (2012).

In the attempt to illustrate the other factors influencing port competitiveness identified in the investigated papers, we have divided the factors into four categories:

- Factors that can benefit cargo to the Southern range ports,
- Factors that hamper cargo flows switch to Southern range,
- Factors that allow the Northern range to maintain its competitive edge and
- Factors that can weaken the competitive position of the Northern range.

In the first category of factors, *factors that can increase cargo to Southern range ports*, we find that due to the shorter sailing distance and time requirements, a greater number of rotations can be achieved on a trade lane with the same number of ships. Furthermore, a vast majority of South European ports have direct sea access, thus allowing for economies of scale that come with the possibility of using larger ships (Cazzaniga et al., 2002). Direct sea access removes some of the tidal limitations imposed by river harbours. South European countries have also begun to develop and modernise infrastructure and facilities and have the advantage of lower costs for logistic facilities development (Ferarri, Parola, & Morchio, 2006).

One of the issues most frequently mentioned as to why *Southern ports are still not attractive for cargo routing* is the slow process of privatisation of the railway sector (Notteboom, 2010)

(Cazzaniga et al., 2002) coupled with the lack of integration between economies (Medda & Carbonaro, 2007). The transport infrastructure related issues seem to be the prevailing negative factors mentioned about ports in the southern range. Government ownership of infrastructure services, especially of railways, means that infrastructure investment is lagging behind other European countries. This restricts the speed at which rail transport can be done (Cazzaniga et al., 2002). The primary development focus of the southern European ports is capacity improvement and modernization. This direction creates the opportunity to handle more cargo and improve existing facilities efficiency. The focus of North European ports has shifted to the next level of development, from capacity increase to attention to variety and quality of service (Ferarri et al., 2006).

Port development is also greatly influenced by past choices or "path dependency" (Notteboom, 2010). The shipping industry is notoriously conservative and major changes in European container flows require a great deal of time. Furthermore, close proximity to large consumption centres is an *important advantage for ports in North Europe* (Cazzaniga et al., 2002), (Notteboom, 2010), (Medda & Carbonaro, 2007). Approximately 40% of containers to or from Antwerp have a destination 50 km away from the port while in Rotterdam the range is around 150 to 200 km away (Notteboom , 2010). This large concentration of cargo flows in a limited number of ports does create issues for the North range ports. Congestion in northern European rail terminals (Ferarri et al., 2006) is one the forces that can push towards shifts of cargo flows away from the incumbent Hamburg – Le Havre range.

2.3 PORT CHOICE

Port choice studies are concerned with the reasons companies have when choosing a specific cargo routing. The literature reviewed is structured on two main streams: stated preferences and revealed preferences. The search for literature was performed by searching for papers that survey port users to uncover the stated preferences and papers that model the revealed preferences of users by looking at the routing of cargo in the hinterland regions, primarily by using the multinomial logit model.

The papers that make use of stated preferences data acquire these data from companies by means of surveys filled in by a number of companies that are operating in the transportation field. Freight forwarders are some of the preferred companies in the literature reviewed (Slack, 1985), (Bird & Bland, 1988), (Tongzon, 2002), (Tongzon, 2009), (De Langen, 2007). Only a limited number of papers focus on the carriers choices (Ng, 2006), (Aronietis, 2010). Another perspective for port choice studies is the one offered by modelling the revealed preferences of companies. In these cases, the authors make use of data available regarding a number of shipments destined for certain ports. These shipment data can be at an aggregate level (Veldman & Bückmann, 2003), (Veldman, 2011), (Blonigen & Wilson, 2006), (Zondag, 2010) or at a disaggregate level (Malchow, 2001), (Malchow, 2004), (Steven, 2012). As the main point of concern for these papers is the final routing choice for the shipments analised, the vast majority of publications, attribute the decision making party in the transportation chain to the shipper.

From the literature reviewed we found that transportation cost is one of the most frequently mentioned factors. This is mentioned in 15 of the papers directly and considered in other three as a linear function of distance which is there the main factor. Moreover, frequency of service is also a term mentioned in more than half of the papers reviewed.

Early users of such the survey technique for uncovering factors behind port choice are Slack (1985) and Bird (1988). The former analyses the responses of end-users of port services on the transatlantic trade route. Respondents were asked to choose factor importance from four categories, port selection criteria, port service criteria, liner characteristics and information services. The latter surveys European freight forwarders. While both arrive at the same conclusion which is that frequency of service at a port is the most important reason for choosing a specific port, Slack (1985) points out to the idea that shippers are generally conservative in their choices, thus improvements especially in port infrastructure do not necessarily translate into increased volumes.

Tongzon and Sawant (2007) adopt the survey approach in analysis carrier’s preferences in South-East Asia. The survey yields efficiency as the most important port choice factor, followed by port charges and connectivity on the same level. Location, infrastructure, port services and cargo size follow on the importance ranking. They then proceed to test these stated preferences against the revealed preferences and find that only port charges, infrastructure and services maintain a significance level while the other factors lose their significance.

De Langen (2007) takes as an example of contestable hinterland Austria. Because of its location, it can be serviced by six ports, the four large northern range ports and also the southern ports of Trieste and Koper. Shippers and forwarders operating in the country are surveyed. A series of factors emerge that determine their shipping choices. The quality of services, infrastructure and connection are the factors most frequently mentioned as having the most importance. Furthermore, interviews revealed that the price is, most of the times, not the deciding factor when choosing a service, even though it bears a great deal of importance (De Langen, 2007; Ng, 2006). The respondents were divided into shippers and forwarders to allow for differentiation between the two groups. Results show that shippers are more price inelastic than forwarders and are less willing to shift from one port to another just on price considerations (De Langen, 2007). Similarly Tongzon (2002) divided the surveyed shippers into three categories, those which have long term contracts with shipping lines, those which outsource their freight movements to logistics companies and the independent shippers (Tongzon, 2002).

Machalow and Kanafani (2004) use a multinomial logit model to analyse disaggregate data for US shipments. Their approach eliminates the price component from the transportation change arguing that it is in fact the carrier that is the main decision maker in terms of port of discharge and inland transportation mode used, and that the proxies used for costs, the oceanic and inland distance have a near-linear impact on the cost and transit time. Furthermore, the authors assume constant returns to scale. Their results come to confirm previous studies in the sense that the increase of distance and travel time has a negative influence on the choice of a specific port. However, the frequency of sailing and the average vessel capacity, although still statistically significant, have lower significance level than the inland and oceanic distances.

More recently, Zondag et al. (2012) base their modelling approach on the trade volumes forecasted with the help of the WORLDNET model. This model provides monetary forecasts country-by-country trade flows which are then disaggregated into commodity groups. The explanatory variables the authors use to explain the freight movements from the ports to the hinterland are the maritime, hinterland and port costs. The study takes a cost oriented approach with individual costs for each of the stages of transportation taken into account from surveys with operators and also with the value of time incorporated into the model. The entry points for cargo are four of the largest North European ports, Antwerp, Bremen, Hamburg and Rotterdam. One of the interesting results the model provides is the almost absolute share of Hamburg over virtually all polish, Austrian and East German regions, while Bremen competes only for a minority of the cargo flows.

Steven et al. (2012) make use of US import data for their conditional logit model. Their main stated objective is to assess the impact of factors that are under the control of port authorities on port choice. Apart from the freight rates and transit times that are widely used in port choice models, the authors also include port metrics such as: crane productivity, port congestion, berths, frequency of service and management type. Results illustrate that crane productivity and port congestion have the expected effects on shippers choices the former having a positive impact on shippers choices, while the latter negatively impacting the choice. Furthermore, private management of the port is found to positively influence the choice of ports.

One of the most interesting attempts is that of Tongzon and Sawant (2007) who compare the results of their survey with the revealed preferences of the surveyed carriers. They make use of the gathered data through the survey which they used as raw data for the binary logistic regression model they estimated. The results were compared with actual cargo flows information. Their result turned out port services at a similar level with the stated preferences at a 5% significance level and port charges, connectivity and infrastructure at a 15% significance level. The low correlation between the two approaches raised some questions as to how much information can be extracted from the stated preferences of companies.

2.3 CONCLUSIONS

Competition between North and South European ports can be approached from a variety of perspectives, either by considering range characteristics, port characteristics or by looking at the distribution of logistics activities. This comes to show that the competitive position of ports is determined by more than their internal strengths. Factors such as proximity to economic concentrations, economic and institutional integration between and within countries and the focus on quality services provide competitive advantage for the Northern Range. Southern countries are still developing towards this stage. The emphasis in South European countries falls on quantitative growth rather than qualitative growth, and the main advantage they provide is the shorter sailing time for mainland Europe the large Far-East production centres.

Until the distance advantage of South European destinations can be translated through economies of scale in a cost advantage, and the cost advantage will grow to overshadow the benefits provided by North European ports, cargo flows shifts are unlikely to occur between the Northern and Southern European ports.

Port choice literature revealed that although costs are an important part of the cargo routing decision, they are not necessarily the most important criteria. Frequency of service, infrastructure development and port operations efficiency are also seen as important factors.

There are large differences in factors considered between papers that have a modelling focus and papers that have a survey approach. The former takes into account the effects of factors that are easily quantifiable such as distances, costs and frequency of service while the latter accounts for qualitative factors such as efficiency, customer orientation or reputation.

Nr.	Authors	Data type	Decision maker	Method	Criteria
1	Veldman, Buckmann (2003)	Revealed preferences	Shippers/ Logistics providers	Multinomial logit model Aggregate data	Transport costs, Transport time, Frequency of service
2	Veldman et al. (2011)	Revealed preferences		Multinomial logit model Aggregate data	Transport costs, Transit time, Frequency of service, Location
3	Veldman et al. (2005)	Revealed preferences		Multinomial logit model Aggregate data	Transport cost, Transport time, Port market share, Frequency of service, Maritime access resistance, Maritime access cost
4	Malchow, Kanafani (2004)	Revealed preferences	Shippers	Multinomial logit model Disaggregate data	Distance, Sailing headway, Average vessel size, Last port of call
5	Malchow , Kanafani (2001)	Revealed preferences	Carriers	Multinomial logit model Disaggregate data	Oceanic distance, Inland transport distance, Average vessel capacity, Frequency of service
6	Bloningen, Wilson (2006)	Revealed preferences	Shippers	Conditional logit model Gravity model Aggregate data	Ocean transport costs, Inland transport costs, Port costs, Port efficiency
7	Steven, Corsi (2012)	Revealed preferences	Shippers	Conditional logit model Disaggregate data	Port efficiency, Port congestion, Management type, Average vessel size, Freight charges, Transit time, Shipper size, Berths , Frequency of service
8	Anderson et al. (2009)	Revealed preferences		Nested logit model	Source coast, Destination coast ,Transit time, Inland transport cost, Reliability of service , Cost
9	Tiwari et al. (2003)	Revealed preferences		Multinomial logit model	Port characteristics, Carrier characteristics , Shipper's characteristics
10	Tongzon, Sawant (2007)	Stated preferences Revealed preferences	Carriers	Survey Binary logistic regression	Efficiency , Port charges, Connectivity, Location, Infrastructure, Port services, Cargo size
11	Zondag et al. (2010)	Modelled flows		Multinomial logit model Aggregate data	Maritime transport cost, Port cost, Inland transport cost
12	Slack (1985)	Stated preferences	Freight forwarders	Survey	Frequency of service, Cost, Information services, Carrier characteristics
13	Bird, Bland (1988)	Stated preferences	Freight forwarders	Survey	Frequency of service, Cost, Time, Labor issues
14	Tongzon (2002)	Stated preferences	Freight forwarders	Survey	Efficiency, Frequency of service, Port infrastructure, Location, Port charges, Response to user's needs, Cargo damage reputation
15	Tongzon (2009)	Stated preferences	Freight forwarders	Survey	Efficiency, Frequency of service, Infrastructure , Location , Port charges, Response to user's needs, Cargo damage reputation
16	De Langen (2007)	Stated preferences	Freight forwarders/ Shippers	Survey	Service, Infrastructure, Connectivity, Location, Information services, Customer focus, Cargo damage reputation
17	Ng (2006)	Stated preferences	Carriers	Survey	Time efficiency, Location, Service, Cost, Delays, Accessibility
18	Aronietis et al. (2010)	Stated preferences	Carriers	Survey	Cost, Connectivity, Port capacity, Reliability, Location, Flexibility
19	Lirn et al. (2004)	Stated preferences	Carriers/ Port operators	Survey/ AHP	Cost, Location, Infrastructure, Mangement
20	Yangbing et al. (2005)	Stated preferences	Carriers/ Shippers/ Port operators	Survey/ AHP	Port scale, Frequency of service, Cost, Infrastructure, Service, Management

Table 1: Overview of literature reviewed for port choice

3. PORT OF CONSTANZA: CURRENT STANDING

The following section provides an assessment of the current competitive position of the port of Constanza. First, we identify a series of the port's key performance indicators such as container throughput, maritime connections and infrastructure. Then, we present and compare key figures of the main South-East European ports. Last, we investigate possible alternative approaches for improving cargo flows in the port of Constanza.

3.1 KEY FIGURES

In order to provide an answer to evaluate the competitive position of the port of Constanza in terms of container flows and the main reasons behind this situation, we present the most important facts and figures of the port. Indicators such as infrastructure and facilities availability or maritime and hinterland links have been identified in the literature surveyed as factors of influence for the competitive position of various ports (see Table 1 for criteria identified in the papers consulted).

3.1.1 CONTAINERISED CARGO

The port of Constanza is situated on the western coastline of the Black Sea. The Romanian coastline is 225 km long and can accommodate a limited number of ports. As a result, only four ports can be found in Romania: Constanza, Mangalia, Midia and Navodari (Searates World Ports, n.d.).

Port of Constanza is the largest port in the Black sea (Ferarri, Parola, & Morchio, 2006). It benefits from depths ranging from 7 and 19 meters that can accommodate a large variety of ships. The depths available at the terminals are sufficiently large to accommodate 250.000 deadweight vessels that carry dry bulk such as iron ore, bauxite, coal and coke. Bulk cargo is the main cargo handled at the port of Constanza in terms of weight. Liquid bulk is the second most important cargo handled at the port, vessels of up to 165.000 deadweight can be handled at the port's terminal. The third most important type of cargo is containerised cargo. Following the route imposed by international trade as to increasing containerization of cargo, Constanza's container volumes show a strong increase compared to general cargo volumes (Constantza Terminals, n.d.).

Figure 1: Romania's coastline

(Retrieved 05 April 2015 from Romanian Ports Website: http://www.romanian-ports.ro/)

Since the late 1990s South and Eastern ports such as those in the Mediterranean basin and the Black sea have been experiencing a process of port reform coupled with increasing involvement of private terminal operators. The investments stevedoring companies made in these ports led to increased container handling productivity and raised competitiveness, while attracting traffic flows especially from Asia. Further momentum was gained by East European ports by the expansion of the European Union (Ferarri, Parola, & Morchio, 2006). One example for a port that benefited from reforms and investments is the port of Constanza.

One container terminal at the port of Constanza, Constanza South Container Terminal, was opened in 2003 and is operated by DP World, a global container operator that oversees 11 container terminals in Europe alone. In Constanza, the company operates a 52 ha terminal with a nominal maximum capacity of 1.2 million TEU. Land for future developments is available at the site as the ultimate surface area for the terminal can potentially reach 76 ha. The water has a depth of 14.5 meters and the main berth has a length of 636 meters while the feeder berth is 411 meters. The availability of space for additional development is emphasized by the company.

A second container terminal, operated by SOCEP, is located on the north part of the port. It operates two berths of a combined length of 467 meters and a water depth of 13.5 meters. The nominal capacity of the terminal is 300.000 TEU. The company, founded in 1991, was developed on the basis of the existing port terminal that dates back from the communist regime in Romania. The majority of the SOCEP's operations is focused on general cargo.

Throughput

Container traffic has had a relatively late start for the port of Constanza with the first container arriving in the port in 2004. This coincides with the opening of the largest container terminal in the Black sea operated by DP World within the port premises (Constantza Terminals, n.d.).

Container volumes showed a sharp increase in the following years, more than doubling in 2005 to 867.000 TEU and topping 1.45 million in 2007. Starting from 2009 however, volumes slumped to around 600.000 TEU. This volume decrease coincides with the repercussions of the financial crisis that started to impact the Romanian economy. Throughput is hovering around the 600.000 TEU/year mark for the last 5 years. While growth is slowly regaining pace, it is far away from the previously seen figures. In terms of tonnage, for 2013, 6.68 million tons of containerised goods were handled, while the peak figure rests at 13.02 million tons in 2008 (Constanta Annual Report, 2012).

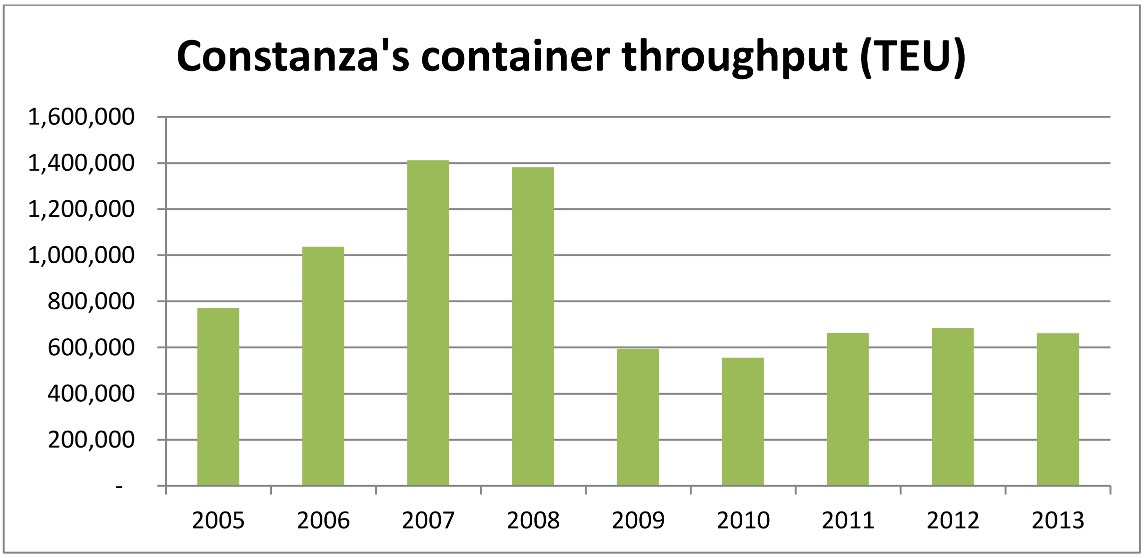

Figure 2: Port of Constanza container throughput (2006-2013)

(Source: Constanza Port Authority compiled from available annual reports)

Trade partners

Figure 2 shows the Constanza's inbound containerised flows divided by partner countries. It is important to note that this figure illustrates the last relay for the cargo and not the country of origin of the cargo. Inbound container flows are presented as data are unavailable regarding outbound cargo destinations.

The direct links from Asian ports provide around 31% of the cargo throughput in Constanza. Main transhipment ports located in countries such as Malta, Israel, Morocco and Egypt have 14% of the total inbound volumes. The largest volumes come from Turkey (17%) and Greece (18%).

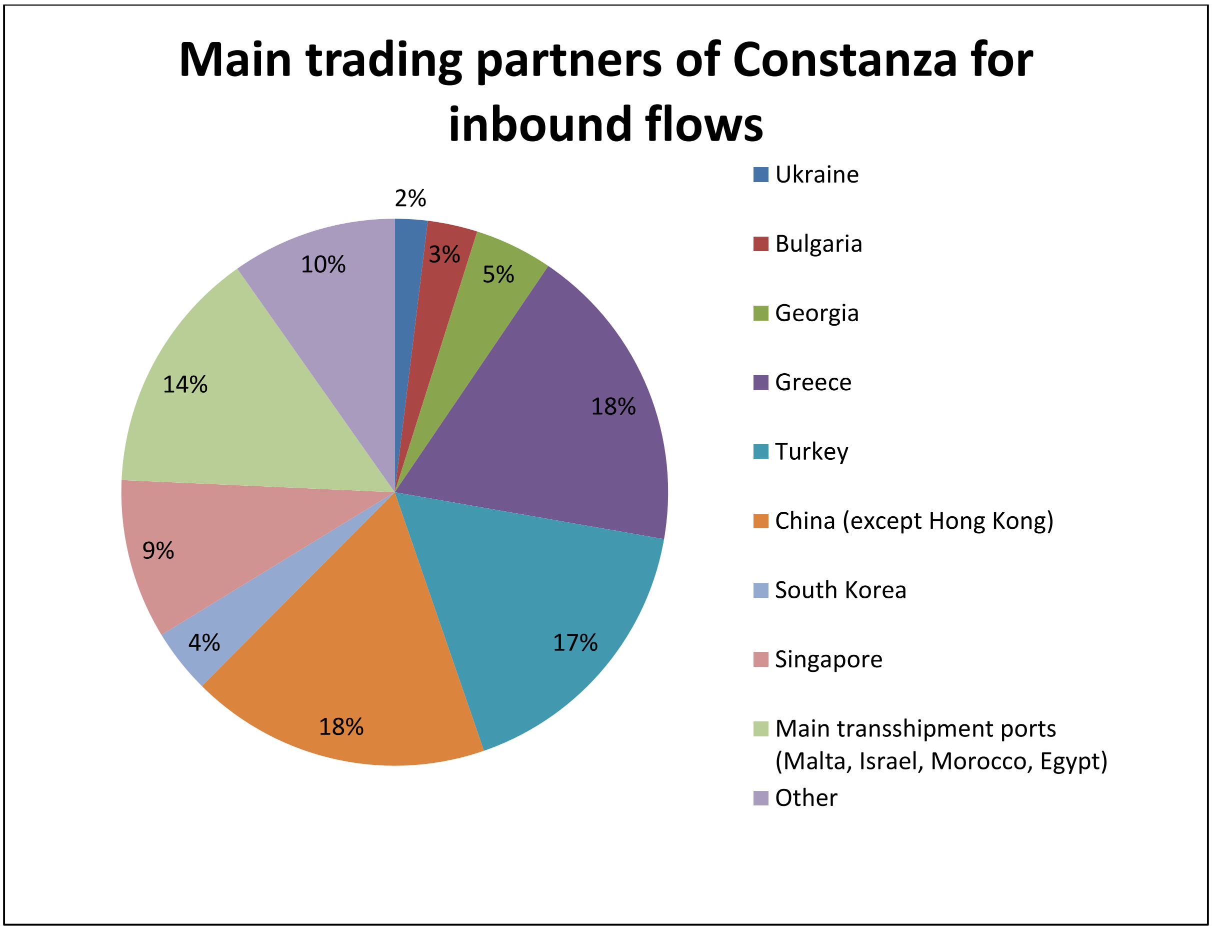

Figure 3: Port of Constanza main maritime partners for inbound containers in 2013

(Source: Compiled from Eurostat: mar_go_am_ro dataset)

The port of Piraeus has grown as the second most important partner port in terms of throughput from 2009 until 2013. In 2009 there was no connection between Greek ports and the port of Constanza. Following the opening of the Piraeus Container Terminal on Pier 2, the throughput of the port of Piraeus has increased exponentially and so have cargo volumes to Constanza. This development pattern of the Constanza's trade relation to Piraeus suggests that, most likely, the latter acts as purely as a transhipment hub for Asian cargo bound for Constanza and not for cargo originating from Greece.

The relatively low share of Asian ports in the total inbound port throughput is in line with what is observed at neighbouring Black sea ports. In Burgas, around 90% of the container throughput comes from Turkish or Greek ports, mainly from Ambarli and Piraeus, while in Varna, 59% of the cargo comes from the two previously mentioned ports.

The distribution of cargo origin patterns for Constanza suggests that even with direct connections offered by shippers from Asia to Constanza, the greater economies of scale offered by the possibility of using unrestricted sized ships at other hub ports outweigh the larger time component the transhipment process involves.

Between 2008 to 2012, the two main ports feeding Constanza from the Mediterranean Sea, Piraeus and Ambarli have increased throughput from Chinese ports by 11 and 6 times respectively. While container flows in Constanza in 2012 have decreased to almost half their value in 2008, Piraeus has grown to 7 times the 2008 value and Ambarli has increased by 50 percent. We consider the failure of Constanza to capture increasing container trade with China as one of the main reasons behind the stagnation and eventual decline of containerised flows in the port. The export flows of Constanza were also affected by its declining cargo flows. Trade with Russia and Ukraine, slacked during the mentioned period, while in Piraeus and especially Ambarli, trade with these countries increased also exponentially.

Hinterland connections

One of the competitive advantages for the port of Constanza is access to the Danube. The river provides navigable river access for cargo transiting the country bound for Western Europe. The Danube, starting from Kelheim until the Danube Delta over a length of 2415 km, is considered the Pan-European Transport Corridor VII. The river passes through 10 Countries and 4 Capital cities, Vienna, Bratislava, Budapest and Belgrade. The capitals represent large consumption centres in their respective countries and operate inland barge container terminals. A total of 73 Danube ports are present on the river, 16 of which are spread over the 1075 km span of the Danube in Romania (Corridor 7, n.d.).

Amongst the Romanian Danube ports, container handling equipment is available in Galati, Braila, Drobeta Turnu-Severin and Orsova (Danube ports, n.d.) . The port of Giurgiu, located about 300 kilometres upstream on the Danube and 60 kilometres south of Bucharest, the Romanian capital, was the only one that handled container traffic in 2012 with 15.374 TEUs (Danube Traffic, 2013).

Furthermore, Constanza has direct access to the Danube via the Danube-Black sea canal (see figure 1). This 64 km channel reduces the travel distance needed to reach the Black sea by around 400 kilometres and makes the journey easier as it circumvents the Danube Delta which poses navigational hazard (Spulber, 1954). The Rhine-Main-Danube channel connects the busiest river in Europe in terms of cargo traffic, the Rhine, with the Danube, the second longest river in Europe, and creates a direct link between the North Sea and the Black Sea.

The road network that links the port of Constanza with the rest of the country has also undergone improvement in recent years. Construction of the A4 ring circumventing the city of Constanza and also the final kilometres of the A2 highway linking Constanza to the capital city, Bucharest, were finalised in 2012.

The railway inside the port has a combined length of 300 km and is linked to the national railways system. The artery linking Constanza to Bucharest measures 225 km and has also undergone improvements in order to allow freight trains to reach speeds of up to 120 km per hours, speeds that are the highest Romanian trains can travel on any railway sector.

Both the highway and the railway artery starting from Constanza are part of the Pan-European Transport Corridor 4 that stretches from the Czech Republic, crossing Austria, Slovakia, Hungary and splitting in Arad, Romania with one sector heading to Constanza through Brasov and Bucharest and the other sector heading to Bulgaria, Northern Greece and Turkey through Craiova and Sofia.

3.1.2 ROMANIA’S TRANSPORT INFRASTRUCTURE

Road Network

The current length on the Romanian road network is 16.550 km including highways, European express roads, and national roads. The length of the highway network is 550 km. The highway currently links the capital city of Bucharest with the large adjacent cities and also with the port of Constanza. Currently highway extensions are under way that would link Arad, one of the main land entry points of the country, with the rest of the highway network. The low level of road infrastructure development in Romania is an on-going concern that will be further analysed in Section 3.2.2.

Rail Network

Romania's standard gauge rail network stretches over 20.000 km from which 8.400 km are electrified (EUROSTAT, 2013). The main and most used rail lines are divided into nine main traffic arteries stretching 3.600 km that provide rail access to the most important locations of the country. In 2013, the Romanian railways handled a total of 233.000 TEU. This figure represents one of the poorest yearly performances of the Romanian railway operators as volumes heavily decrease from their peak numbers in 2006 when they topped 523.000 TEU.

The national railway operator of the country is CFR Marfa and is also the main operator in terms of cargo handled. It is not anymore the only operator on the market. The deregulation of the rail transport market paved the way for competing companies to offer their services using the existing infrastructure. Previous to Romania's entrance in the European Union, only 14 railway and infrastructure operators were registered in the country. The rail market deregulation meant that in the year when Romania joined the EU, no less than 55 new railway companies and infrastructure operators opened for business (EUROSTAT, 2013).

Inland waterway

The main inland waterway that connects the port of Constanza to inland destination is the Danube. There are a limited number of large European inland waterways. The Rhine and the Elbe are some that are worth mentioning.

Inland waterways are classified according to the type of vessels they can accommodate. For example, class VI waterways allow for convoys that vary from 95 to 280 meters, width ranging between 11.4 and 33 meters and depths varying from 2.5 to 4.5 meters while tonnages allowed vary from 3.200 to 18.000 tons. Class VII waterways can accommodate the largest types of push convoys of 275 to 285 meters in length, 33-34 meters in width and 2.5 to 4.5 meters in depth allowing ships up to 27.000 tons. The waterways are also required to provide a minimum of 1.2 meters of draught at all times (UNECE, 1996). The Danube is a class VI waterway for most of its length. Starting from Belgrade, the river is a class VII waterway. By comparison, the Rhine and Elbe are both class VI waterways for most of their length.

Even with a classification similar or even greater for a portion of the length than the Rhine, the Danube does not come close to it in terms of container traffic. The barge services linking Constanza to other destinations transport relatively small quantities when compared to the volumes posted by services on the Rhine or ports on the upper Danube. The Constanza – Budapest service posted in 2013 a volume of only 5.000 TEU, while the link with Giurgiu posted a volume of 15.000 TEU. By comparison, the largest inland port volume on the Rhine belongs to Duisburg with 2.25 million TEUs (Siedelmann, 2011) while Wien, one of the largest Danube ports posted a volume of 477.000 TEUs in 2012. A closer look at the reasons behind these differences given in Section 3.3.1.

3.1.3 CONCLUSION

The port of Constanza has the capacity to handle significant cargo flows, yet this capacity is currently unused to its full potential. The increase of volumes in the port was mainly due to the arrival of a new terminal operator, DP World that spurred volumes growth. In 2009 volumes fell by more than half. A closer look at the situation inside the port and the infrastructure surrounding the port yielded some potential reasons as to the causes of this sharp decrease. An important remark is that the direct access to a large navigable artery that should provide competitive advantage for the port as the river has the capacity to support containerised cargo flows between hinterland destinations and the port. The inland waterway link however is an alternative seldom used, meaning that a potential asset of the port is underutilised.

The port’s trade partners were analysed. The distribution of inbound cargo flows revealed dependence on the transhipment ports of Piraeus (Greece) and Ambarli (Turkey) with more than 35% of volumes coming from these ports and only 30% of cargo coming from direct Asia links. The cargo distribution patterns observed also in the neighbouring ports of Burgas and Varna suggest that Piraeus has taken the place of Constanza as a transhipment port for Black sea bound cargo.

3.2 COMPETITORS

An important part of identifying the competitive position of the port of Constanza and its potential to become a gateway port for cargo in South-East Europe the analysis of the competing ports in the region. This section will focus on presenting Constanza's main competitors.

The structure of the section is as follows. First, the ports' main figures are presented and discussed. Second, we conduct an analysis of the ports throughput relation to the country's GDP to illustrate the level of integration of the port in the country's economy, and third, we conduct an inland transportation efficiency analysis.

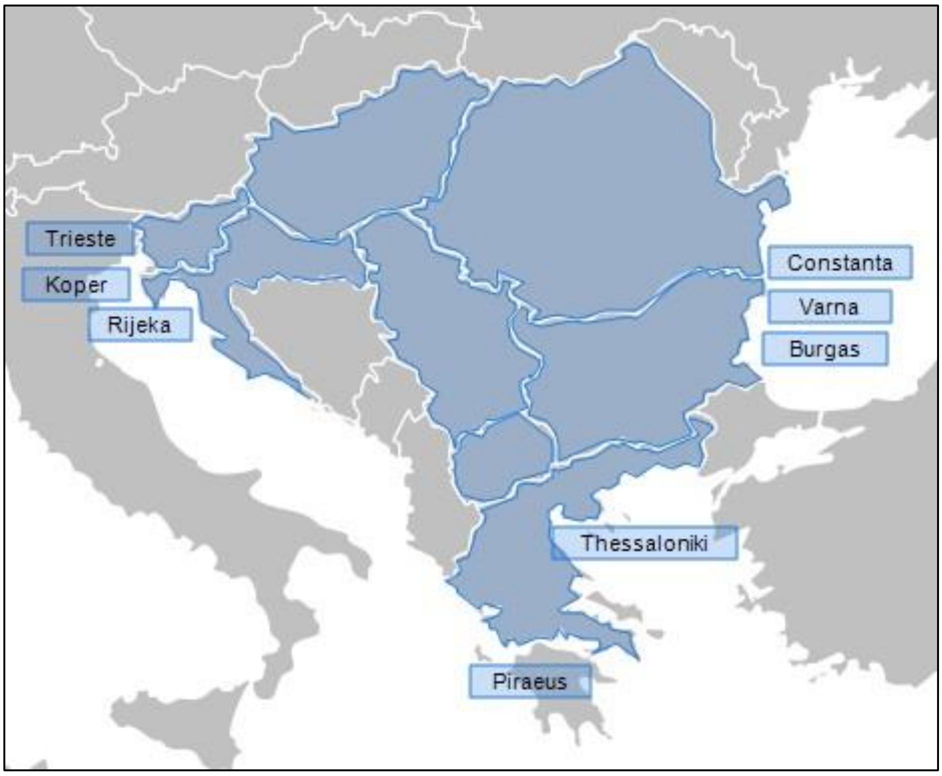

Figure 4: South-East Europe map with the countries and ports of interest highlighted

3.2.1. PORTS

The South-East European region as defined by the scope of this study is bordered on three sides by water. A large number of ports are present along the coast of the region. Narrowing down the number of ports was done according to a number of criteria. Ports that handled more than

20.000 TEU in 2013 were selected. This limit was selected as a number of small ports posted marginal container throughput figures and represented a small proportion of the country's container flows. Furthermore, the ports represent major cargo entry ports for the countries they are situated in and, with the exception of Trieste, all of them provide over 80% of their countries container imports and exports. The port of Trieste was selected due to the geographical proximity to the region, and has the potential to serve the same hinterland regions as the Slovenian port, Koper.

The selection yielded 7 competitors for Constanza in 5 countries: Varna and Burgas in Bulgaria, Thessaloniki and Piraeus in Greece, Koper in Slovenia, Rijeka in Croatia and Trieste in Italy. These ports were divided into three groups according to their coastal position respective to the South-East European region. Thus, the ports of Trieste, Koper and Rijeka represent the Adriatic ports. Piraeus and Thessaloniki represent the Aegean ports, while Burgas and Varna represent the Black Sea ports. Table 2 presents an overview of the facilities present on each port, while table 3 presents the volumes that the ports have handled over the past years and the shifts in market shares in the region.

Port range	**Adriatic Ports**			**Aegean Ports**			**Black Sea Ports**				
Port name	Trieste	Koper	Rijeka	Piraeus		Thessaloniki	Burgas	Varna		Constanza	
Total TEUs handled (2013)	458,497	596,430	112,876	2,302,943		264,240	48,935	131,454		659,375	
Container Terminal	Trieste CT	PA	Braidica CT	Pier I – PA	Pier II – PCT	PA	PA	Varna West	Varna East	SOCEP	CSCT
Nominal Capacity (TEU)	650,000	750,000	384,000	1,000,000	3,700,000	N/A	150,000	N/A	N/A	200,000	1,300,000
Maximum draft (meters)	18	13	14	17	16	12	11	11	8	13	15
Quay length (meters)	770	596	628	1,000	2,783	550	450	500	338	450	636
Quay cranes (gantry)	7	8	4	7	20	4	N/A	2	1	3	5
Asia- Europe links	2	2	2	N/A	N/A	N/A	N/A	N/A	N/A	0	2
Short Sea links	7	12	5	9		6	N/A	N/A	N/A	3	9

Table 2: Competing ports overview

Port name	2007	Share	2008	Share	2009	Share	2010	Share	2011	Share	2012	Share	2013	Share
Piraeus	1,383,831	34.90%	437,301	15.20%	667,135	29.76%	850,254	31.87%	1,680,856	43.00%	2,815,064	55.36%	2,302,943	50.88%
Constanza	1,444,655	36.43%	1,369,554	47.59%	584,458	26.07%	546,056	20.47%	653,306	16.71%	675,403	13.28%	659,375	14.57%
Koper	306,942	7.74%	356,885	12.40%	334,317	14.91%	480,981	18.03%	586,913	15.01%	556,392	10.94%	596,430	13.18%
Trieste	121,689	3.07%	147,383	5.12%	156,219	6.97%	261,055	9.79%	409,979	10.49%	427,139	8.40%	458,497	10.13%
Thessaloniki	459,920	11.60%	242,041	8.41%	264,014	11.78%	289,224	10.84%	327,061	8.37%	359,260	7.06%	264,240	5.84%
Varna	100,370	2.53%	154,304	5.36%	112,469	5.02%	118,863	4.46%	122,881	3.14%	128,390	2.52%	131,454	2.90%
Rijeka	148,161	3.74%	170,388	5.92%	123,373	5.50%	121,091	4.54%	128,390	3.28%	123,549	2.43%	112,876	2.49%
Burgas	31,200	0.79%	46,559	1.62%	23,909	1.07%	23,565	0.88%	29,325	0.75%	46,007	0.90%	48,935	1.08%
Total	3,965,568	100%	2,877,856	100%	2,241,985	100%	2,667,524	100%	3,909,386	100%	5,085,197	100%	4,525,815	100%

Table 3: Port throughput and market shares between 2007 and 2013 (in TEU)

Port name	Port range	Total TEU 2004	T/S TEU 2004	T/S %	Total TEU 2008	T/S TEU 2008	T/S %	Total TEU 2012	T/S TEU 2012	T/S %
Piraeus	Mediterranean	1,541,563	790,822	51.30%	433,582	35,554	8.20%	2,734,004	2,187,000	80.00%
Constanza	Black Sea	386,368	154,547	40.00%	1,380,935	1,036,000	75.00%	684,059	170,000	24.90%
Koper	Mediterranean	153,347	0	0.00%	353,880	0	0.00%	572,263	0	0.00%
Trieste	Mediterranean	174,729	0	0.00%	335,943	0	0.00%	408,023	0	0.00%
Thessaloniki	Mediterranean	336,069	n/a	n/a	238,940	n/a	n/a	317,751	n/a	n/a
Varna	Black Sea	78,598	n/a	n/a	154,304	n/a	n/a	128,390	n/a	n/a
Rijeka	Mediterranean	-	n/a	n/a	170,388	n/a	n/a	123,549	n/a	n/a
Burgas	Black Sea	26,636	n/a	n/a	46,559	n/a	n/a	46,007	n/a	n/a

Table 4: Transhipment (T/S) incidence at selected pots (2004-2012)

Source: Notteboom et al., 2014

Competition types

Although all the ports in this study handle various volumes of containerised cargo, we can classify the cargo according to its destination: Cargo destined for the local economy (or "primary hinterland"), cargo destined for the port's extended hinterland and transhipment cargo. We will classify Constanza's competitors according to these three categories.

Primary hinterland

The first category represents cargo destined for the local economy. This "primary hinterland" represents the regions where the port enjoys dominant competitive advantage and is able to offer reduced transport costs (Morgan, 1951). Identifying the regions where the port can offer reduced generalised transport costs is not straightforward. The competitive advantage of the port can be also affected by Europe wide agreements such as the Schengen area, or by commercial and political relations between countries. One example of the primary hinterland of the port is the region in which the port is situated. In these regions, the ports can offer a transport cost that cannot be matched by competitors due to geographical proximity.

Extended hinterland

The second category of cargo is the one destined to the extended hinterland of the port. This can be considered the secondary hinterland, where more rival ports can offer competing services and no port has a dominant competitive advantage (Morgan, 1951). For this type of cargo, we divide competitors between the ranges where the ports are situated. The closest competitors for Constanza are the Bulgarian ports situated in the Black sea range Varna and Burgas. Both ports are still under government administration via their respective Port Authorities. The port of Burgas is the smallest port out of the ports considered, posting an annual throughput of 49,000 TEU in 2013. It is also the only port that does not have gantry cranes for loading and unloading operations and relies on traditional level lifting cranes.

Both Burgas and Varna are direct competitors for the port of Constanza for hinterland cargo due to the geographic proximity within the range. More detailed information about the two Bulgarian ports such as transhipment volumes or modal split of cargo destined for hinterland is unavailable. After taking a closer look at the concentration of containerised volumes in the

East Mediterranean region, we believe we can safely assume that the two ports handle a vast majority of gateway cargo and have limited transhipment incidence.

For hinterland destinations located further away from Constanza, the port faces more competitors from the adjacent port ranges. Trieste and Koper are the largest competitors in the Adriatic range and will be covered more in depth, as these ports are focused exclusively on gateway cargo and the have the largest number of hinterland links. These facts prompt us to consider them a larger competitive threat than Rijeka.

The deep draft of the Trieste container terminal would make it a very interesting and suitable candidate for shipping lines that have very large container vessels in their fleet. However, at close inspection of throughput volumes of the port, it appears that the advantage of the deep draught that the port can offer does not reflect itself in the containerised cargo volumes the port handles. The neighbouring port of Koper has a 5 meter lower draught available but handles 29% more cargo than Trieste.

This paradox can however be partly explained when taking a closer look at the rail links that the container terminal in Trieste offers. The main destinations the terminal offers rail services to are Germany, Austria and Italy, with weekly connections. Munich, Cologne, Duisburg, Wien and Linz are each serviced by shuttles departing 5 times per week. For Hungary and Czech Republic, only 7 and 10 shuttles respectively are available. The large demand in Germany and Austria also entails high competition. De Langen (2007) identifies no less than 6 potential suppliers for Austria, including Trieste and Koper. The other 4 competitors are the northern range ports of Rotterdam, Antwerp, Bremen and Hamburg. Apart from the multitude of port calls the northern range ports offer, surpassing the ones from Trieste and Koper, the study identifies differences in port infrastructure, hinterland infrastructure and efficiency in favour of the former competitors. Furthermore, the main cargo type handled in Trieste is liquid bulk, and especially crude oil which amounts to 36 million tons from a total of 49 million tons of cargo handled. This may imply that containerised cargo has a secondary role in the port's priorities.

Another interesting observation about the two ports is that Koper and Trieste do not handle any transhipment volumes. The two ports are strictly focused on cargo destined for the local economy and cargo destined for the extended hinterland. This is an aspect strengthens the two ports' competitive position in relation to Constanza. The focus of the two ports on gateway cargo means that the hinterland connections are well developed. No less than 29 weekly rail departures are offered by both ports (Intermodal Links, n.d.) towards destinations in Austria, Czech Republic, Hungary or Germany (that the ports essentially share their hinterland connections as the distance between the ports is less than 30 kilometres). Compared to Constanza's by-weekly rail shuttle towards the western regions, the advantage is evident.

Transhipment

The third and last category of cargo we focus on is transhipment cargo. This category of cargo is delivered to the terminal by ocean going vessels sailing on established trade routes and is then transferred by lower capacity vessels to the final port of discharge. This operation is more time consuming than providing a direct call from a main vessel, but can offer the advantage of increased delivery frequency and economies of scale. The information related to transhipment volumes at each port can be observed in Table 4.

The port of Piraeus is one of the ports that handle primarily transhipment cargo. Piraeus stands out with the largest throughput, more than 2.7 million TEUs in 2012 out of which 2.1 million TEU of transhipment. This makes it the largest port and the largest transhipment hub from the ports in our scope.

The situation at Piraeus changed radically over the past decade. Throughput at the port was in constant decline from 2003 onwards, falling from 1.6 million TEU in 2003 to 1.4 million TEU in 2007. From these volumes, 900.000 TEU were transhipment cargo in 2003 and about 500.000 TEU in 2007. Due to labour disputes related to the privatization of the Pier II terminal, throughput fell to 430.000 TEU in 2008 and transhipment volumes disappeared (Notteboom et al., 2014).Coincidentally, 2004 represents the year when operation started in Constanza's DP World terminal. This ensured that starting from a 40% transhipment incidence in Constanza translating into about 150.000 TEU, volumes topped 1.4 million TEU in 2008 with more than 1 million TEU of transhipment cargo.

In October 2009, the privatization of the Pier II facility was complete and COSCO Pacific, the sister company of COSCO Container Lines took over the terminal operations. Furthermore, 2009 marked the start of cargo throughput decline at some ports in the region. Constanza lost substantial volumes, as did Rijeka, Burgas and Varna. The throughput drop observed is believed to be due to the general economic slowdown observed worldwide. Container lines were obliged to look at more cost efficient solutions, thus a number of direct Asia links were cancelled (Notteboom et al., 2014).

A substantial role in the drop observed in Constanza can be attribuited to the opening of the Pier II terminal at Piraeus which caused a redesign of trade lanes in which cargo would be concentrated in Piraeus rather than Constanza. One factor influencing the redesign in favour of Piraeus can be the direct interest of COSCO in the financial performance of its sister company. Furthermore, COSCO is part of a shipping alliance in which it shares its vessels on four Asia-Mediterranean trade routes (K-line, 2014). This means that alliance partners would also shift volumes to the same terminal.

Discussion

On a European level, it is interesting also to notice the difference between North and South European ranges. While the Northern range ports cannot be split in transhipment or gateway hubs, as they generally fulfil both purposes, the situation in South Europe is different (Rodrigue & Notteboom, 2010). Here, ports are more radically defined with ports that have a very high transhipment incidence such as Algeciras, Gioia Tauro or Piraeus, and ports that have limited or no transhipment incidence such as Genoa, Trieste or Koper.

One conclusion that we can draw from the information at hand is that a relatively clear distinction can be made also between the ports in our list. Ports can be divided into those that serve a gateway purpose and the ones that share a transhipment purpose. Up until 2009 the latter position was occupied by Constanza and to a lesser extent by Piraeus, while from 2009 Piraeus became the sole transhipment hub per se. The former position is occupied by the rest of the ports in our list. Although we have limited information available about the transhipment incidence of Thessaloniki, Rijeka and the Bulgarian ports, we consider these ports as serving an almost exclusive gateway purpose. Since the concentration of transhipment flows is high only in a limited number of hubs, it is unlikely that these ports handle substantial transhipment volumes.

The second conclusion we have arrived at is that on a short and medium term, it is unlikely that the port of Constanza can achieve growth by attracting more transhipment cargo. If before 2009 it was one of the large transhipment hubs in the East Mediterranean region, after 2009 it lost this position. Although it retains about a quarter of its volume as transhipment cargo, the rest of the volumes are gateway cargo. Piraeus possesses several advantages, one of which is the central position with respect to the Black Sea and Adriatic Sea and the direct interest of carriers in the terminal's performance. Both advantages have assured its position as a central transhipment hub for the East Mediterranean region for the coming years.

3.2.2 COMPETITIVE POSITION ANALYSIS

This section will include the analysis of the integration of the port's activity with the national economy and also the evaluation of the South-East European countries infrastructure. Our aim is to answer the following questions: What is the degree of dependency of port and economic performance on a European level. How do the South-East European countries fare compared to the other European countries. Last, what is the infrastructure condition in the countries in South-East Europe compared to the situation observed in the major North European gateway countries.

Connection with national economy

An aspect that we focus on is the relationship between port throughput and the national economic output. Why is this relation interesting in our case? The dependence of port throughput on the economic output can be a signal of the level of integration of the ports current business with the economy. We believe that a high level of integration with the local economy is beneficial for the port. Our reasoning is as follows.

Containerised cargo can be divided into cargo destined for local economy, cargo destined for the hinterland and transhipment cargo. The demand for cargo in local economy is in direct relation to a country's GDP, which is a reflection of its economic and industrial performance. The economic component of the GDP is comprised of a number of industrial, social and financial factors. These factors, although interrelated, do show a degree of independence in the business cycles they are subjected to. As one economic branch suffers a decline, another one may grow. Serving a wide array of economic branches can provide stability in the port's volumes and revenues and also reduce uncertainty when planning future investments.

Transhipment cargo is the type of cargo that is almost entirely reliant on the port's endowments and less on the national development. Since this type of cargo typically spends a limited time on the terminal before being transhipped, the main factors of interest for carriers are the handling efficiency and price and the connections available. The limited requirements for transhipping cargo make this operating model easily reproducible by competitors. For this reason, transhipment cargo is a more volatile type of cargo.

Capturing demand from the port's hinterland requires a competitive advantage of the port over its competitors. A prerequisite for this is the infrastructure available to transport the goods on. The availability of infrastructure will be discussed in the next section in more detail.

Literature and data

The GDP - Port throughput relationship has been recognised in the literature in a number of occasions. Especially for forecasting purposes, GDP is a solid factor used for predicting port throughput (van Dorser, Vanoutive, De Langen).The economic rationale behind the dependence between the two variables is explained by van Dorser et al (2012).As port throughput is a function of exports and imports and exports and imports are fractions of consumption and production functions which are components of economic output of GDP. Other factors can be imports, exports or labour conditions (Zall 2021).

It is our belief that a high degree of connection with the local economy can help the port's business as economic downturns in one industry have diminished amplitude when included in the collection of factors that comprise the GDP. Furthermore, the main component of port throughput is the demand of physical goods (Zall 2021). An organic relationship of the port with the local economy can increase the chance that this demand is satisfied by the port.

We attempt to quantify the relationship between the throughput and economic output and identify differences between the South-East European countries that represent the focus of this thesis: Bulgaria, Croatia, Greece, Romania and Slovenia. The common factor that unites these countries is that they are served by one or two national ports that represent at least 80% of their annual throughput. Italy is singled out from the South-East European ports as the Trieste has a small contribution (between 5-7%) on the total throughput of the country.

The dataset used in this analysis comprises 24 European countries with yearly observations over 14 years, between 2000 and 2013. The dataset used can be consulted in Data Appendix 1. One drawback that we recognise is the short time span of the dataset, which can lead to estimation inconsistency. The length of time span included is due to the fact that almost half of the countries in the dataset do not have any reported containerised volumes before the year

2000. However, containerisation has seen different rates of adoption across the European continent, we believe that the time span chosen reflects current conditions. The data were extracted from the Eurostat database and contains throughput, GDP, import and export figures for the respective countries.

Estimation and results

Authors dispute the variable specification that does yield the best estimation in modelling the relation between throughput and economic output. Van Dorser et al. (2012) consider linear regression models in their paper. They use the indexed and logarithmic transformation and growth rates of the two variables in their proposed models. Vanoutrive et al. (2010) use GDP seasonally adjusted quarterly growth figures to identify the relationship between the variables. We have also chosen to compare the nominal values, the logarithmic transformation and the growth figures of the variables and identify the specification that yields the most accurate estimates. The Pearson correlation coefficient (Moore et al., 2011) between the GDP and Trade variables of 0.93 suggests that the two variables are highly correlated. Introducing two correlated variables in the regression would do little to improve the estimation results, thus the trade variable is not used for the estimations.

The estimation was performed using the linear regression method. Table 5 contains the explanation of the variables used. Three initial specifications were tested and compared with each other to determine which type of relation would be the best fit for the data available. The following three models strengthen the model that was found to provide the best fit for the data (Equation 4) by introducing additional control variables. The results for the first 5 equations are summarised in Table 6. Equation 6 includes the country binary variables. The estimation results are summarised in Table 7.

$$Throughput = \alpha + \beta \times GDP + \varepsilon \qquad (1)$$

$$\Delta Throughput = \alpha + \beta \times \Delta GDP + \varepsilon \qquad (2)$$

$$\ln(Throughput) = \alpha + \beta \times \ln(GDP) + \varepsilon \qquad (3)$$

$$\ln(Throughput) = \alpha + \beta \times \ln(GDP) + \beta \times \ln(trade) + \varepsilon \qquad (4)$$

$$\ln(Throughput) = \alpha + \beta \times \ln(GDP) + \beta \times \ln(trade) + \beta \times \ln(population) + \varepsilon \qquad (5)$$

$$\ln(Throughput) = \alpha + \beta \times \ln(GDP) + \beta \times \ln(trade) + \beta \times \ln(population) + D_{Rom} + D_{Bul} + D_{Cro} + D_{Gre} + D_{Slo} + \varepsilon \qquad (6)$$

Included factors	Regression variable name	Measurement unit
GDP	GDP	Millions of euros
Trade with other EU countries	Trade	Millions of euros
Country population	Population	Inhabitants
Country binary variable: Romania	D_rom	Binary variable that takes the variable 1 when observations refer to Romania and 0 in all other cases
Country binary variable: Bulgaria	D_bulg	Binary variable that takes the variable 1 when observations refer to Bulgaria and 0 in all other cases
Country binary variable: Greece	D_gre	Binary variable that takes the variable 1 when observations refer to Greece and 0 in all other cases
Country binary variable: Croatia	D_cro	Binary variable that takes the variable 1 when observations refer to Croatia and 0 in all other cases
Country binary variable: Slovenia	D_slov	Binary variable that takes the variable 1 when observations refer to Slovenia and 0 in all other cases

Table 5: Regression variables used for estimating Throughput to GDP relationship

One fact that captured our interest was the low explanatory value of Equation 2. When using nominal or logarithmic values, the GDP evolution could explain more than 50% of the variation in throughput while when using growth figures, it could explain only 13%. The answer became apparent when looking at the structure of the dataset. The GDP growth figures have a 0.046 average value and a standard deviation of 0.067. The throughput growth figures have a mean value of 0.086 and a standard deviation of 0.199. Approximately 200 observations stand between 0% and 0.1% of GDP growth.

A separate regression was ran that accounted only for the GDP growth figures that were larger than 0.1% or smaller than 0%. The model's GDP coefficient is positive and statistically significant at a 1% significance level. The R-squared figure improves from the initial 0.14 to 0.27, signalling that the additional variation in the data does add explanatory power to the model. The alternative specifications of the linear regression that we have estimated produce however more interesting results in terms of explanatory power. In particular, Equation 4 produces the most interesting results, especially due to the high explanatory power of the model.

Coefficients	Equation 1	Equation 2	Equation 3	Equation 4	Equation 5***
Intercept	651.47	0.0346	-3.421	-3.929	-2.888
t-stat	4.26**	2.68**	-11.89**	-13.49**	-4.64**
GDP	0.00374	1.097	0.846	0.313	0.435
t-stat	20.74**	6.82**	35.71**	3.08**	3.24**
Trade				0.594	0.584
t-stat				5.34**	4.48**
Population					-0.149
t-stat					-1.85
R-squared	0.5827	0.1407	0.8055	0.8238	0.8268
Adj. R-square	0.5814	0.1377	0.8049	0.8227	0.8251
F-test	430.15	46.5	1275.53	713.16	732.37
Observations	310	286	310	308	308

* significant at 5% significance level

** significant at 1% significance level

***heteroskedasticity robust error terms

Table 6: Linear regression results for GDP figures relation to port containerised throughput

We tested for homoscedasticity of the error terms for equation 5 and uncovered that the variance of the error terms was not the same. The Breusch-Pagan test yielded a chi^2 of 17.18 which leads us to reject the null hypothesis of homoscedasticity at a 5% significance level. We proceeded in using the heteroskedastic robust error terms for the equation. One important result was the decrease of the significance of population which crossed the 5% significance boundary and is not statistically significant in our model. Furthermore, the addition of the population has a marginal effect on the explanatory power of the model thus we decided not to include this variable in the subsequent attempts.

Van Dorser et al. (2012) report a coefficient of 1.19 for the GDP in their linear regression model using the logarithmic transformation of the variables. The model we estimated produced a coefficient of 0.8. The difference between the two coefficients is quite large. Containerisation is more prevalent in finite products rather than raw materials which could are more sensitive to economic swings. This should translate in a larger coefficient of the impact of GDP evolution on port throughput. In our estimation however, this is not the case, and we believe that there are a number of factors that can help explain this difference:

First, there are large differences between the levels of adoption of containerisation between countries. The European average stands at 168 containers per 1000 inhabitants. While countries like The Netherlands and Belgium lead the ranks by facilitating containerised flows for their neighbours, countries like the UK, which are more self-serving stand at 126 TEU per 1000 people. When compared to the levels seen in South-East Europe, the differences become striking. Bulgaria, Croatia and Romania stand at 23.7, 33.7 and 33.6 TEU per 1000 inhabitants while Poland, one of the largest countries in the European Union has 42.8 containers per 1000 inhabitants. This means that a vast majority of finite consumer goods destined for South-East Europe are not containerised and thus are not captured in the data that we have. Second, our study is focused on a limited time span of only 14 years, while the aforementioned study uses data that stretches over more than 65 years. It is a possibility that the increases in economic activity seen in the 50's and 60's across Western Europe have a strong impact on the estimation of Van Dorser while our estimation covers more recent times where economic growth of large magnitude are not a common occurrence.

Port economic integration for the five SE European countries

The objective of this analysis is to investigate degree of integration between the local economies and the national port's containerised volumes. In order to evaluate this, we include binary variables for each South-East European country included in our study. We consider that having a statistically different coefficient for the country variable can be interpreted as a different level integration between the country's economy and its port throughput when compared to the average of the other 19 countries in the dataset. In other words, a change in the control variables namely GDP and trade would have a larger or smaller impact ceteris paribus than the same change would have on the other countries in the dataset.

Equation 6***	Intercept	ln(GDP)	ln(trade)	D_Rom	D_Cro	D_Slov	D_Gre	D_Bulg
Linear coefficient	-3.419	0.126	0.749	-0.153	-0.994	-0.256	0.685	-1.005
T-stat	-11.96**	1.03	5.30**	-1.17	-10.21**	-2.13	4.26**	-14.66**
R-squared	0.8568	**F-test**		256.53				
Adj. R-squared	0.8535	**Observations**		308				

* significant at 5% significance level

** significant at 1% significance level

***heteroskedasticity robust error terms

Table 7: Linear regression results for GDP figures relation to port containerised

From the five binary variables included, Bulgaria and Croatia have negative statistically significant coefficients, while Greece has a positive coefficient. The interpretation of the binary variables values can be that for these three countries, the level of dependence of the country's economy and its ports is lower than the European average. We argue that a low level of integration with the local economy can be disadvantageous for the port's business. In the case of Bulgaria and Croatia, we can consider that the port serves a smaller part of the economy when compared to the average of the other 19 countries. Furthermore, heavy dependency on transhipment flows rather than hinterland originating cargo does not require the same level of hinterland infrastructure development. It does however leave the port susceptible to unexpected shifts of cargo flows to other marginally cheaper destinations. This can hamper planning for substantial development or maintenance investments.

Romania and Slovenia show however insignificant coefficients of the binary variable. Statistically, the relationship between GDP and port throughput does not differ when compared to the European level. This means that changes in the GDP and trade values of the country are expected to have the same effect on the port throughput as they would have in the other 19 countries in the dataset. In our view this can signal that the ports in Romania and Slovenia are well connected with the local economy.

Efficiency of inland transportation

Hinterland infrastructure does represent an important point of concern for shippers and forwarders together also with its quality. When considering alternative ports, the quality of hinterland connections and their number represents points of concern and can tip the scale in favour of certain ports. When questioned regarding the reasons for choosing a more expensive port for container transport to Austria, 67% of forwarders frequently mentioned quality of hinterland connections as reason for their port choice (De Langen, 2007).

The comparison between different countries infrastructure requires that figures are comparable. Therefore, the density of the highway and railway network measured in meters of track per square kilometre, are the first indicators used to evaluate countries' infrastructure.

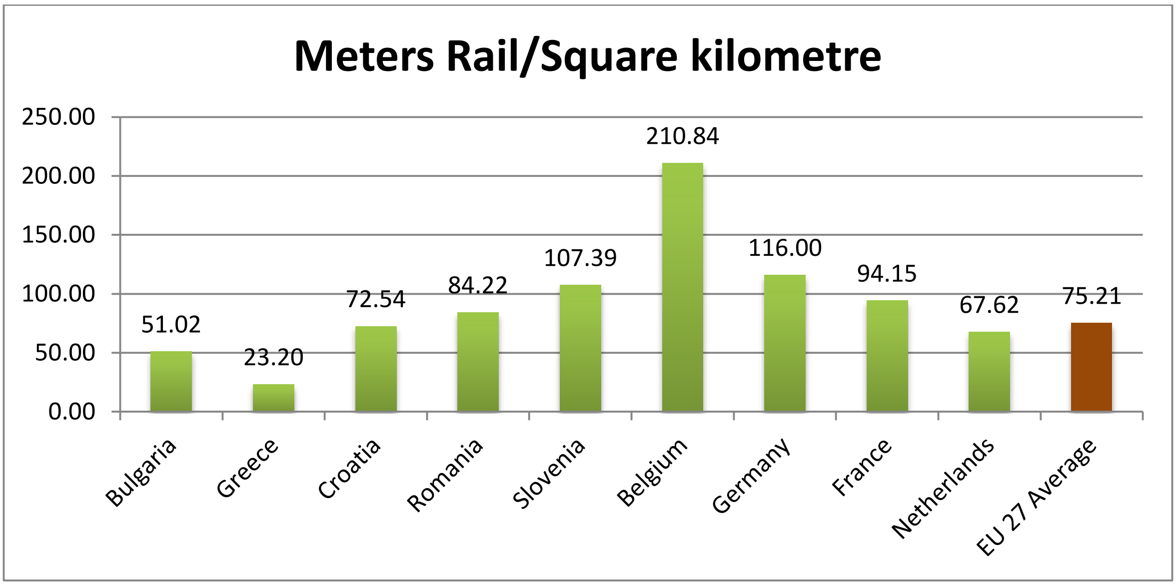

Figure 5: Railway meters per square kilometre per country in 2013

(Source: Retrieved from Eurostat rail_if_line_ga database)

Figure 5 shows the railway network density for the countries that operate container ports considered in this study, the density of the network in the main northern range countries and also the European Union average. One of the main observations is the low density that Greece' railway network. Greece's fragmented territory combined with over 80% of its land composed of mountains may be the reasons behind the low figure of the railway network density. On the opposing spectrum, Belgium leads European density figures with more than 200 meters of rail per square kilometre. The country's relative small surface combined with a large concentration of transport and logistics related activities have most likely been the drivers behind this extended development of the railway system.

The rail systems of Bulgaria, Greece and the Netherlands fall behind the European average. The low development of the Bulgarian railway is somewhat unexpected as it has a relatively milder terrain setting when compared to the other countries. Croatia, Romania and Slovenia have hilly and mountainous settings for more than 50% of their territories yet these countries have a higher rail network density. Such a low figure for Bulgaria can indicate a structural deficiency in infrastructure development and we consider this as a possible reason for which throughput figures in the country are lower than for neighbouring ports. For the Netherlands, we consider that the low numbers are not a because of lack of infrastructure development but are due to the fact that it has one of the largest population concentrations in Europe with more than 400 people per square kilometre (CBS, n.d.) which could have an impact on the concentration of economic development in the country and the efficiency with which the rail infrastructure is used in the country.

Railway density figures are also relevant when combined with railway usage for cargo transport. These data were extracted from the Eurostat database (EUROSTAT, 2013). From this perspective, the largest user of containerised cargo trains is Germany with around 6 million TEU on its railways in 2011. Netherlands, France and Belgium each transported around 1 million TEU each during the same year. In South-East Europe, Romania and Slovenia each handled around 350.000 TEU in 2011 while Croatia and Bulgaria handled 44.000 and 51.000 TEU respectively. Greece has no container transport by rail in 2011.

The figures presented require interpretation, as they do not necessarily show the distribution of cargo flows within the country. This is especially the case for Germany, where the high rail usage for containerized cargo contrasts with a much smaller infrastructure figure. In this case, the west of the county is more economically developed, especially in the Ruhr industrial area, and thus, a higher concentration of both railway infrastructure and containerised cargo flows is expected in that part of the country compared to the other regions.

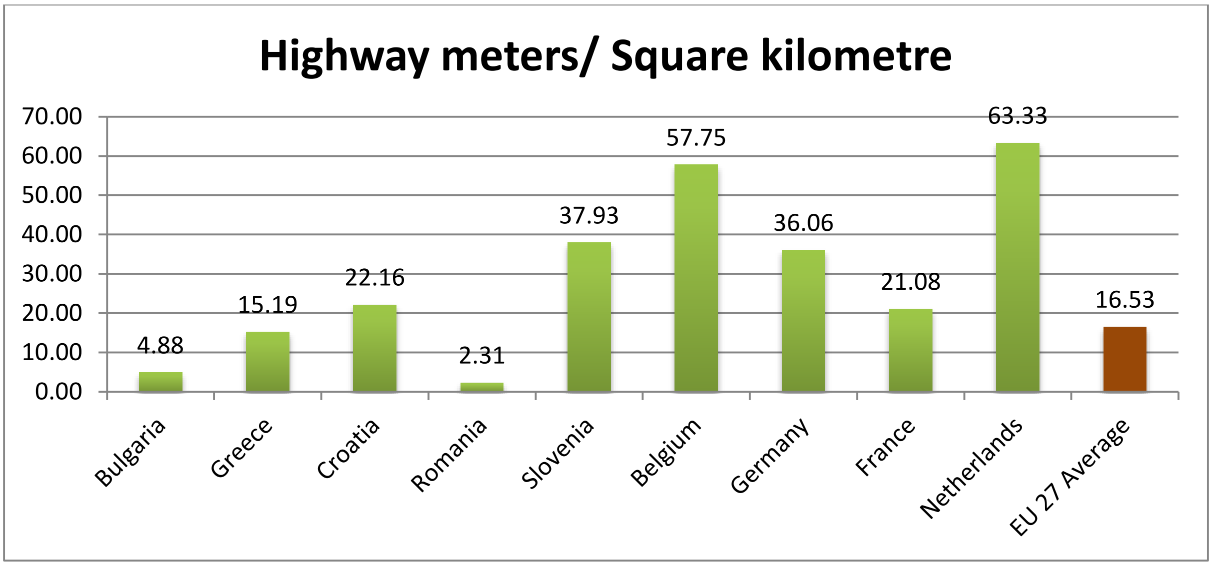

Figure 6: Highway meters per square kilometre per country in 2013

(Source: Compiled from Eurostat road_if_roads databse)

As in the case of the railway network, the highway density is also analysed. The West European countries show some of the highest densities of road networks in Europe with Netherlands and Belgium reporting more than 55 meters of highway per square kilometre. Figure 6 creates a clear picture of the road infrastructure development in the selected countries. France displays a different pattern with a lower density per square-kilometre. However, the country has the largest national road network from any European country, with more than a million kilometres or roads. This suggests that, in the case of France, the highway density does not present the full picture.

Among the countries in South-East Europe, Bulgaria and Romania stand out with the smallest highway density. The mountainous terrain can no longer explain the lack of highway development as Greece and Croatia show relatively much higher densities. From 2003 to 2012 the Romanian and Bulgarian highway network was lengthened by 0.18 meters per square kilometre, whereas in neighbouring countries such as Slovenia this figure stood at 1.44 meters per square kilometre and in Hungary it was 1.04 meters per square kilometre. In our view the extremely low pace of highway development in Romania and Bulgaria is due to deficiencies in infrastructure development and could be a potentially impeding factor of faster development of containerised road transport.

The highway infrastructure development indicators depict a clear image of the European situation. However indicators cannot capture the entire infrastructure development picture of a country. There are a few reasons for this statement that will be presented below.

The existence of railway and roadway are not the only prerequisites for container transport. One example is that of Romania, where an interview with a freight forwarder brought to light new aspects of road container transport. One of which is that some containers that arrive in the port of Constanza, heading for national and international destinations, are unloaded in the port and their cargo moved into as standard truck trailer. The operation is performed on the terminal with the help of cranes and this ensures that containers remain on port premises. We believe there are a few reasons that led to the appearance of this situation: (1) the relatively low labour cost available in Romania ensures that labour time spent on moving goods from the container into a standard trailer is inexpensive compared to the alternative options; (2) flatbed trailers able to handle containers are in short supply, allowing road haulers to charge for a premium for container transport. In most cases, this premium can rise to 20-30% over the standard kilometre freight rate; (3) some road hauling companies that offer the container transport service will also charge for the empty return trip because they consider it is virtually impossible for them to find a return fare.

The density of rail and road infrastructure takes into account the length of the network irrespective of their actual capacity. Furthermore, indices such as density do not contain information regarding the quality and continuity of the infrastructure. For example, in Romania the highway network is under expansion, but the completed highway segments may not be adjacent. In this case, the expansion of the network cannot achieve its full planned potential. An indicator that accounts for the finer differences of infrastructure development may reveal a deeper gap between the developed and developing countries.

One such index is the World Bank's Logistics performance index. This index ranks countries on a scale of 1 to 5 (with 1 being the worst possible choice and 5 the best possible choice) on six dimensions of trade. These are customs performance, infrastructure quality, ease of shipping arrangements, quality of logistics services, tracking and tracing and timelessness. Ranking is done by surveying logistics professionals about the foreign countries they operate in (World Bank, 2014).

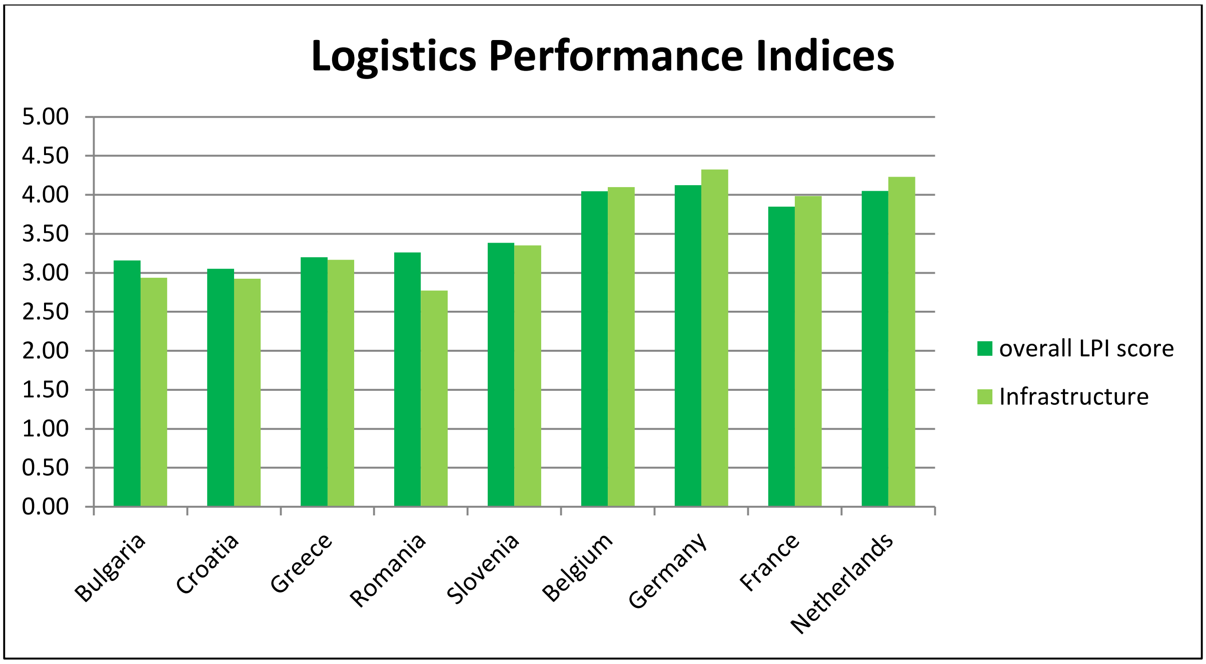

Figure 7: Logistics performance indices for 2014

(Source: World Bank, 2014)

The absolute leaders of the logistics performance index for 2014 are Germany, Netherlands and Belgium in this order. A similar standing holds for infrastructure where Germany and Netherlands also score the top two places while Belgium is on the 8th place. These countries typically tend to score better at infrastructure development than the overall index. For the South-East European countries, the opposing statement is true, as the LPI is usually higher than the infrastructure development index. Romania scores significantly lower in terms of infrastructure when compared to the selection of countries. The deficiency previously identified in highway density in the country is most likely one of the reasons for the relatively low score that the country has in that section.

3.2.3 CONCLUSIONS

The competitors of Constanza have been divided into three categories to clearly illustrate the challenges the port is currently facing. The port competes in attracting cargo for local economy, cargo for its extended hinterland and transhipment cargo. The first two categories are difficult to separate because of the multitude of factors involved. The main competitor for transhipment cargo is Piraeus, which handled in 2013 half of the region's cargo out of which 80% was transhipment cargo. Piraeus' main advantages are the favourable geographical proximity to main ports in the East Mediterranean region and the ownership structure which makes carriers directly interested in channelling volumes to the terminal. In light of these findings, Constanza's outlook for improving transhipment volumes for the near future has little chance of improvement.

Growth can be achieved by attracting gateway cargo or cargo destined for the local economy. Thus, we shift our focus from the maritime component to the hinterland component. Here we analyse the connection of the port to the local economy to determine the potential to satisfy local market demands and the infrastructure development to uncover the potential to serve the extended port hinterland.

Port throughput is influenced by the economic output of the country. We consider that the influence that the GDP has on containerised throughput is a proxy for the symbiosis of the two elements. The level of integration between the two varies between countries in the study. While for Romania, Slovenia and Greece, it does not significantly vary when compared to the average figures of the 19 European countries in the dataset, for Croatia and Bulgaria these figures vary significantly. This can be a signal that the ports in the later countries require a stronger focus on the national market to build up a solid and constant throughput. For the former countries, we view the results illustrate a solid relationship between the ports and the national economies which translates into a symbiotic evolution of throughput volumes and economic output.

Shifting the focus from the port to its hinterland, our analysis brought forth deficiencies in highway infrastructure development, especially in Bulgaria and Romania. Furthermore, the expansion rate for infrastructure is very low. On the other hand, railway infrastructure is relatively well developed in all the countries considered with the exception of Greece, where railway infrastructure is well below the average. Density indices do not provide a complete picture of the territorial distribution, actual quality of the infrastructure and its capacity. The economic and industrial concentration and development as well as terrain can be important determinants in the actual density of infrastructure. Moreover, existence of infrastructure is not a guarantee of usage. In some cases, a mix of factors such as the availability of cheap labour supply and the short supply of truck trailers can be factors that reduce the actual usage of container chassis, terminals or even inland container transport overall. To account for these factors, the logistics performance index was presented and analysed. Overall LPI scores do not vary significantly between the countries in South-East Europe putting all ports on a similar competitive level from this perspective. The infrastructure deficiency identified is however a factor of concern for the port of Constanza and will be further analysed to determine the impact an improvement on this point would have on port throughput.

3.3 IMPROVING CARGO FLOWS

Improvement of cargo flows can be achieved in two ways, either by attracting more transhipment cargo, or by attracting more gateway cargo. The ports of Piraeus and Ambarli have managed to secure the status as main transhipment ports in the Mediterranean (Container Insight, 2014). Thus, competing on transhipment cargo could prove to be a difficult task for Constanza. A healthy growth potential can be found in attracting cargo destined to South-East Europe.

In interview with Mr. Burgess (Strategic research manager at Panteia) regarding the Danube's modest container volumes it was pointed out that one of the main reasons behind the lack of container traffic on the Danube is the scarcity of options for transporting goods to inland destinations. It became apparent from the interview that, Constanza could achieve a stronger position as a gateway port by developing and maintaining infrastructure and by expanding its offer of inland transport services. Special attention needs to be paid to the immediate hinterland as a substantial amount of containers are usually delivered in proximity to the port (Notteboom, 2010). The question, however, is how to do this in the most efficient way.

This subsection is structured as follows: The first section raises a number of issues that, in our opinion, have a negative impact on the position of Constanza as a gateway port. The second section brings forth a series of possible solutions to the issues raised. Last, the third section presents the conclusions of the subsection.

3.3.1 MAIN ISSUES

The shortcomings presented below have been uncovered by comparing the literature on other ports with the factual data gathered from the port and its hinterland. Furthermore, the interview with Mr. Burgess raised a number of topics worth investigating. We arrived at two main issues that have a negative influence on the position of Constanza as a gateway port. These are:

1. The underused potential of the Danube;

2. The underdevelopment of transport infrastructure.

1. The underused potential of the Danube

The details presented in the previous subchapters regarding the Danube suggest that its size should be sufficient to allow for the development of containerised traffic. In 2010, an Austrian company inaugurated a weekly containerised barge transport service between Constanza, Belgrade and Budapest. This however lasted only until 2012 when the service was discontinued (Tita-Calin, 2012). Generally, inland waterway transport provides a low cost solution for inland delivery of goods (Rodrique et al., 2013). The Danube should be an advantage, both because it can offer a cheap alternative for inland transportation but also as an option value by offering flexibility to shippers. The port of Constanza does not exploit the full potential of the Danube. A number of reasons can stand behind the current situation.

One is the unpredictable water level of the river during the year. This can occur from insufficient river debit during warmer periods in the summer (Burgess, 2014). The Danube provides a fairway depth of 2.5 metres 314 days in 2012 (European Commission, 2014). For similar low water level situations occurring on the Rhine river, barge operators levy a low-water surcharge on the containers to make up for the lost cargo hold availability. If this were to be applied on the Danube, the comparative advantage of the barge would diminish over the other intermodal alternatives.

Second, the barge transport alternative does require quality in last mile transportation. Furthermore, inland waterway transport requires the availability of other intermodal alternatives. In times when the barge transport is unavailable, a reasonable alternative must exist for shippers to deliver their cargo to its final destination (Burgess, 2014). The quality of last mile transportation and the alternative intermodal options available are closely related to the development of inland transport infrastructure which represents the second discussion point in this section.

2. The transport infrastructure underdevelopment

Ports are integrated elements in supply chains (Tongzon, 2009). When a set of routing options is considered, although the port characteristics will impact the choice, the set will be analysed from the benefit it can deliver on the entire transport chain. From a supply chain perspective of ports, the hinterland infrastructure available from the port is of high importance.

Road transport remains the dominant transportation modality for freight in most European Union countries (Fuchs, 2010). The analysis performed in section 3.2.2 illustrated deficiencies in infrastructure development, especially in the case of Romania and Bulgaria. The lack of adequate road connections can have a negative impact on the cargo volume. Development of transport infrastructure is thus an important aspect in order to improve the position of Constanza as a gateway port.

3.3.2 RECOMMENDED APPROACH TO ATTRACT GATEWAY CARGO

For the issues that we have identified there we have a selected a number of approaches that have the potential to improve the cargo flows to and from Constanza.

1. Ensuring sufficient water levels on the Danube

The issue of maintaining the navigability of the Danube on a year-round basis has also come to the attention of the European Commission. On the 13th of November 2014, the Commission presented the strategy for the Danube region under the “Fairway Rehabilitation and Maintenance Master Plan”. The Danube flows through ten European countries and thus issues regarding river navigability are shared between the riparian states. Romania has the largest access to the Danube and shares maintenance responsibility with Bulgaria.

Ensuing sufficient fairway on the Danube requires a number of elements present and working together to achieve the maximum possible output of the investments made. The three main elements proposed in the Master Plan for the development of the Romanian section of the Danube are: monitoring, fairway dredging and information (European Commission, 2014).

Improving monitoring will provide more information regarding the current water level status and regarding the status of the riverbed. The equipment current available for monitoring is unable to cover the all the fairway sections that require regular surveillance. Insufficient information at this stage could lead to a wrong prioritization of the dredging tasks. Additional equipment must be purchased to ensure adequate river coverage.

The dredging stage is heavily reliant on the information provided from monitoring. It also relies on equipment and personnel available for the task. Additional dredging and signalling equipment must be purchased and made available for this stage of the project. At an administrative level, the public acquisition procedure requires simplification and standardisation of procedures for a more expedient delivery (European Commission, 2014).

The last element of the Master Plan is information. Forecasts for water levels must be publicly provided. These should also be made available to operators in a consumer-friendly manner. We believe that this last step would have a high impact on the importance of the Danube as a transport alternative. Regular forecasts would improve the ability of barge operators to plan the cargo that can be loaded on the vessel, thus avoiding delays due to unexpectedly low water levels. Furthermore, forecasts would give shippers and forwarders more time to react to changes by looking at other transport alternatives.

2. Highway network development focus

One of the issues identified in Section 3.2.2 in Romania and Bulgaria, is the lack of development of road infrastructure. Infrastructure development and quality were mentioned in the literature review as having an impact on the routing choice of shippers. Road freight has a considerable share in the cargo modal split. Our hypothesis is that increasing the highway infrastructure of the country will have a positive effect on the amount of cargo transiting the country. In order to test this, we analyse the evolution of two variables, the number of tons of cargo that transit a country and the density of the country's highway network measured in hundreds of meters per square kilometre.

Literature and data

The literature that is centred on infrastructure development is mainly concerned with studying its return on investment (Agbelie, 2014) or the close relationship that road freight has with the economic performance of a country (McKinnon, 2007, Banister & Berechman, 2001). The direct effect of highway density on transit cargo was not mentioned explicitly in the literature reviewed. Keeler et al. (1988) provide an ample economic explanation of the infrastructure density effect on traffic. Their paper underlines that the traffic handled by an expanded highway system is likely to increase in volume. The authors reason that development of the highway system reduces transit time which in turn reduces the transport cost. The cost reduction will be passed on to the users of the system, creating a comparative cost advantage for the road traffic.

This advantage leads to an increased demand in road services and thus increases the traffic in the system (Keeler et. al, 1988).

We chose the highway network as it is most frequently used for long transit voyages, as opposed to other types of roads, and the tons of transit freight per year as this value is influenced by the country's internal economic factors but also on the routing alternatives available and their quality. The literature examined uses GDP, trade figures and population in the analysis performed.

This analysis was performed on a dataset consisting of 22 EU countries that reported figures with EUROSTAT regarding their cargo flows, imports and exports using STATA 12 software. These countries are: Belgium, Bulgaria, Czech Republic, Denmark, Germany, Estonia, Spain, France, Croatia, Italy, Lithuania, Luxembourg, Hungary, Netherlands, Austria, Poland, Romania, Slovenia, Slovakia, Finland, Sweden and the United Kingdom. The infrastructure density figure, measured in kilometres of highway per 100 of square kilometres, was constructed by using the last reported highway measurement figure and dividing it to the surface of the respective country. The dataset can be found in Data Appendix 2.

Infrastructure and Transit cargo relation modelling

We applied a linear regression model and tested a large number of specifications. We will focus on a limited number of models that provide the most interesting results.

$$Transit = \alpha + \beta \times Density + \varepsilon \tag{7}$$

$$\ln(Transit) = \alpha + \beta \times \ln(Density) + \varepsilon \tag{8}$$

$$\ln(Transit) = \alpha + \beta 1 \times \ln(Density) + \beta 2 \times \ln(Trade) + \varepsilon \tag{9}$$

$$\ln(Transit) = \alpha + \beta 1 \times \ln(Density) + \beta 2 \times \ln(Trade) + + \beta 3 \times \ln(GDP) + \varepsilon \tag{10}$$

$$\ln(Transit) = \alpha + \beta 1 \times \ln(Density) + \beta 2 \times \ln(Trade) + + \beta 3 \times \ln(GDP) + \beta 4 \times \ln(Population) + \varepsilon \tag{11}$$

$$\ln(Transit) = \alpha + \beta 1 \times \ln(Density) + \beta 2 \times \ln(Trade) + + \beta 3 \times \ln(GDP) + \beta 4 \times \ln(Population) + cluster2.1 + cluster2.2 + \varepsilon \tag{12}$$

The first relationship tested was the direct transit cargo to highway density relationship. The relationship proved to be positive and statistically significant. The low explanatory value of the simple regression model (0.16) signalled that additional factors should be introduced to estimate the impact of infrastructure on cargo flows. Moreover, information from the literature consulted suggested that the relationship between the two variables can follow a non-linear pattern. For this reason, we estimated also the linear regression between the logarithmic transformations of the two variables. The relationship between the two variables remains positive and significant, but the R squared of the model increases to 0.36. We concluded that the logarithmic transformation provides a better estimation of the relationship between the two variables.

Furthermore, we investigated additional explanatory variables that could strengthen the model. The trade variable was included. This variable represents the value of all the trade relationship between the country and its partners. Further, the GDP value of the country was added in a subsequent model. One of the striking outputs of the estimation was the fact that the GDP influence on transit cargo was negative. We suspected that this is due to the high correlation between trade and GDP. However, since both variables are significant and result in an improvement of the R-squared we prefer equation 11 over the previous attempts. Table 8 illustrates the estimation results for the effect of highway density on cargo transiting the country.

Moreover we tested for the homoscedasticity of the error terms. We plotted the residuals from the equation to see the distribution of the error terms. The distribution is skewed towards the left. This suggests that one of the assumption of the regression equation is violated, namely the assumption of equal variance of the error terms. We tested for homoscedasticity by using a Breusch-Pagan test for identically and independently distributed error terms. The result ($chi^2 = 39.07$) led us to reject the null hypothesis of constant variance at a 1% significance level. Therefore, the robust command will be used for obtaining standard errors that are heteroskedasticity robust. This command has no effect on the value of the coefficients, however it is expected to change the significance of relationships.

Following similar reasoning for equation 12, we proceeded on testing for homoscedasticity for the model that includes the cluster dummy variables. The Breusch-Pagan test yielded a value of 31.54 that led us to reject the null hypothesis at a 1% significance level. This implies that standard errors that are robust for heteroskedasticity must be obtained.

Coefficients	Eq. 7	Eq. 8	Eq. 9	Eq. 10	Eq. 11***
Intercept	6169.457	8.474	4.153	1.795	-0.490
t-stat	3.49**	95.16**	5.12**	2.39*	-0.43
Density	4311.733	0.838	0.666	0.575	0.726
t-stat	6.67**	11.12**	8.55**	8.39**	7.60**
trade			0.3665	2.294	2.189
t-stat			5.35**	9.70**	11.22**
GDP				-1.691	-1.947
t-stat				-8.42**	-9.22**
Population					0.409
t-stat					2.69**
R-squared	0.1693	0.3618	0.4363	0.5757	0.5939
Adj. R-square	0.1655	0.3589	0.4311	0.5698	0.5863
F-test	44.43	123.61	83.96	97.68	102.77
Observations	220	220	220	220	220

* significant at 5% significance level

** significant at 1% significance level

***Equation 11 errors heteroskedasticity robust

Table 8: Linear regression results for highway density influence on transit cargo

Infrastructure impact differences

An aspect that was worth investigating was if the impact of additional highway was different between the countries that had different levels of development. We hypothesized that adding an extra kilometre of highway in developed countries from an infrastructure point of view will not have such a dramatic impact as adding an additional kilometre of highway in a country that is lacking infrastructure development. Moreover, a closer look at the data revealed cases in which growth of transit cargo was very high when compared to the highway density increase. Table 9 shows some examples of growth that surpassed the development in highway density.

Country	Density change*	Transit cargo change*
Czech Republic	+44%	+152%
Hungary	+174%	+68%
Poland	+237%	+84%
Romania	+386%	+81%
Slovenia	+61%	+205%
Slovakia	+34%	+74%

*increases are measured from the first year of observation (2003) to the last observation year available in the dataset (2012)

Table 9: Highest transit cargo changes coupled with infrastructure density changes

It is important to highlight the very high infrastructure density changes that occur for Poland and Romania. From 2003 until 2013 the highway density increased by 237% and 386% respectively. These figures are striking but fail to divulge the full picture of infrastructure development in the two countries. In 2003, Poland had a highway network that measured 405 kilometres, while Romania had 113 kilometres available. Put into perspective, Italy, a country with a similar surface as the previous two countries, had in 2003 approximately 6.500 kilometres of highway. As the differences between the countries become apparent, so does the need to divide the countries in the dataset in clusters that differentiate between economic development stages.

The identification of clusters in the data was not straightforward. The main issue with clustering data is determining the number of clusters in which to divide the variables. We suspect that there are differences between countries with low infrastructure and with high infrastructure development. However, it is possible that other factors contribute to these differences. For this reason we performed a k-mean clustering analysis, which uses an iterative refinement technique to identify clusters in the dataset (Verbeek, 2008). The data was clustered in 2, 3, 4 and 5 groups according to the GDP, population, infrastructure density and trade variables of each country. We estimated the regressions for each cluster and evaluated the coefficients and their significance in order to choose the number of groups for the final model. The resulting clusters and the results of each of the regressions can be found in Appendix 3. The estimation with 3 groups performed best and is discussed below.

The summary statistics for the three clusters that yielded from the cluster analysis are presented in Table 10. The groups are fairly similar in sizes, with the first group containing 2 more countries than the rest of the groups. Furthermore, there is a clear distinction between groups 2 and 3. While group 3 consists of countries that have the highest average GDP, trade and population figures. Furthermore, infrastructure and transit cargo figures are also the highest recorded in the data. Group 3 also consists of some of the largest and most economically developed countries in Europe such as Germany, France or the United Kingdom. On the opposite side, group 2 contains the countries with the lowest figures in all 5 categories. It also consists of some of the smaller countries in Europe, such as the Baltic countries, Slovakia and Slovenia. The rest of the countries form group 1. These countries show figures for GDP, trade and population that stand in between groups 2 and 3. An important observation is that the average infrastructure density figure is the lowest from all groups. A closer look at the countries that form this group can help explain why this is the case. Countries such as Finland and Sweden which are highly developed from an economic perspective do not have an extended highway infrastructure system. On the opposing spectrum, countries such as Romania and Poland are developing economies, thus the GDP and trade are lower also do not have well developed highway infrastructure.

Variable	**Group 1**			**Group 2**			**Group 3**		
	Obs	Mean	Std. Dev	Obs	Mean	Std. Dev	Obs	Mean	Std. Dev
Transit (1000t)	86	10,673.34	12,383.63	64	4,851.06	4,367.57	70	29,035.50	26,129.11
Density (km/100 sq km)	86	0.93	0.84	64	1.92	1.98	70	3.40	1.77
Trade (millions of euros)	86	149,229	62,000	64	28,819	11,334	70	761,796	428,135
GDP (millions of euros)	86	192,828	95,647	64	30,204	9,975	70	1,347,165	709,068
Population (inhabitants)	86	12,898,351	10,303,946	64	3,298,972	2,340,146	70	48,214,454	24,379,042

Table 10: Summary statistics for the three clusters resulting from cluster analysis

Results

Linear regressions with all the clustering alternatives were estimated. We will focus our attention on the estimation that uses the clustered data into 3 groups. The coefficients for the two groups are both positive and statistically significant when compared to the third group. Group 3 is composed from some of the European countries which have the highest developed infrastructure and economies. The linear regression estimations show that development of additional highway kilometres in countries from Groups 1 and 2 would have a greater impact on the amount of cargo that transits the country than additional infrastructure constructed in countries from the third group.

Equation 12***	Coefficient	t-stat	Group1	Group2	Group3
Intercept	-9.193	-4.67**	Austria	Bulgaria	Belgium
Density	0.879	8.05**	Czech Rep.	Croatia	France
Trade	2.451	11.88**	Denmark	Estonia	Germany
GDP	-1.835	-8.99**	Finland	Lithuania	Italy
Population	0.595	3.76**	Hungary	Luxembourg	Netherlands
Group1	1.483	5.98**	Poland	Slovakia	Spain
Group2	2.151	5.69**	Romania	Slovenia	UK
R-squared	0.629		Slovakia		
Adj. R-square	0.619		Sweden		
F-test	85.58				
Observations	220				

* significant at 5% significance level

** significant at 1% significance level

***Heteroskedasticity robust error terms

Table 11: Regression results with cluster binary variables

Discussion

Based on these our findings from the linear regression model, our recommendation is that road development investments be given priority in infrastructure spending. Although they are not the single determining factor in the routing road cargo, they are a prerequisite for the ability to have this type of transportation in the first place on the country's territory. Agbelie (2014) finds also that spending in infrastructure does return in the shape of economic growth. The models estimated in the paper show a positive and significant impact of infrastructure spending.

3.3.3 CONCLUSIONS

The throughput of Constanza can be increased by attracting cargo destined towards the hinterland of the port. This cargo does however require sufficiently developed infrastructure. A strong emphasis should be placed on developing the national highway network, as facilitation of goods flow inside the country can reduce transport costs and in turn encourage usage. The analysis performed on 24 European countries revealed that the amount of transit cargo is influenced by the density of the highway infrastructure. Thus, highway network development should be a priority.

Furthermore, the Danube could provide a viable inland transport alternative. Currently it suffers from unpredictable water levels and by a lack of last mile transport alternatives. The need for maintenance works has been recognised also by the European Commission in the "Fairway Rehabilitation Master Plan". This project consists of three key elements that require improvement in order to improve the Danube's potential as a viable transport alternative. The focus of Danube investments should first fall on monitoring to improving the availability of actual and reliable information of water flows. Dredging would eliminate uncertainty in water flows and would ease transport planning. Finally, updated information on the river's state should be made available in an accessible format to encourage usage.

4. CASE STUDY: GATEWAY FOR SOUTH-EAST EUROPE

This chapter is centred on modelling cargo flows between the 8 ports and the South-East European hinterland. Our aim is to identify the factors behind shippers' port choice and their impact on the ports' market shares. The first section presents the evaluation of the research approach and the setup. The second section presents the findings of the research while the third section presents the conclusions drawn from this approach.

4.1 EVALUATION AND RESEARCH SETUP

The following section will provide an overview of the research approach of this study. Moreover it includes a detailed look at the methodology, the factors included in the analysis and the geographical scope and the description of the dataset.

4.1.1 RESEARCH APPROACH

This research follows the guidelines of the paper of Veldman and Bückmann (2003). Our aim is to illustrate the expected market share of the 8 ports included in our study by modelling a series of characteristics that are determined by the literature as having an effect on port performance. Modelling the expected market share will be performed with the help of the multinomial logit model. This approach is designed to explicitly deal with trade-offs between the quality of service and costs of service, and is thus a suitable alternative in studying port choice (Veldman & Bückmann, 2003).

We focus our study on the containerised flows between the major South-East European ports (Constanza, Burgas, Varna, Thessaloniki, Piraeus, Rijeka, Koper and Trieste) to the countries in the region. We chose containerized freight flows because, in general, the hinterland transport of containers is independent of the commodities stored inside. This allows us to gain better understanding of the factors behind port choice.

Containerization flows between the ports and countries on a sufficiently detailed level were unavailable on national statistics institutes databases or on European databases such as EUROSTAT. Thus, containerisation flows were modelled from commodity flows using the probability of containerisation per commodity. The probabilities are derived from the literature and permit the recreation of estimated container flows between the ports and the hinterland regions.

The main focus falls on the hinterland transport part. The maritime leg of the journey has been included in the form of a variable containing the deviation from the main trade lane. The main assumption behind this variable is that the vast majority of the goods originate or are destined in a country that is served via the main Mediterranean trade route running from Gibraltar to the Suez Canal. For example, cargo originating in the Far East and Middle East will have to pass through the Suez Canal and then deviate from the main trading route in order to reach the destination port. Similarly, cargo originating from U.S. East Coast or South America will follow the trade route until Malta and thereafter will deviate from the trade route to the destination ports. The deviations from the main shipping route to the port of call originate from the literature (Notteboom & Dooms, 2014). In cases where the deviations were not readily available, they were calculated using an already known deviation for a port on the same coastline to which the port-to-port nautical distance was added.

In order to help explain the pattern of trade flows, a number of factors are included in our modelling approach. These factors are discussed in the following paragraphs.

Included factors

The following factors will be included in our analysis:

The first factor is the transport cost. This is widely mentioned in the literature thus it will be included in our analysis. The cost component is assumed as linear function of distance travelled. The terminal handling costs are included for each of the ports studied.

Second, the transport time factor will be included. Time is one of the main differentiating factors for the ocean leg and also for the inland transportation modal choice. The time difference in the ocean leg is not explicitly included in the transport time variable. Since the maritime deviation will be directly proportional with both the extra time required for the maritime leg and the extra cost, the diversion distance in nautical miles is used as a proxy for both the additional ocean transport time and the additional transport cost.

Third, infrastructure related aspects will be included. Port related issues fall under this category such as berths and cranes available. Moreover, a measure of port congestion will be constructed and included in the analysis. This will be evaluated by using the approach of Steven et al. (2012), using the ratio of containers loaded to the number of cranes. In the absence of data as to how long it takes to discharge containers from vessels and release them from the terminals, this variable will be used as a proxy (Steven, 2012).

Excluded factors

The decision whether or not to include the factors was mainly based on the availability of information and the ease of translating information into usable data. Among the factors that have been excluded we mention port efficiency, management type, location and labour issues, response to user needs, cargo damage reputation, accessibility and quality of service. In the absence of reliable data, variables containing the hinterland frequency of service and also the short sea frequency of service cannot be constructed.

Geographical scope

The geographical scope defines the countries considered in this study which are Macedonia, Serbia, Greece and the countries that have joined the European Union starting from the year 2004: Slovenia, Croatia, Hungary, Romania and Bulgaria. The eight countries are divided into NUTS 3 regions. In total, 212 NUTS 3 subdivisions are included.

The NUTS classification stands for Nomenclature of Territorial Units for Statistics (NUTS, 2014). This classification is a hierarchical system of dividing territories into administrative regions. The NUTS classification sizes the regions according to population thresholds. Thus, the NUTS 1 territories have between 3 and 7 million people, the NUTS 2 between 800.000 and 3 million and the NUTS 3 between 150.000 and 800.000.

Eight container handling facilities that currently handle volumes over 20.000 TEU per year are considered in our study. The ports of Volos in Greece and Ploče in Croatia handle containerized cargo, however the volumes handled in 2013 are between 11.000 and 14.000 TEUs. For this reason the two ports have been left out from the current analysis. The selected ports handle volumes that range from 49.000 TEU to approximately 2.3 million TEUs in 2013 (EUROSTAT, 2013). The selected ports are Burgas, Varna, Constanza, Thessaloniki, Piraeus, Rijeka, Koper and Trieste.

4.1.2 METHODOLOGY

In order to study the port choice, a multinomial logit model will be used. This type of approach is considered best suited to deal with trade-offs between costs and quality of service because of its configuration (Veldman & Bückmann, 2003).

The probability of cargo flows to be routed through a specific route, represented by maritime transport to harbor, mode choice for inland transit and transport to final destination, from a set of all possible routing is expressed as:

$$P_m(m = r | r = 1 \dots M) = \frac{e^{U_m}}{\sum_{r=1}^{r=M} e^{U_r}} \quad (13)$$

Where P_m is the probability of choosing routing m from all possible routings r and U_m is the utility attached to route m (out of a total of M routes) by shippers. The probability assigned for each port can be considered as the market share of the respective port with respect to all ports currently serving the region.

The utility function is a linear combination of factors for a particular route choice from the shipper's perspective. Rationality of choice is an underlying assumption in this model. Actors on the market are expected to choose according to the option that provides the highest overall utility. The utility function can be expressed as:

$$U_m = \alpha_1 \times C_m + \alpha_2 \times T_m + \alpha_3 \times M_m \quad (14)$$

Where Cm represents the transport costs for a specific routing *m*, T_m represents the total transportation time for routing *m* and M_m represents the maritime deviation distance for routing *m*. The literature also mentions a variety of factors such as reliability of service or the responsiveness to customer's demands. These factors cannot be easily quantified and aggregated for this analysis (Veldman & Bückmann, 2003).

Each of the routings is evaluated against a base routing in the respective region. All the regions served by the port of Constanza by truck represent the base routing. This choice was determined by the fact that Constanza serves the most hinterland regions by truck. In the cases where the hinterland region had no container flows to and from Constanza, a small probability was assigned for the route. Thus, the relative position of any one routing can be assessed against the base option. Equation 15 expresses the probability that a shipper would choose routing *m* over routing *n*:

$$\frac{P_m}{P_n} = \frac{e^{U_m}}{e^{U_n}} = e^{U_m - U_n} \quad (15)$$

Taking the logarithm of both sides of the equation and combining equations 14 and 15 results in:

$$Ln\left(\frac{P_m}{P_n}\right) = Ln\left(\frac{e^{U_m}}{e^{U_n}}\right) = \alpha_1 \times (C_m - C_n) + \alpha_2 \times (T_m - T_n) + \alpha_3 \times (M_m - M_n) \quad (16)$$

The logit function described above is based on the underlying assumption of Independence of Irrelevant Alternatives (IIA). The odds between any pair of alternatives do not change according to the total number of alternatives available. This is a strong assumption that, if violated, can decrease the efficiency of the modelling choice (Hill, et al., 2008).

4.1.3 DATASET DESCRIPTION

The dataset used was created by using a number of assumptions. As mentioned, data on containerised freight flows is not available. These data were compiled from a number of data sources.

Hinterland freight flows

The starting point of the dataset development was the ETISplus database (ETISplus, 2014). This contains observed and modelled freight flows between European regions. These data originate either from national or international reports to organisations such as EUROSTAT. The data are divided according to the mode of transportation, the direction of the flow (inbound or outbound) and according to NST2 commodity types. The freight flows are distributed on NUTS 3 territorial units.

For our study, origin and destination freight flows were extracted from the database for Bulgaria, Greece, Croatia, Hungary, Romania, Slovenia, Serbia and Macedonia. The flows of interest connected the hinterland regions with the regions where the main ports of the countries are located: Varna, Burgas, Thessaloniki, Attiki (region where Piraeus is found), Primorskogoranska Zupanija (region where port of Rijeka is found), Trieste, Constanza and Obalno-kraska (region where Koper is found). In total, the 8 ports and the 212 NUTS 3 hinterland regions create 1696 possible routing combinations.

All three inland transport modalities are included in the dataset. All of the ports have road access to all the hinterland regions in the study, yielding 1696 road freight OD patterns. This means that any region in our dataset can be reached from any port using truck. For rail, the number is reduced to 1505 combinations. This is because not all regions have access to a rail connection. The barge alternative is the one that shows the smallest number of possibilities, only 49. One of the reasons behind this is that in the South East European area, there is only on river large enough to accommodate constant barge traffic, which is the Danube. The Danube is also connected only with Constanza, as an origin port, and to destinations in Romania, Bulgaria, Serbia, Hungary and Croatia. The data regarding the availability of road, rail or barge connections between the regions and ports, the distance and transport speed were obtained from the ETISplus database (ETISplus, 2014).

The data is not categorised on whether it is containerised or not. For this reason, the probability of containerisation per commodity was used. For this purpose, the study of Dr. Hoffman was used (Hoffman et al., 2006). The study reports the probability of containerisation based on STIC, Revision 3, three digit commodity divisions. SITC stands for Standard International Trade Classification and it is used by the OECD for aggregating commodity flows for economic analysis and international comparisons (OECD -SITC, 2015). Commodities are classified into 10 main groups. Each group contains subdivisions that add another layer of detail to the commodity. For example, group 1 is Beverages and Tabacco which is then subdivided into group 11 Beverages and group 12 Tabacco. These groups are further subdivided and can reach a maximum of 5 digits. The SITC 3 classification takes into account only the first 3 digits or layers of detail of the commodities.

Containerisation probabilities are divided in three categories: high containerisation probability, medium probability and low probability. The excluded SITC categories are assumed not to be containerisable and have containerization probability of zero. These divisions are more detailed than the NST 2 classifications. Thus the SITC commodities had to be matched to the according NST 2 classification in order to be able to use these probabilities. Appendix 1 contains the correspondeces between the two classifications.

Following this transformation, the last step is the creation of a virtual container containing the commodities that are transported between destinations. An average weight of 14 tons net weight per container was assumed. This quantifies the freight flows in the number of containers transported.

We compared the resulting containerised flows with the real flows observed in at the ports. One of the issues identified was that the volumes modelled were substantially higher than the observed ones. Particularly the flows in the home region of the ports were extremely large, in some cases, making up more than 75% of the modelled flows of the port. One reason behind this is that the NST 2 goods categories contain a variety of goods under one category, some of which can be more prone to containerization than others. Second, we relied on the assumption that all the goods transported from the home region of the port originate from the port itself. We decided to exclude the home region of the port from our dataset. This is because the ports have a natural dominant competitive advantage in their regions.

The total flows originating from each port were compared and weighted against the real flows observed in 2010 for the respective port excluding the transhipment volumes. Two ports have a large proportion of their volumes consisting of transhipment cargo, Piraeus and Constanza. Both ports have approximately 50% of their cargo flows in 2010 consisting of transhipment cargo. These volumes were subtracted from the total port throughput, meaning the remaining throughput represents solely hinterland cargo. The remaining 6 ports are considered pure gateway ports with no transhipment incidence.

The observed hinterland flows were divided by the modelled throughput resulting in a correction coefficient. The coefficient was applied on the modelled throughput. This procedure ensures that the volumes of the hinterland regions remain anchored in the real figures.

Transport costs

We had access to a number of costs for some routings from several freight forwarders operating in the European territory. Data for all the routings in the study were unavailable, and thus had to be modeled. An average cost per kilometer and per transport mode was obtained from the available rates and applied to all routings.

This reduces considerably the advantage that the barge and rail alternatives have over road transport. In essence, by applying an average tariff over the distance that would be travelled, the rail alternative would always be cheaper than the barge. This would virtually eliminate the latter from the choice matrix. A closer look at the rates revealed that the barge option was indeed cheaper in some cases over the rail alternative. This meant that applying average rates would not be the optimal approach. The prices for rail and barge were regressed on the distance. The resulting coefficients represented the modeled fixed costs for each transport mode and the distance based cost. An allowance was added for the drayage from the terminals to the final destination. Detailed explanation on the transport costs used can be found in Appendix 4.

Hinterland transport time

The ETIS plus database (ETISplus, 2014) includes detailed transport time observations for each of the transport modes available on each of the routes in this study. The transport time is dependent on the transport mode, distance travelled and also on the infrastructure quality.

The transport mode influences the average transport time as different means have different speeds. Moreover, different means of transport must abide to national and international regulation. For example, truckers are only allowed to drive up to 10.5 hours with small brakes, after which they are obliged to take a sleeping break. This means that destinations situated further than the distance that can be covered by a trucker in one day will have much lower average speeds than distances that are closer. The maximum distance that can be covered in one day according to our dataset 750 kilometers. All destinations further than this see their average speed decreased. The average road transport speed in the dataset is 35.52 km/h. The average speed is 47.47 km/h for destinations closer than 751 kilometers and 28.19 km/h for destinations further than 750 kilometers. Figure 8 depicts the distances and associated speeds of the destinations in our dataset serviced by truck.

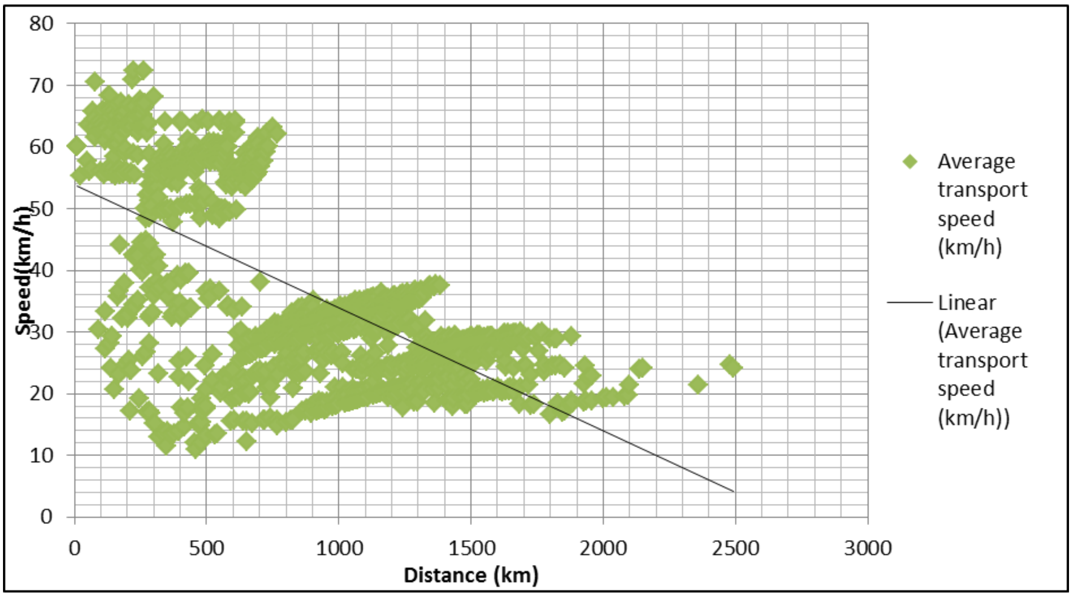

Figure 8: Road transport average speed (km/h)

Rail transport average speeds show the opposite behavior, as the average transport speed increases over the distance travelled. Rail transport average transport speeds gradually increase from a low starting point of only 13 km/h for distances smaller than 100 kilometers. The transport speed stabilizes around the value of 50 km/h for distances that are greater than 1000 kilometers. The average transport speed for all routings in the dataset is 44.11 km/h. Rail transport speeds and distances are illustrated in Figure 9.

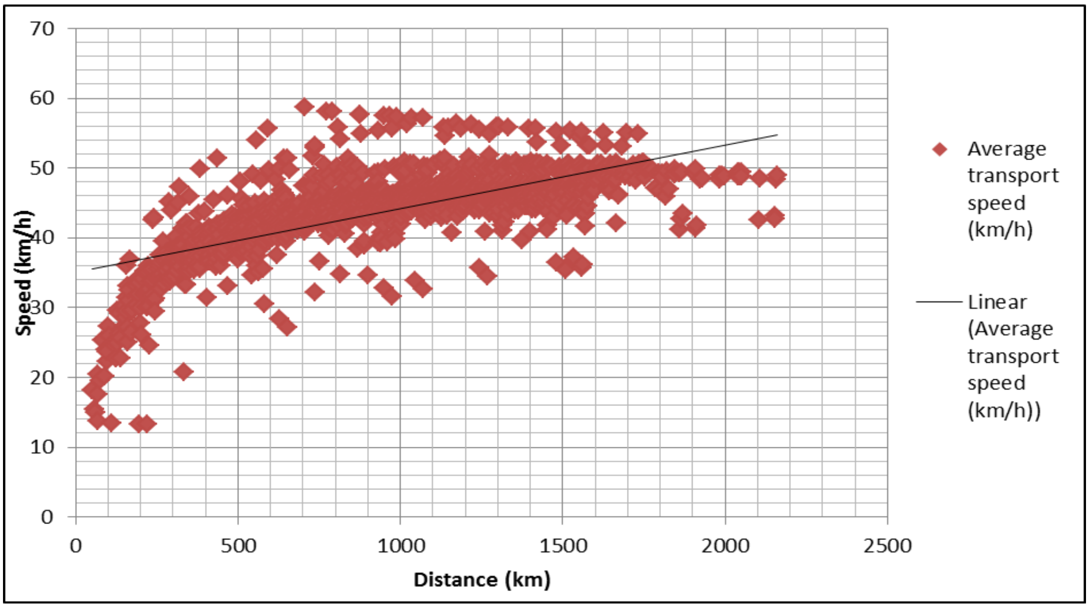

Figure 9: Rail transport average speed (km/h) excluding terminal waiting time

The barge average speeds vary between 7.1 and 6.5 km/h. Speeds are relatively stable around the 7 km/h mark until the 850 kilometer marker is reached, further they start steadily decreasing towards a minimum of around 6.5 kilometers. The decrease is due to the time taken to pass the locks at the Iron Gates power station and then further up the course of the Danube to other locks. The average speed of the barge transport in our dataset is 6.84 km/h.

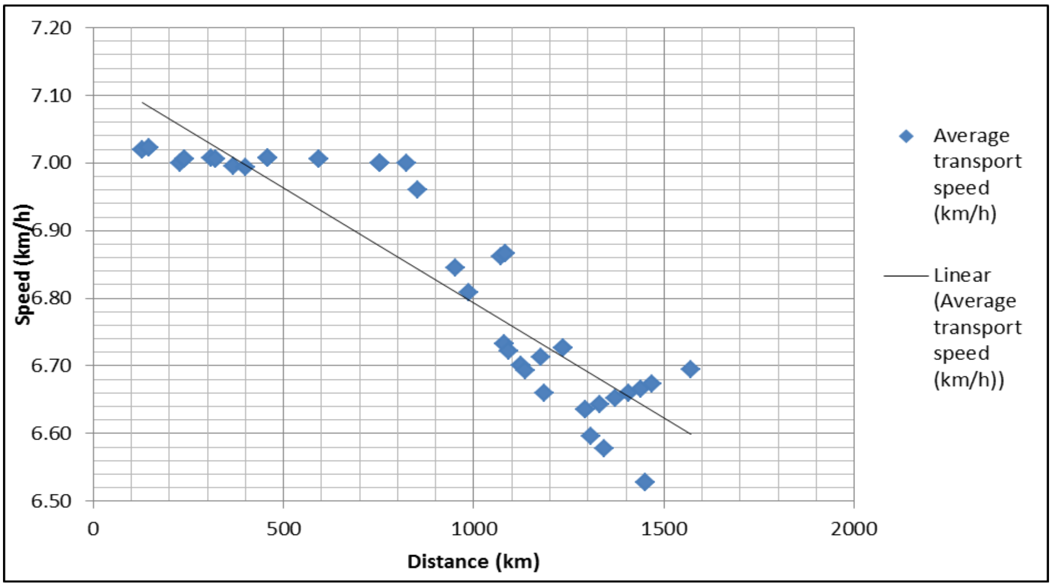

Figure 10: Barge transport average speed (km/h) excluding terminal waiting time

The infrastructure quality is also accounted for in the average speed data. For routings with the same distances, it is possible to have different transit times. This is expected as travelling on mountain roads allows for different speeds than travelling on straight roads and the speeds that can be reached on a highway are much higher and steadier than the ones reachable on national roads. This observation is particularly true for flows originating from Greece and Croatia that have much higher total transit times than other routings with similar distances.

Table 12 shows the influence of distance on the average transport speed split per mode. The coefficients correspond to the regression lines in Figures 8, 9 and 10.

Average Speed - Distance			
Coefficient	Road	Rail	Barge
Distance	-0.0199	0.009	-0.0003
t-stat	-33.01	36.1	-14.86
Constant	53.801	35.28	7.1319
t-stat	86.92	131.4	322.15
R-sqare	0.4006	0.474	0.8276
Adj. R-sqare	0.4003	0.4736	0.8239
Nr. Obs	1632	1448	48
F-test	1089.49	1303.09	220.88

Table 12: Average Speed - Distance relationship

On all rail and barge routings, the inland terminal handling time was also included. This was considered 24 hours for both modalities. Inland terminals were assumed to exist for all hinterland destinations in the dataset.

Relative market shares

The relative market share transformation represents the last step in preparing the dataset for running the regression models. The relative market shares are the dependent variables on which the influence of the independent variables will be assessed.

The relative market shares are determined by dividing the market share of the port in the hinterland region to the base market share (the market share of Constanza in the respective hinterland region). The base market shares vary from 0.0001 to 1. The former value was chosen as a minimum boundary to ensure that it is possible to assess the impact of independent variables even if no cargo flows are identified from Constanza and also to limit the number of extreme results.

These transformations yield a total of 1204 non-zero observations that will be used in the multinomial logit model. From these 974 represent truck routings, 208 are rail routings and only 22 are inland waterway. As expected, a number of regions in the proximity of the observed ports show very large market share when compared to Constanza’s market share. This is especially true for some regions in Greece which are almost entirely served by Piraeus or some regions in Croatia that are served by Rijeka.

Table 13 provides an overview of the variables used in our analysis.

Factors Included	Variable Name	Measurement Unit
Transport time	T_m	Minutes per trip (including terminal dwell time)
Transport cost	C_m	Euros per trip
Maritime diversion distance	M_m	Nautical miles distance from main trade lane
Hinterland mode: Rail	$\mathrm{D_{Rail}}$	Binary variable that takes the value 1 when rail is used and 0 in all other cases
Hinterland mode: Barge	$\mathrm{D_{Barge}}$	Binary variable that takes the value 1 when barge is used and 0 in all other cases
Crane congestion	$Crane\ congestion$	Throughput in TEU in 2013 divided by number of gantry cranes available at terminal
Terminal handling charge	THC	Euros per TEU
Maximum port draft	$Port\ depth$	Water depth in meters
Available berths	$Port\ berths$	Berthing space in meters
Same country shipments	$\mathrm{D_{Same\ country\ shipment}}$	Binary variable that takes value 1 when the origin and destination of a routing are in the same country
Terminal ownership: Shipping line	$\mathrm{D}_{Ownership(shipping\ line)}$	Binary variable that takes the value 1 when the terminal used is owned by a shipping line and 0 in all other cases
Terminal ownership: Terminal operator	$\mathrm{D}_{Ownership(terminal\ op)}$	Binary variable that takes the value 1 when the terminal used is owned by a terminal operator and 0 in all other cases

Table 13: Linear regression variables

4.2 MAIN FINDINGS

This main findings section contains the regression estimates, the result interpretation and validation of estimates.

4.2.1. MULTINOMIAL LOGIT ESTIMATIONS AND RESULTS

For the multinomial logit estimations we progressively introduced variables that impact the utility of the shippers for a certain routing. A multitude of models were estimated, however only the most interesting ones are mentioned:

$$\ln\left(\frac{P_m}{P_n}\right) = \alpha_1 \times \Delta T_m + \alpha_2 \times \Delta C_m + \varepsilon \quad (17)$$

$$\ln\left(\frac{P_m}{P_n}\right) = \alpha_1 \times \Delta T_m + \alpha_2 \times \Delta C_m + \alpha_3 \times \Delta M_m + \varepsilon \quad (18)$$

$$\ln\left(\frac{P_m}{P_n}\right) = \alpha_1 \times \Delta T_m + \alpha_2 \times \Delta C_m + \alpha_3 \times \Delta M_m + \alpha_4 \times \mathrm{D}_{\text{Rail}} + \alpha_5 \times \mathrm{D}_{\text{Barge}} + \varepsilon \quad (19)$$

$$\ln\left(\frac{P_m}{P_n}\right) = \alpha_1 \times \Delta T_m + \alpha_2 \times \Delta C_m + \alpha_3 \times \Delta M_m + \alpha_4 \times \mathrm{D}_{\text{Rail}} + \alpha_5 \times \mathrm{D}_{\text{Barge}} + \alpha_6 \times \mathrm{D}_{\text{Same country shipment}} + \varepsilon \quad (20)$$

$$\ln\left(\frac{P_m}{P_n}\right) = \alpha_1 \times \Delta T_m + \alpha_2 \times \Delta C_m + \alpha_3 \times \Delta M_m + \alpha_4 \times \mathrm{D}_{\text{Rail}} + \alpha_5 \times \mathrm{D}_{\text{Barge}} + \alpha_6 \times \mathrm{D}_{\text{Same country shipment}} + \alpha_7 \times \mathrm{D}_{Ownership(shipping\ line)} + \alpha_8 \times \mathrm{D}_{Ownership(terminal\ op)} + \varepsilon \quad (21)$$

$$\ln\left(\frac{P_m}{P_n}\right) = \alpha_1 \times \Delta C_m + \alpha_2 \times \Delta M_m + \alpha_3 \times \mathrm{D}_{\text{Rail}} + \alpha_4 \times \mathrm{D}_{\text{Barge}} + \alpha_5 \times \mathrm{D}_{\text{Same country shipment}} + \alpha_6 \times \mathrm{D}_{Ownership(shipping\ line)} + \alpha_7 \times \mathrm{D}_{Ownership(terminal\ op)} + \varepsilon \quad (22)$$

$$\ln\left(\frac{P_m}{P_n}\right) = \alpha_1 \times \Delta T_m + \alpha_2 \times \Delta C_m + \alpha_3 \times \Delta M_m + \alpha_4 \times \mathrm{D}_{\text{Rail}} + \alpha_5 \times \mathrm{D}_{\text{Barge}} + \alpha_6 \times \mathrm{D}_{\text{Same country shipment}} + \alpha_7 \times \mathrm{D}_{Ownership(shipping\ line)} + \alpha_8 \times \mathrm{D}_{Ownership(terminal\ op)} + \alpha_8 \times \Delta Crane\ congestion + \alpha_9 \times \Delta THC + \alpha_{10} \times \Delta Port\ depth + \alpha_{11} \Delta Port\ berths + \varepsilon \quad (23)$$

The decision to introduce an additional variable in the estimations was based on two criteria. First, the variable should be mentioned in the literature as potentially impacting port choice. Second, using the variance inflation factor (VIF) to identify multicollinearity between the variables. This provides a measure of the variance increase in the regression estimates that is due to multicollinearity between variables. It is determined by regressing the explanatory variables on each other and taking the inverse of the resulting tolerance (Kutner et al., 2004). An inflation factor greater than 10 signals high multicollinearity. If two variables exhibit high collinearity, adding them both to the regression will do little to improve the fit of the model. The results for the VIF estimations and an explanation of the process we followed to decide which variables would be included in the models tested can be found in Appendix 6.

Table 14 contains the results of the multinomial logit models estimations.

Coefficients	Eq. 17	Eq. 18	Eq. 19	Eq. 20	Eq. 21	Eq.22	Eq. 23
ΔTm	0.000716	0.000372	0.000927	0.000993	0.000842		0.000613
t-stat	8.5**	4.79**	6.54**	7.08**	5.92**		4.31**
ΔCm	-0.00524	-0.0047	-0.00616	-0.00596	-0.0055	-0.0037	-0.00489
t-stat	-22.04**	-21.91**	-17.77**	-17.33**	-15.97**	-20.25**	-13.75**
ΔMm		-6.363	-6.51712	-5.66772	-8.6843	-9.3303	-2.28183
t-stat		-17.63**	-17.97**	-14.7**	-13.3**	-14.29	-1.74
D Rail			-2.36156	-2.94026	-2.99239	-1.6075	-2.93537
t-stat			-6.8**	-8.25**	-8.55**	-6.08**	-8.18**
D Barge			-2.61301	-3.51471	-2.9796	2.0362	-1.40492
t-stat			-2.29*	-3.1**	-2.66**	2.75*	-1.16
D in country				1.501664	1.444617	1.3145	1.186003
t-stat				5.9**	5.77**	5.19**	4.69**
D Private(S comp)					-3.02126	-3.1577	6.770348
t-stat					-5.77**	-5.95**	2.05*
D Private(operator)					0.460561	0.7611	0.438828
t-stat					2.03*	3.40**	0.78
ΔCrane Congestion							-3.88688
t-stat							-2.01*
ΔTHC							-3.12156
t-stat							-0.93
ΔCranes							1.028143
t-stat							1.74
ΔPort Depth							-2.41611
t-stat							-1.42
ΔPort Berths							-3.65693
t-stat							-3.03**
R-square	0.3024	0.4458	0.4677	0.4827	0.5013	0.4867	0.5301
Adj. R-square	0.3012	0.4444	0.4654	0.4801	0.4980	0.4837	0.5262
F-test	260.48	322.02	210.66	186.29	150.31	162.15	134.72
Observations	1204	1204	1204	1204	1204	1204	1204

* significant at 5% significance level

** significant at 1% significance level

Table 14: Results of multinomial regression analysis

The first model includes the hinterland transport cost and hinterland transport time. The hinterland transport cost has a negative and statistically significant coefficient at a 1% significance level. This implies that an additional euro on the transport cost have a negative impact on shipper's utility for the respective routing. A lower utility means a lower probability that users will consider the routing versus the base routing. The time variable however has a positive value. This is somewhat unexpected since it would signal the preference of shippers for longer routings.

The R-square value of the first model is relatively low, meaning that additional variables could help explain the variation in the dependent variable.

The second estimation includes the maritime diversion distance along with time and hinterland transport cost. All three variable signs remain negative as anticipated and the model's explanatory power is increased to 0.44, meaning it can explain rougly 44% of the variation in the data.

The third step is the inclusion of hinterland transport mode binary variables. The binary variable for rail and the one for barge were both included. The model's R-square value has been increased and all coefficients are statistically significant at a 1% level. The signs of the previously included variables remains unchanged. Both rail and barge binary variables have a negative and statistically significant coefficient. These results suggest that shippers derive lower utility from shipments by the two modalities when compared to truck shipments. Lower utilities in this case mean that the probability of choosing the truck alternative is higher than rail or barge options.

One hypothesis we tested was that shippers prefer shipments to be discharged in the same country as their final destination. In order to test this, the subsequent model includes the binary variable for shipments inside the country where the port is located. This variable takes the value 1 when the shipment is performed inside the country of container discharge and the value 0 when containers cross borders. The variable has a positive influence on shippers' utilities. This result suggests that the hypothesis of routing preference within the country is correct and that if the port is situated in the same country as the hinterland region of destination, it has a higher probability of capturing cargo.

In the next model we tested, we included the port ownership variables. Ownership of ports in the dataset is divided into three categories. The largest category is of terminals operated by publicly owned port authorities. This includes Burgas, Varna, Thessaloniki, Rijeka and Koper. The second category includes terminals managed by terminal operators. This consists of Trieste and Constanza. The last category includes the terminals managed by terminal operators affilitated to shipping lines. The last category inlcudes only the port of Piraeus which is managed by COSCO Pacific Limited, a sister company of COSCO shipping line (PCT, 2015).

The coefficient for ports operated by terminal operators is positive and significant at a 5% significance level. This suggests that shippers have a preference for routing cargo through privately managed terminals when compared to publicly owned terminals. Furthermore, the coefficient for terminals managed by shipping lines is negative and significant. Shippers would derive lower utility from routing cargo through ports that are operated by shipping lines, thus decreasing the probability that the ports will be chosen.

In the following model, the transport time variable was exluded from the estimation. The positive coefficient of the variable raised some questions regarding the correlation of the variable with other explanatory factors. The remaining factors maintain their significance and their signs. Two notable exeptions are the transport mode binary variables. The rail variable maintains the negative sign, however the coefficient is smaller than in previous estimations. The barge variable switches sign altogether. Consequently the issue of the possible correlation between transport time and the other factors is addressed in the discussion section below.

The seventh model includes measures of port performance and infrastructure to the specification of equation 21. The terminal handling cost is included along with the available berths, cranes and water depth. Finally, a measure of congesion was included. All variables are in an indexed form. The maritime diversion distance looses its significance as does the binary variable for barge transport. Moreover, the binary variable for terninals operated by terminal operators also looses its statistical significance. Both the maritime diversion distance and the port ownership variables are port related factors. The VIF analysis illustrated that addional port factors such as water depth, berths, THC or other infrastructure factors do not significantly help the estimation perfomance since the variables are correlated.

The terminal handling cost variable has the expected negative sign, signifying that the increase in handling cost lowers the shipper’s utility. Moreover, the crane congestion variable displays the same sign. On one hand, it is expected that shippers desire limied exposure to congestion since congestion can affect the handling times of cargo. On the other hand, high levels of crane congestion can also be translated into high level of container handling efficiency, which is desired feature of ports, since container efficiency handling increase should translate into lower terminal handling times. In the absence of a standardised crane efficiency variable that could shed more light on which of the two characteristics has a more significant impact, we will consider that additional crane congestion negatively impacts the shipper's utility. The number of available cranes has a positive impact on shippers utility. The port depth and port berth values have a negative and statistically significant value at 1% significance level. This is somewhat unexpected since the additional depth of the harbour or berthing space available should be the signs of a larger port.

For all models we reported the R-squared and Adjusted R-sqared figures as measures of explanatory power of models. Explanatory power was one of the main deciding factors behind chosing to add another variable to the estimation and chosing between models. The F-test values were also included. The F-test is used to decide whether the model has predictive capabilities for the dependent variable or if the coefficients are simulatneously zero. The F-test values for all models are over the threshold in all cases. The null hypothesis is rejected, the models have predictive power for the dependent variable. The number of observations is lower than the total number of routings available. From the total of 3250 routing options, only 1204 are used by shippers.

The port related variables were also regressed on the other explanatory variables to determine the VIF. The VIF was found to be over 5 for these variables, signifying high multicollinearity between the variables. Although all port related variables were tested and found to be jointly significant meaning that port related factors do influence the shipper's utility. Including all variables in the estimation does not improve the model's explanatory power because of the overlapping information these contain. This can be seen from the differences in explanatory power of models 21 and 23. With the inclusion of the 5 additional port related variables, the explanatory power of the estimation increases from 0.498 to 0.526. Because of the mentioned reasons, model 21 is our preferred model.

Discussion

The hinterland transport cost and maritime deviation have a stable negative influence on shipper's utilities. This is consistent with findings in the literature. Our results suggest that additional spendings on transport reduce the share of the port when compared to cheaper alternatives.

The hinterland transport time coefficient shows a positive influence on port choice probability. The positive effect of the variable on shiper's utility indicate that additional time spent in transit would actually increase the proability that the respective port is chosen instead of alternatives that would offer shorter transit times.

One item of concern was that the hinterland transport time and transport cost were correlated. Both variables are derived from the distance travelled. In order to evaluate the relation between the two variables we estimated a number of models. The first includes all observations with their associated travel time and cost. The estimation produces statisticall significant coefficients, however it only manages to explain 12% of the variation in the data.

Coefficient	General	Only Truck	Only Rail	Only Barge
Transport time	0.0942	0.3181	0.2271	0.0247
t-stat	19.96**	85.17**	195.1**	212.78**
Constant	475.37	288.13	-119.24	206.81
t-stat	19.96**	85.17**	195.1**	182.80
Obs.	2924	1428	1448	48
F-test	398.44	7254.6	38062.62	45274.44
R-square	0.12	0.8357	0.9634	0.999
Adj. R-squared	0.1197	0.8356	0.9634	0.999

Table 15: Transport time influence on Transport cost

The perspective on the relation between time and costs changes if it is evaluated while taking into account the transport mode differences. The explanatory power of the models changes significantly, in this case, the transport time can explain between 83% and 99% of the variation in the data. The mode-dependent relation of time and costs is also illustrated in Figure 11. The slopes of the variables differ significantly as shown in Table 15 coefficients' values.

The high explanatory power of the regressions on transit time and transport cost show that the two variables are positively correlated. They also show that the degree of correlation is quite high. For our analysis, having correlated variables as explanatory factors is not a desirable feature because the effect each factor has on the dependent variable cannot be separated.

In reality, it is most often the case that transit time and transport costs are influenced by a common factor and have a similar behaviour, if one decreases then so does the other. One such factor can be the improvement of infrastructure quality. Another can be increase of infrastructure density. Both factors would have a negative effect on transit time as improvement of infrastructure quality allows for higher average speeds and increase of infrastructure density adds to the total network capacity. At the same time, a reduction in transit times would be directly translated into lower transport costs. The number of driving hours required to complete a delivery would decrease. Fuel consumption can be also positively influenced because of fewer kilometers travelled at slower speeds than the design speed.

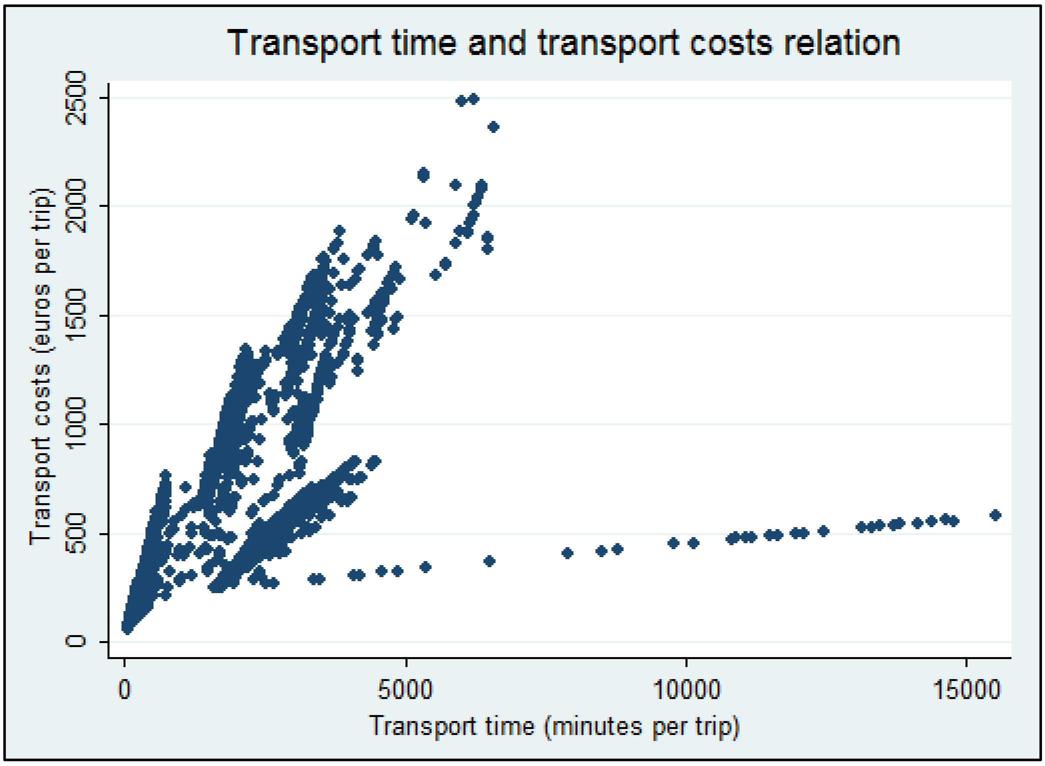

Figure 11: Transport time and transport costs relation

The coefficient for delivery in the same country as the discharge port is further discussed. The reasoning behind the introduction of the coefficient was the unexpected positive sign of the time variable. This suggested that, although faster alternatives were available, these were not always chosen and one of the reasons behind this can be that the discharge port is not in the same country. This pattern is repeated in our dataset especially for the Croatian hinterland regions. The regions in northern Croatia should face tough competition from Trieste and Koper, which in many cases offer both a time and a cost advantage to the port of Rijeka. Interestingly enough, Croatian hinterland regions are almost exclusively served by Rijeka although a cheaper or faster alternative is available.

Finally, the terminal operator variables are discussed. We will pay special attention to the variable for terminal operators that are affiliated to a shipping line which, in our case, is Pier II in the port of Piraeus. The coefficient sign is unexpected, especially when compared to the performance of the terminal during the past 5 years. Throughput volumes at the port increased at an astonishing rate with year on year increases constantly exceeding 20%. The question that arises is why, if additional cargo is attracted by the port, the port does not become a more attractive alternative for shippers. The type of cargo attracted by the port might provide an answer to this question. The focus of the port during the past 5 years seems to be almost exclusively on transhipment cargo, with limited hinterland cargo incidence. Although throughputs increase constantly, hinterland cargo volumes show a decreasing trend both in absolute and relative values.

Validation

The observations were randomly split into two samples. This was to test whether the estimation of one sample would give similar results as the full sample estimation. Furthermore, the signs of the coefficients in each subsample were compared with the signs observed in the full dataset estimation. If the coefficients have the same sign in both samples and are statistically significant, then they are representative for the full dataset. Moreover, the average of the coefficients in the two subsample equations should not be different than the coefficients in the full sample.

Table 16 contains the estimations of Equation 21 on the full sample, and on the two subsamples. For both subsample estimations, the coefficients have the same sign as in the full sample equations and are statistically significant at a 1% significance level. The averages of the coefficients in the 2 subsample estimations stay within a +/- 2% variation.

Coefficients	Equation 21 Full sample	Equation 21 Sample 1	Equation 21 Sample 2	Sample 1 and 2 average (% change to full model)
ΔTm	0.000842	0.001154	0.000571	0.000863
t-stat	5.92	5.51	2.99	2.49%
ΔCm	-0.0055	-0.0064	-0.00477	-0.00559
t-stat	-15.97	-12.67	-10.23	1.47%
ΔMm	-8.6843	-7.91581	-9.50804	-8.71192
t-stat	-13.3	-8.28	-10.76	0.32%
D Rail	-2.99239	-2.7428	-3.2863	-3.01455
t-stat	-8.55	-5.21	-7.04	0.74%
D Barge	-2.9796	-3.60626	-1.92811	-2.76719
t-stat	-2.66	-2.12	-1.31	-7.13%
D in country	-3.02126	-2.87237	-3.08948	-2.98092
t-stat	-5.77	-3.73	-4.36	-1.34%
D Private(S comp)	0.460561	0.383624	0.538201	0.460912
t-stat	2.03	1.16	1.75	0.08%
D Private(operator)	1.444617	1.533526	1.236083	1.384805
t-stat	5.77	4.01	3.73	-4.14%

* significant at 5% significance level

** significant at 1% significance level

Table 16: Multinomial regression results validation

The largest deviation from the full sample estimation can be found in the hinterland transport time variable which is larger by 37% in sample 1 estimation and smaller by 32% in sample 2 estimation. The same deviation is seen in the barge binary variable where in sample 1, the coefficient is 21% higher than the full estimation coefficient while in sample 2, the coefficient is 35% smaller. One reason can be the uneven distribution of transport modalities between the two samples. Sample 1 contains 14 barge routings, while sample two contains only 8.

4.2.2. GATEWAY FOR SOUTH-EAST EUROPE

Our main question of interest is if Constanza can play a central role in supplying the South-East Europe or, in other words, if it can become a gateway for goods destined for the region.

One way to answer this question is by looking at the observed and the modelled container flows and evaluate their composition in terms of countries. The modelled flows reveal the destinations where some ports in our dataset enjoy competitive advantage over other ports. We are particularly interested in the countries of origin and destination of the containers because the observed flows show a high concentration of intra-national flows rather than international flows. The modelled volumes reveal the competitive advantage ports have with respect to the factors included in the estimations. Analysing the differences between the modelled and observed flows can reveal areas of competitive advantage the ports in our dataset.

Figure 12 depicts the observed values per port and the flows resulted from the multinomial logit model. The modelled results were obtained by using the coefficients of Equation 21. The last 3 columns represent a scenario analysis for the market share of Constanza based on transport costs differences and will be discussed in detail in the following paragraphs.

We look at the market shares of the ports from the perspective of ratios and of composition. One observation is that the flows are made up especially from demand originating inside the country where the port is located. Bulgarian flows make up 94% and 88% of the flows of Varna and Burgas, respectively. Piraeus and Thessaloniki both have more than 90% of flows originating in Greece, while Constanza's volumes are made up from 90% of cargo destined for Romania. A less radical picture is observed for the three ports on the Adriatic coast. Although the home countries of the ports make up for more than 60% of their volumes, substantial volumes flow to neighbouring countries.

The differences between the observed and modelled values are generally not large. The largest ones can be seen for Thessaloniki and Piraeus. The volume handled by both ports together is relatively stable, however the modelled results show that the position of Thessaloniki is better than the current state and the port would enjoy a competitive advantage over Piraeus. The modelled volumes for the Adriatic ports are generally smaller than the observed ones. This can signal that other ports have a competitive advantage over some of the hinterland they currently serve.

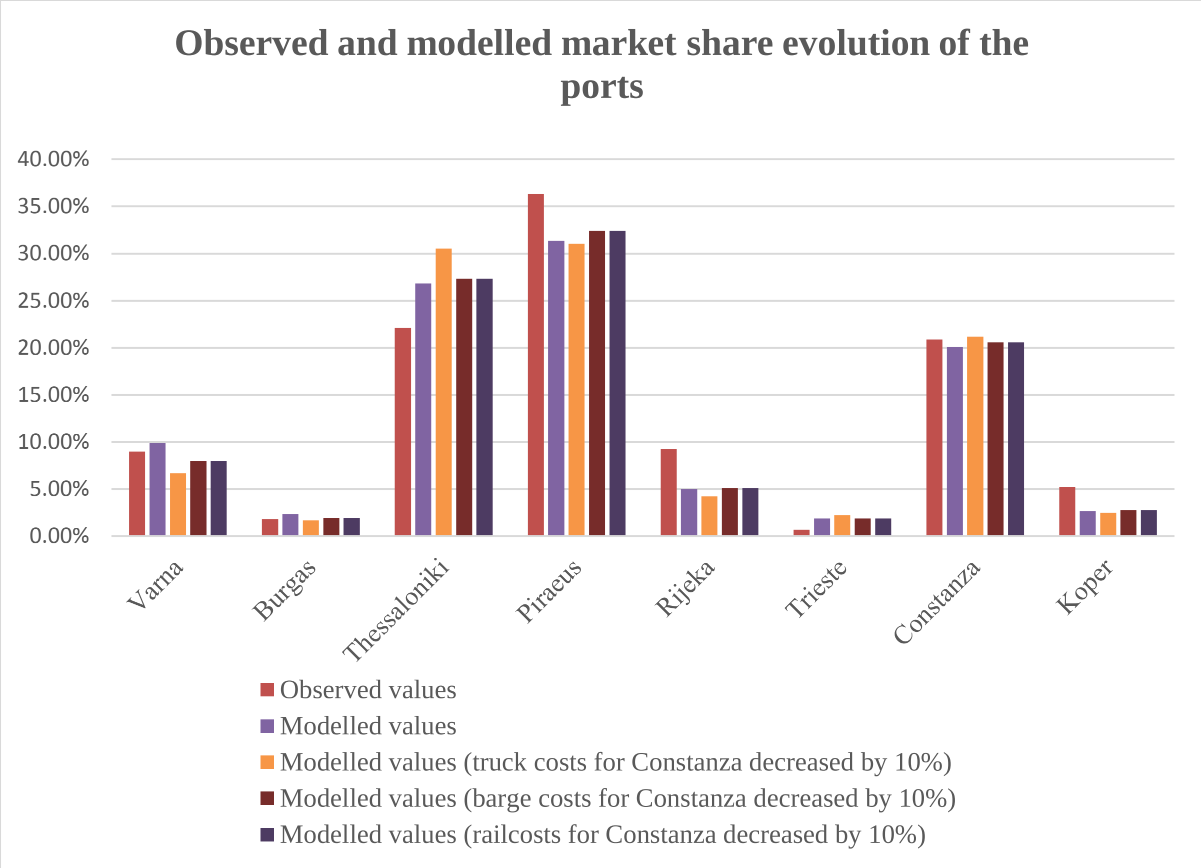

Figure 12: Observed and modelled market share evolution of the ports

We turn our attention to the cargo composition of the ports in our analysis. The modelled values reveal that Thessaloniki and Piraeus should maintain a very high ratio of cargo served in Greece with more than 85% of their volumes remaining in the region. Thessaloniki would have the potential to capture additional market share from Bulgarian and Romanian regions. Varna and Burgas also maintain a high percentage of intra-national cargo. More than 70% of their volumes are expected to come from Bulgaria. The modelled values reveal however that the ports could be a competitive threat to Constanza in serving a number of regions in Romania. About 25% of each port's market share could potentially come from serving the Romanian hinterland. Structural differences also arise between the Adriatic ports. The volumes from Croatia and Slovenia are redistributed among the three ports. One interesting observation is that the modelled volumes for both Koper and Rijeka show a significant decrease of the flows from the two ports to Hungary in favour or Romania.

The observed and modelled volumes for Constanza are shown in Figure 13. Although in absolute terms they are very similar, their structure is different. The share of Romanian cargo the port is expected to flow through the port is still significant but smaller. However, large volumes are expected to originate from Hungary and Croatia. About 70% of the Hungarian hinterland and 50% of Serbian demand is expected to be served by Constanza. Volumes from Croatian hinterland are also expected to transit through Constanza.

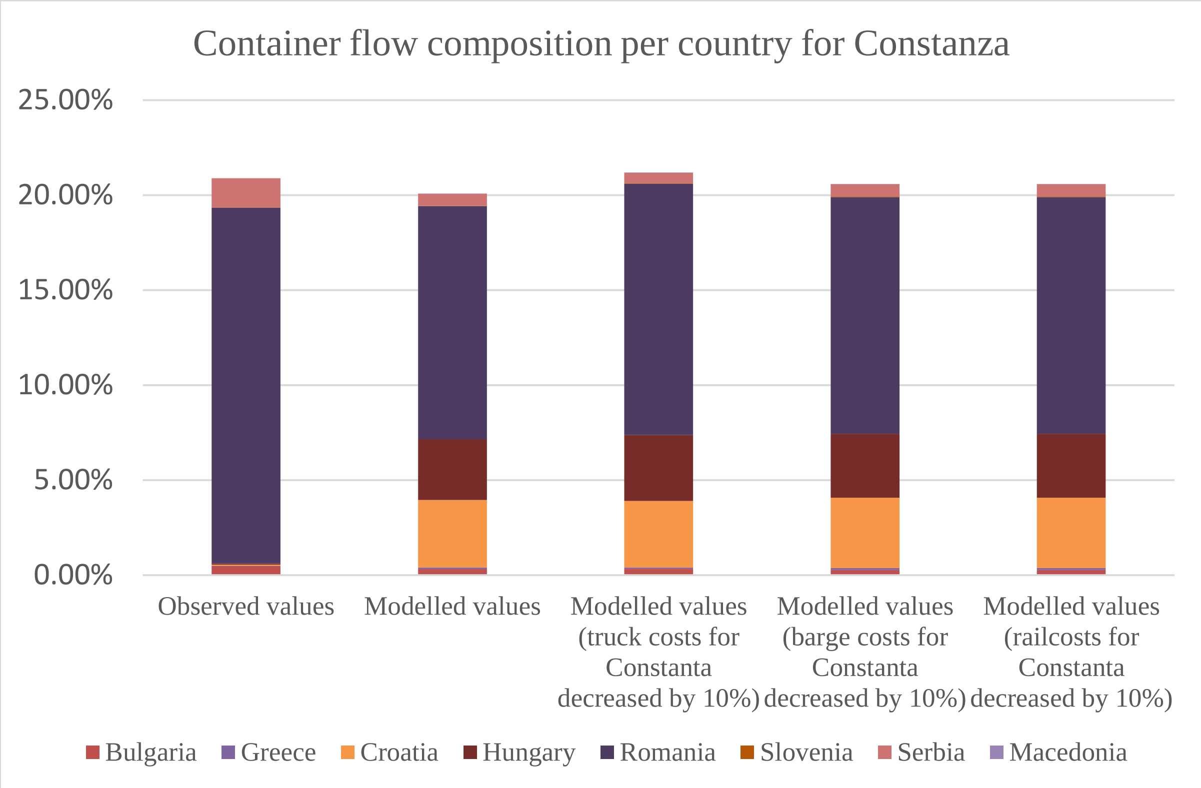

Figure 13: Container flow composition per country for Constanza

One important conclusion that we can draw from these differences is the fact that Constanza is currently enjoying a very strong position for intra-national flows. Although the Bulgarian and to some extent the Greek ports would have the possibility to serve some Romanian destinations, intra-national volumes are channelled in an overwhelming proportion through the country. The port does have the potential to serve a wide array of South-East European landlocked countries such as Hungary and Serbia. The barge connection in particular is expected to provide significant advantages for Constanza against its competitors.

Second, inland waterway plays currently plays an important role in the port's volumes and is expected to play an even more important role in serving international destinations with access to the Danube.

Third, direct competition for the Romanian hinterland is expected from Bulgaria and Greece. For the more central destinations in South-East Europe, competition comes especially from the Adriatic ports.

Scenario analysis

We turn our focus to the market share evolution scenarios for Constanza to evaluate the impact of transport prices changes on the relative market shares. A decrease in transport costs can come, in particular, from infrastructure improvements that would reduce driving time and fuel expenses. We simulate the effect of an improvement of Romania's infrastructure by decreasing the transport costs from the port of Constanza to the hinterland destinations for each of the transport modes and analysing the effect the changes have on the port's market share. For simplicity of calculation, we only changed the transport costs per mode. If a corresponding transport time reduction would have been included, the effect on the port's market share is expected to be larger.

A 10% decrease of truck transport costs (from 1 Euro per kilometre to 0.9 Euros) from Constanza to the hinterland destinations would have a positive effect on the market share of Constanza increasing it by approximately 2%. This increase would mainly come from a stronger position against the Bulgarian ports which would stand to lose most in this situation. A decrease in truck transport costs to and from Constanza would particularly strengthen the port's national competitive position.

Two additional scenarios were analysed. The barge and rail variable costs for routings from Constanza to and from hinterland regions were decreased by 10%. The fixed cost component was preserved. An important observation is that the barge and rail variable cost coefficients are significantly lower than the ones for trucking, between 0.22 and 0.27 euros. The variation of the absolute values is much smaller than the one for the truck. Both variable cost reductions produce the same 0.4% in market share increase for Constanza. The additional market share is mainly captured from the two Bulgarian ports, Burgas and Varna.

The differences in infrastructure development, particularly for road network, within South-East Europe, together with the current issues on the Danube have been discussed in detail in Chapter 3. The findings in this chapter come as a strong support for our previous statements. Based on the multinomial logit model's results we can confirm that developments in infrastructure that have on the transport costs to and from the port have a positive impact on the market share of Constanza. Therefore, highway development is critical to extend the reach of the port to its extended hinterland and unlock the full potential of Constanza as a gateway port. In parallel, the barge product should be first appropriately marketed and second improved to accommodate the market's demands.

4.3 CONCLUSIONS

In this section, we estimated the impact of the differences in routing characteristics such as hinterland transport cost and time or port characteristics on the relative market shares of each of the ports on the available routings. The hinterland flows originating from the 8 ports included in our study were analysed using a multinomial logit approach.

The dataset consists of commodity flow information from 212 NUTS 3 regions in 8 South-East European countries and transiting through 8 ports of interest. The commodity flows were transformed in containerised volumes by using the probability of containerisation. Inland transport rates were made available from a number of forwarders operating in the European market. These were decomposed into fixed and distance based components using linear regression and applied on all the included routings. The resulting origin-destination matrix contains information on more than 3.200 routings. The barge modality is under-represented amongst these routings since it is available only from the port of Constanza.

A considerable number of models were estimated in order to examine the impact of the independent variables on the relative market shares of the ports in the hinterland regions. The preferred estimation includes hinterland transport time and cost differences, maritime diversion, transport mode binary variables, terminal operator variables and a binary variable for shipments within the country.

Differences in transport costs were found to be significant in all estimations and have a negative impact on the utility of shippers on the respective routing. Increased transport costs reduce the probability that shippers will use the respective routing when compared to the base routing. The probability that the routing is chosen against the base option is decreased when the transport cost is increased.

Differences in transport time were found to have a positive significant impact on routing utility. This is contrary to literature findings. However, further investigation revealed that transport time and transport cost are positively correlated. Therefore, the effect of each variable on pots' market shares cannot be separated.

The transport mode specific variables were found to have a negative impact on shipper's utility. This means that the barge and rail alternatives are less valued by shippers when compared to the truck alternative. The truck alternative remains the favourite modal choice for shippers in our dataset.

The maritime diversion distance served as a proxy both for additional costs and time expenses incurred by diverting from the main trade lane. The coefficient of the variable is negative and can be interpreted as a negative impact on shipper's routing utility with every additional nautical mile of sailing required.

The comparison between the observed and modelled flows yielded a series of interesting results. Currently, almost all ports have a strong position in handling intra-national cargo. This is especially the case for the Black Sea and Aegean ports where intra-national volumes make up for more than 85% each port's market share. The modelled values paint a different picture for Constanza and for the Adriatic ports. Constanza is shown to have a competitive advantage also in Hungary and Serbia, and generally gains a larger reach for its flows. The Adriatic ports redistribute volumes between themselves and to some extent lose ground against Constanza. However, the Aegean ports are the most important competitors for the South-East European contestable hinterland. Varna and Burgas emerge as much stronger competitors for cargo destined to Romania, as do the two Greek ports, Piraeus and Thessaloniki.

The evolution of Constanza's market share was evaluated in scenarios in which the transport costs to and from the ports are decreased. In all cases the reduction of costs had a positive effect on the port's market share. The decrease in trucking costs by 10% is shown to have a 2% increase on the port's market share, while the decrease of either rail or barge variable costs by 10% adds 0.4% to Constanza's market share. The market share gains for Constanza come mostly from decreasing the shares of Varna and Burgas.

5. CONCLUSIONS AND RECOMMENDATIONS

The final section of this thesis presents the conclusions of the analyses performed as well as the recommendations derived from our analysis and also its limitations.

5.1 CONCLUSIONS

The main focus of this thesis is the competitive position of the port of Constanza in the South-East European context. In order to create a comprehensive picture regarding the position of Constanza, the port's characteristics, the main competitors and shippers' preferences regarding inland transportation were analysed.

The port's container handling capacity is currently under-utilized. After peaking in 2007, volumes decreased and stabilised at around half the peak value. The decrease in throughput can be linked to the general economic slowdown Romania experienced from 2007 onwards. The analysis of the relation between port throughput and GDP revealed that throughput evolution is influenced by economic performance. Moreover, the opening of Pier II terminal in 2009 in Piraeus had a large impact on the transhipment volumes handled by Constanza.

The current situation at Constanza can be improved if additional attention is paid to the infrastructure development and if the Danube is utilized as an asset that enriches the port's hinterland transport alternatives.

Next, Constanza's competitors in the South-East European region were analysed. Ports that handled a significant portion of their country's throughput were of interest. Significant competitive threat is faced by Constanza from the ports of Koper and Trieste for the hinterland regions situated west of Romania. The two ports are exclusively focused on gateway cargo and have a wide array of inland transport services on offer. The Bulgarian ports of Burgas and Varna represent a competitive threat for Constanza due to their geographical proximity, but the ports are less developed in terms of infrastructure. The main competitor on transhipment cargo is the port of Piraeus which has managed to attract significant transhipment volumes during the past 5 years. We believe that the air draught limitation posed by the Bosphorus Straight bridges combined with the additional sailing deviation from the main Mediterranean trade route are the reasons behind the significant throughput decline at Constanza.

Furthermore, shipper's preferences were analysed by modelling the relative market shares of the 8 ports in the South-East European countries. Our analysis revealed that additional transport costs and maritime diversion negatively impact the market share a port has in a hinterland region. Moreover, trucking remains the favourite transport alternative, with both rail and barge lagging behind in shippers' preferences.

Transportation time was found to have a positive impact on the port's market share. We believe that one of the main reasons behind this result is that since not all ports benefit from the same connections, shippers are willing to transport the goods to the port where the maritime connection is available and then accept the additional transport time and cost, rather that transhipping the containers to a closer port.

Ports delivering in the same country as the hinterland regions have a higher probability of being chosen when compared to other available alternatives. Furthermore, terminal management structure also appears to have an influence on shippers' choices. Compared to terminals managed by publicly owned corporations, terminal operators are more likely to be chosen by shippers. On the opposing spectrum, terminals managed by operators affiliated to shipping companies show a lower market share for hinterland cargo.

Constanza enjoys a strong position in handling intra-national cargo and has the potential of serving a wide range South-East European destinations. Hungary and Serbia are two countries where Constanza's share can see the greatest developments. The main competitors for the central hinterland in South-East Europe are the three Adriatic ports which are already focused on gateway cargo. A portion of the Romanian hinterland comes under competitive threat from Bulgarian ports and Greek ports.

5.2 RECOMMENDATIONS AND LIMITATIONS

We approached the issue of port competition from two perspectives. One perspective is that of the factors influencing port competitive position in the context of the country where it is located. The second is the perspective of the port itself. Therefore, the recommendations that will follow will be also divided in recommendations on a national level and on a port level for Romania and Constanza respectively.

Recommendations

On a national level, the main deficiency we observed was the lack of developed infrastructure. While there are multiple reasons for this situation, the current level of infrastructure development does have a negative impact on the port's development. Focus on highway development that connects the port with the main cargo arteries should be one of the main national priorities. It is important not to neglect the other modalities. The inland waterway connection that Constanza has via the Danube is a unique differentiating feature of the port that should be used as a valued asset in attracting cargo. The waterway does require constant maintenance and development, however it can constitute an option for shippers in terms of transport costs and transport time.

On a port level, focus on gateway cargo should have priority over transhipment cargo. As a transhipment destination, Constanza presents a series of drawbacks when compared to Piraeus, one of its main competitors in this category: first is the additional sailing distance from the main trade lane and the second is the Boshporus straight limitation. One way to increase gateway cargo is by focusing on customers located inside the country rather than foreign customers. Our analysis illustrated a preference of shippers for ports located in the same country as the port of discharge thus, national customers should be encouraged to use Constanza as the preferred port of service.

Limitations

No analysis is without drawbacks and this one makes no exception. The main focus of the limitations presented is the multinomial logit model used and its assumptions. Most drawbacks come from the assumptions made in order to operationalize the multinomial logit model. We will focus on the drawbacks that we consider as having a large impact on our estimation results and the ways that these can be overcome in order to provide more accurate results.

First of all, the limited availability of real containerised flows forced us to use the commodity flows transformation to container flows.

Two assumptions stand behind this transformation: first, the probabilities of containerisation used are the correct depiction of preferences observed in real life and the probabilities are the same for all countries. Second, the flows that originate from the region the port is located represent the port flows. We acknowledge that through the transformations we have performed on the data, there can be some loss of information and that if the two assumptions used were to be violated, the relative market shares of the ports could be different than the ones we obtained.

The adoption rate of containerisation is different across the European continent. While some countries have reached a very high degree of commodity containerization, others are in the process of a widespread adoption of container transport towards the hinterland. The most obvious solution for this would be to use the real containerised flows from the port to the hinterland regions. These flows should contain more accurate routing information including the drayage moves from inland terminals and can provide a clear picture both on goods containerization levels and shippers' routing preferences. In the absence of such information however, we consider that the data utilised is the best available representation of the situation in South-East Europe.

Second, more hinterland and port related variables can be used. We noticed that rail and barge container flows follow a different pattern than expected. One of the reasons behind this can be the availability of a terminal that can handle containerised cargo. It was not possible to gather information on the inland terminals availability but accounting for this should help explain some of the flow's distribution. Moreover, information regarding the hinterland service frequency and short sea frequency could not be acquired from reliable sources. Including such characteristics in the modelling approach should provide additional insight on shipper's port choice.

Third, some of the ports in our dataset are relatively similar to each other. One of the assumptions of the multinomial logit model is the independence of irrelevant alternatives or IIA. This rather strong assumption of the model means that the utility levels of two particular choices are independent of each other. An issue arises when the alternatives are very similar to each other.

The classic literature illustration of the IIA assumption is the blue bus/ red bus example. If the choice of travelling would be split into blue bus and red bus instead of bus, the expectation would naturally be that the two variables would be positively correlated. When a new transport choice is introduced, for example, travel by train, the probability ratios of the variables will not account for the existence of a similar alternative.

In our dataset, a similar situation can be identified for Trieste and Koper which are 30 kilometres apart and share most of the services to the South-East European hinterland. Thus the quality of the hinterland services offered by both ports is remarkably similar. The ports are however treated as separate and independent entities in the estimation. An alternative resolution for this issue is the use of a nested logit model.

Fourth, the countries in South-East Europe have various degrees of economic development. Although the differences between the countries have diminished during the past decades, these can still be observed in all European countries. These differences are especially large between developed and developing economies. Hinterland freight rates and quality of service can be affected by these differences. Especially freight rates for which the wage cost makes a substantial part of the total cost are sensitive to country differences. We have used the same kilometre freight rates irrespective of the origin of the shipment and we believe that additional port information can be revealed if the freight rates differences are accounted for.

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APPENDICES

APPENDIX 1 – GENERAL FIGURES PER COUTNRY

Table I: Containers per capita in European countries in 2012 (in TEU)

Representative	TEU per capita 2012 Average
European Union (28 countries)	168.47
European Union (27 countries)	169.62
Belgium	826.06
Bulgaria	23.75
Denmark	136.90
Germany	190.34
Estonia	172.05
Ireland	159.73
Greece	289.40
Spain	302.06
France	63.49
Italy	156.55
Cyprus	350.34
Latvia	178.99
Lithuania	126.85
Malta	251.47
Netherlands	659.82
Poland	42.79
Portugal	183.35
Romania	33.59
Slovenia	270.49
Finland	223.47
Sweden	156.49
United Kingdom	126.10
Croatia	33.68
Turkey	96.25

Table II: Terminal handling costs per port (in euro per TEU)

Port	THC	ISPS and B/L	Total/Container	Total/TEU
Varna	150	50	200	125
Burgas*	150	50	200	125
Thessaloniki	111	50	161	101
Piraeus	117	50	167	104
Rijeka	149	50	199	124
Trieste	157	50	207	129
Constanza	101	50	151	94
Koper	132	50	182	114

*No information available. Assumed to be similar to Varna

Source: Mueller, M. (2014). Container Port Development. A Port Choice Model for the European Mainland. Unpublished master's thesis. Delft, The Netherlands: Delft University of Technology

APPENDIX 2 - GDP-PORT THROUGHPUT ANALYSIS

Equation 1 estimation results

```
. reg throughput gdp

      Source |       SS       df       MS              Number of obs =     310
-------------+------------------------------           F(  1,   308) =  430.15
       Model |  2.0221e+09     1  2.0221e+09           Prob > F      =  0.0000
    Residual |  1.4479e+09   308  4700956.34           R-squared     =  0.5827
-------------+------------------------------           Adj R-squared =  0.5814
       Total |  3.4700e+09   309  11229816.8           Root MSE      =  2168.2

------------------------------------------------------------------------------
  throughput |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         gdp |   .0037447   .0001806    20.74   0.000     .0033894       .0041
       _cons |   651.4727   152.9018     4.26   0.000     350.6084    952.3369
------------------------------------------------------------------------------
```

Equation 2 estimation results

```
. reg throughputgrowth gdpgrowth

      Source |       SS       df       MS              Number of obs =     286
-------------+------------------------------           F(  1,   284) =   46.50
       Model |  1.59901336     1  1.59901336           Prob > F      =  0.0000
    Residual |  9.76530069   284  .034384862           R-squared     =  0.1407
-------------+------------------------------           Adj R-squared =  0.1377
       Total |  11.3643141   285  .039874786           Root MSE      =  .18543

------------------------------------------------------------------------------
throughput~h |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   gdpgrowth |   1.090711   .1599437     6.82   0.000     .7758853    1.405537
       _cons |    .034663   .0129517     2.68   0.008     .0091695    .0601566
```

Equation 2 estimation results excluding GDP growth between 0 and 0.1

```
. reg throughputgrowth gdpgrowth if gdpgrowth>0.1 & gdpgrowth<0

      Source |       SS       df       MS              Number of obs =      98
-------------+------------------------------           F(  1,    96) =   35.94
       Model |  1.65302734     1  1.65302734           Prob > F      =  0.0000
    Residual |  4.41551834    96  .045994983           R-squared     =  0.2724
-------------+------------------------------           Adj R-squared =  0.2648
       Total |  6.06854569    97  .062562327           Root MSE      =  .21446

------------------------------------------------------------------------------
throughput~h |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   gdpgrowth |    1.15597   .1928242     5.99   0.000     .7732165    1.538723
       _cons |   .0400469   .0229765     1.74   0.085     -.005561    .0856549
```

Equation 3 estimation results

```
. reg ln_throughput ln_gdp

      Source |       SS       df       MS              Number of obs =     310
-------------+------------------------------           F(  1,   308) = 1275.53
       Model |  632.558209     1  632.558209           Prob > F      =  0.0000
    Residual |  152.742703   308  .495917866           R-squared     =  0.8055
-------------+------------------------------           Adj R-squared =  0.8049
       Total |  785.300912   309   2.5414269           Root MSE      =  .70421

------------------------------------------------------------------------------
ln_through~t |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      ln_gdp |   .8464829   .0237013    35.71   0.000     .7998459    .8931199
```

```
       _cons |  -3.421394   .2878581   -11.89   0.000    -3.987811   -2.854977
```

Equation 4 estimation results

```
. reg ln_throughput ln_gdp ln_trade

      Source |       SS       df       MS              Number of obs =     308
-------------+------------------------------           F(  2,   305) =  713.16
       Model |  642.815093     2  321.407546           Prob > F      =  0.0000
    Residual |  137.457065   305    .4506789           R-squared     =  0.8238
-------------+------------------------------           Adj R-squared =  0.8227
       Total |  780.272158   307  2.54160312           Root MSE      =  .67133

------------------------------------------------------------------------------
ln_through~t |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      ln_gdp |   .3135935   .1019769     3.08   0.002     .1129261    .5142609
    ln_trade |   .5948453    .111299     5.34   0.000     .3758342    .8138565
       _cons |  -3.929193   .2912904   -13.49   0.000    -4.502386      -3.356
```

Equation 5 estimation results

```
. reg ln_throughput ln_gdp ln_trade ln_population

      Source |       SS       df       MS              Number of obs =     308
-------------+------------------------------           F(  3,   304) =  483.64
       Model |  645.108221     3  215.036074           Prob > F      =  0.0000
    Residual |  135.163937   304  .444618214           R-squared     =  0.8268
-------------+------------------------------           Adj R-squared =  0.8251
       Total |  780.272158   307  2.54160312           Root MSE      =   .6668

-------------------------------------------------------------------------------
ln_throughput |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
--------------+----------------------------------------------------------------
       ln_gdp |   .4359834   .1147336     3.80   0.000     .2102108     .661756
     ln_trade |   .5845937   .1106402     5.28   0.000      .366876    .8023114
ln_population |  -.1494454   .0658055    -2.27   0.024    -.2789373   -.0199535
        _cons |   -2.88827    .542028    -5.33   0.000    -3.954872   -1.821669
```

Equation 6 estimation results

```
. reg ln_throughput ln_gdp ln_trade d_rom d_cro d_slo d_gre d_bulg

      Source |       SS       df       MS              Number of obs =     308
-------------+------------------------------           F(  7,   300) =  256.53
       Model |  668.575608     7  95.5108011           Prob > F      =  0.0000
    Residual |   111.69655   300  .372321833           R-squared     =  0.8568
```

```
-------------+------------------------------           Adj R-squared =  0.8535
       Total |  780.272158   307  2.54160312           Root MSE      =  .61018

------------------------------------------------------------------------------
ln_through~t |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      ln_gdp |   .1264347   .1027622     1.23   0.220    -.0757913    .3286606
    ln_trade |   .7495098   .1113418     6.73   0.000     .5304001    .9686196
       d_rom |  -.1538501   .1974144    -0.78   0.436    -.5423425    .2346423
       d_cro |  -.9947436   .2122327    -4.69   0.000    -1.412397   -.5770902
      d_slov |  -.2561257   .1815705    -1.41   0.159    -.6134387    .1011874
       d_gre |   .6850202   .1788545     3.83   0.000     .3330518    1.036988
      d_bulg |   -1.00592   .1800367    -5.59   0.000    -1.360215   -.6516249
       _cons |  -3.419634   .2864215   -11.94   0.000    -3.983283   -2.855984
```

Table III: Correlation between control variables for throughput and economic output

Correlation	Ln Population	Ln Trade
Ln Trade	0.8725	1.0000
Ln Population	1.0000	

APPENDIX 3 - TRANSIT CARGO DENSITY ANALYSIS

Cluster summary statistics

Table IV: Cluster summary statistics with 2 groups

Variable	Obs	Mean	Std. Dev	Obs	Mean	Std. Dev
transit	91	27094.99	24438.09	129	6164.465	6962.083
density	91	2.84	1.90	129	1.42	1.59
trade	91	640307.9	436501	129	75471.76	54623.97
gdp	91	1109373	759319.1	129	91975.4	78792.11
population	91	41692387	25438191	129	6987574	6488219

Table V: Cluster summary statistics with 3 groups

Variable	Obs	Mean	Std. Dev	Obs	Mean	Std. Dev	Obs	Mean	Std. Dev
transit	86	10673.34	12383.63	64	4851.063	4367.573	70	29035.5	26129.11
density	86	0.93	0.84	64	1.92	1.98	70	3.40	1.77
trade	86	149229	61999.55	64	28819.31	11334.01	70	761796.4	428134.7
gdp	86	192827.6	95646.72	64	30204.08	9975.064	70	1347165	709067.7
population	86	12898351	10303946	64	3298972	2340146	70	48214454	24379042

Table VI: Cluster summary statistics with 4 groups

Variable	Obs	Mean	Std. Dev	Obs	Mean	Std. Dev
transit	43	25330.98	16744.44	63	7393.873	7105.698
density	43	3.98	1.95	63	0.47	0.33
trade	43	330948.6	198839.4	63	141075.8	65079.95
gdp	43	326986	143071.5	63	180677.1	103546.6
population	43	10194689	3939765	63	14949787	11336974
transit	64	4851.063	4367.573	50	27906.92	29990.93
density	64	1.92	1.98	50	2.36	0.70
trade	64	28819.31	11334.01	50	860817.5	464580.2
gdp	64	30204.08	9975.064	50	1708834	484925.2
population	64	3298972	2340146	50	62081236	12115027

Table VII: Cluster summary statistics with 5 groups

Variable	Obs	Mean	Std.	Obs	Mean	Std.	Obs	Mean	Std.
transit	46	16707.41	13849.56	20	31856.95	12165.88	50	27906.92	29990.93
density	46	1.53	0.74	20	6.02	0.27	50	2.36	0.70
trade	46	147220.9	47507.78	20	514243.6	136851.9	50	860817.5	464580.2
gdp	46	163154.9	79464.44	20	442994.2	121056.5	50	1708834	484925.2
population	46	8121833	2116263	20	13547501	2965120	50	62081236	12115027
transit	40	3734.15	4536.716	64	4851.063	4367.573			
density	40	0.25	0.12	64	1.92	1.98			
trade	40	151538.2	75916.96	64	28819.31	11334.01			
gdp	40	226951.2	102077.1	64	30204.08	9975.064			
population	40	18391347	12975924	64	3298972	2340146			

Table VIII: Correlation between control variables for transit cargo density relationship

Correlation	Ln GDP	Ln Population	Ln Trade
Ln GDP	1.0000	0.8638	0.9715
Ln Population	-	1.0000	0.8355
Ln Trade	-	-	1.0000

The estimation with 4 clusters produces the least stable results. None of the coefficients for the groups are statistically significant at 5%. The estimation with 5 clusters produces relatively more stable results. However, not all the groups are statistically significant at a 5% level, leading us to believe that the data has been split into too many groups. The coefficients of the estimation with 3 groups are both statistically significant both at a 1% and at a 5% level .Furthermore, the R-sqared value of the regression is marginally different than the one of the 5 group estimation and higher than the other estimations.

Table IX: Cluster analysis groups evaluation

Variables	Coefficients			
ln(Highway Density)	0.68	0.88	0.83	0.93
t-stat	8.02**	8.76**	7.10**	6.22**
ln(Trade)	2.11	2.45	2.19	2.67
t-stat	9.03**	9.38**	7.83**	8.87**
ln(GDP)	-2.01	-1.83	-1.90	-2.19
t-stat	-9.44**	-8.89**	-7.02**	-6.28**
ln(population)	0.36	0.60	0.44	0.55
t-stat	2.75*	4.35**	3.03**	3.81**
D 2 clusters	0.64			
t-stat	2.41*			
D 3 clusters - group 1		1.48		
t-stat		4.51**		
D 3 clusters -group 2		2.15		
t-stat		3.90**		
D 4 clusters group 1			-0.09	
t-stat			-0.23	
D 4 clusters - group 2			0.43	
t-stat			0.94	
D 4 clusters - group 3			0.35	
t-stat			0.51	
D 5 clusters - group 1				-0.37
t-stat				-0.99
D 5 clusters - group 2				-2.08
t-stat				-3.76**
D 5 clusters - group 3				-1.28
t-stat				-1.62
D 5 clusters - group 4				-0.25
t-stat				-0.43
Constant	1.62	-9.19	-1.69	-5.08
t-stat	1.19	-3.85**	-0.63	-2.26*
Observations	220	220	220	220
F-test	65.44	60.28	45.4	45.86
R-square	0.6046	0.6294	0.5998	0.6349
Asj. R-squared	0.5953	0.6189	0.5866	0.621

*significant at 5% significance level

**significant at 1% significance level

APPENDIX 4 – TRANSPORT COSTS ANALYSIS

Figure I: Transport cost (regressed)

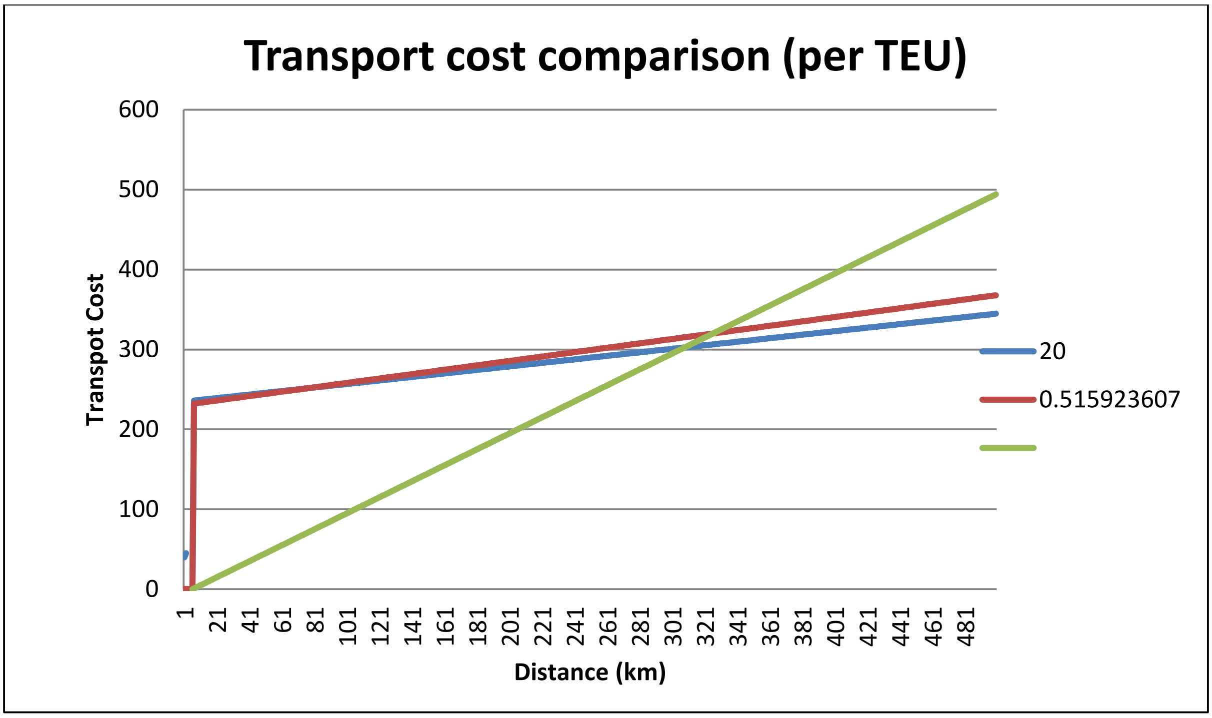
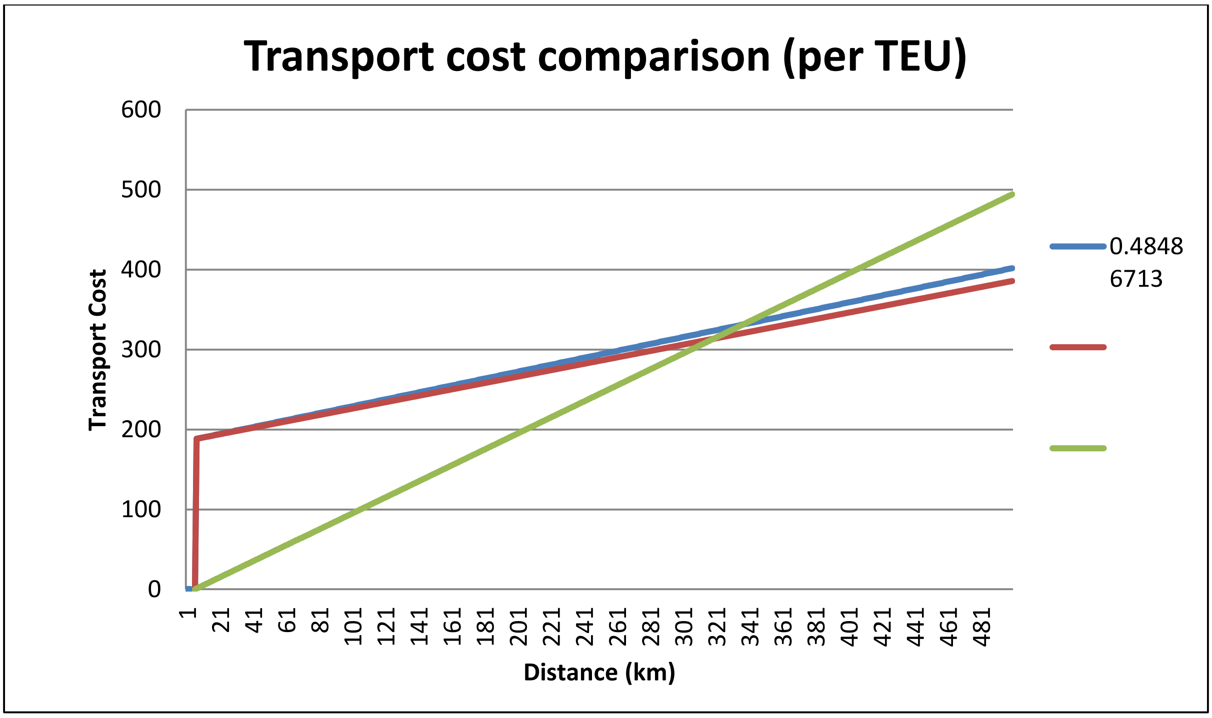


Figure II: Transport costs (average cost/km)



We have compared two alternative transport costs settings, one where the average cost per kilometre was extracted from the data and the other where the average costs for rail and barge were regressed on the distances between the origin port and the destination container yard. In both cases, the allowance for the final mile transportation was included in the final calculation to insure a realistic setting.

Figure II illustrates the estimation results when distance was regressed on the cost of transportation per TEU. Figure III illustrates the cost for each hinterland mode when using the average cost of transport extracted from the vendor data available. For both rail and barge the regression found a positive intercept which is added as a fixed cost of the intermodal transport. The slope at which the two cost figures increase is lower when compared to the average cost calculation.

Table IX shows the barge and rail average costs in a numerical manner and compares the values obtained. In both cases, the average obtained by means of regression is lower than a general average applied to the rates. We obtained the averages by combining the three container types vendors quote for into one value. This approach was chosen because we use the TEU (20 foot equivalent) measurement unit throughout our analysis. However, we aimed at capturing the rate information from the 40 foot and 45 foot containers. Thus, the rates for the 40 foot container were divided by 2 and the rates for the 45 foot container by 2.25 and the resulting figures were averaged out with the 20 foot rate.

Table X: Average cost per kilometre versus regressed costs per kilometre

Transport mode	Barge				Rail			
Average cost (euro/km)	20 ft	40 ft	45 ft	General Average	20 ft	40 ft	45 ft	General Average
	0.48	0.41	0.40	0.43	0.52	0.36	0.33	0.40
Regression coefficient	20 ft	40 ft	45 ft	Regression Average	20 ft	40 ft	45 ft	Regression Average
Distance	0.27	0.20	0.19	0.22	0.36	0.24	0.22	0.27
t-stat	6.49**	6.72**	6.4**		6.47**	7.71**	8.13**	
Constant	58.99	40.63	44.40	48.00	52.66	39.69	40.27	44.20
t-stat	3.17**	3.1**	3.26**		1.99	2.68*	3.13*	
F-test	42.09	45.20	40.99		41.88	59.45	66.18	
R-squared	0.79	0.80	0.79		0.78	0.83	0.88	
Adjusted R-squared	0.77	0.79	0.77		0.76	0.82	0.87	

* - significant at 5% significance level ** - significant at 1% significance level

APPENDIX 5 – DEMAND CONSTRUCTION

Table XI: SITC 3 to NST 2 correspondence and containerization probability

High containerisation probability								Medium containerisation probability				Low containerisation probability	
SITC	NST	SITC	NST	SITC	NST	SITC	NST	SITC	NST	SITC	NST	SITC	NST
111	12	575	89	686	45	785	91	211	9	524	81	511	81
112	12	58	13	687	56	811	69	222	18	591	89	579	89
12	14	581	89	689	45	812	97	223	18	592	89	662	69
12	14	582	89	694	94	813	94	231	9	634	5	671	51
121	13	583	89	695	94	821	97	232	9	635	97	672	51
122	13	59	16	696	94	831	94	244	5	663	69	673	52
16	14	593	89	697	93	841	96	245	5	675	52	674	54
17	14	597	34	733	93	842	96	265	4	676	53	677	53
212	9	598	81	735	93	843	96	269	4	678	53	691	94
22	13	611	96	737	93	844	96	277	61	679	55	693	94
261	4	612	96	74	13	845	96	284	45	692	94	722	92
263	4	613	96	74	13	846	96	285	45	699	55	731	93
264	4	62	13	741	93	848	96	286	45	711	93	791	91
266	4	621	97	742	93	851	94	287	45	712	93	792	91
267	4	625	97	743	92	871	97	288	45	713	93	793	91
268	4	629	97	744	91	872	93	291	9	714	93		
289	45	633	97	745	93	873	93	292	3	716	93		
35	14	641	89	746	93	874	93	42	1	718	93		
37	14	642	97	747	93	881	97	431	18	72	13		
48	16	651	96	748	93	882	97	46	16	721	92		
515	81	652	96	749	93	883	97	47	16	723	93		
525	56	653	96	75	13	884	97	512	18	724	93		
531	89	654	96	751	93	885	96	513	81	725	93		
532	89	655	96	752	93	891	89	514	81	726	93		
533	89	656	96	759	93	892	97	516	81	727	93		
541	81	657	96	762	93	893	89	522	81	728	93		
542	89	658	96	763	97	894	96	523	81				
551	9	659	96	764	93	895	89						
553	89	664	95	771	93	896	97						
554	89	665	95	772	93	897	97						
56	1	666	95	773	93	898	93						
57	3	667	63	774	93	899	89						
571	89	681	56	775	93	98	12						
572	89	683	45	776	93								
573	89	684	56	778	89								
574	89	685	56	784	91								

Table XI shows SITC 3 commodity groups divided according to their containerization probability. These groups have been obtained from the paper of Hoffman et al. (2006). Commodities that are not mentioned in this table have a probability of containerisation equal to zero. The SITC 3 commodity groups are transformed into NST 2 groups in order to operationalize the multinomial logit model. The transformation requires the transfer from a three digit coding to a two digit coding with only 52 possible combinations. Some NST 2 commodities appear to have a high containerisation probability although their equivalent SITC 3 group would not be considered a containerizable good such as fuel derivatives and petroleum. These cases were individually evaluated and a decision was made whether the commodity should be excluded from the list or the containerisation probability diminished.

APPENDIX 6 - MULTINOMIAL LOGIT ANALYSIS

Regression Estimations

Equation 17 estimation

```
. reg ln_p_relative delta_transp_time delta_transp_cost, noconstant

      Source |       SS       df       MS              Number of obs =    1204
-------------+------------------------------           F(  2,  1202) =  260.48
       Model |  7583.45196     2  3791.72598           Prob > F      =  0.0000
    Residual |  17497.1693  1202  14.5567132           R-squared     =  0.3024
-------------+------------------------------           Adj R-squared =  0.3012
       Total |  25080.6213  1204  20.8310808           Root MSE      =  3.8153

------------------------------------------------------------------------------------
    ln_p_relative |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
------------------+-----------------------------------------------------------------
delta_transp_time |   .0007157   .0000842     8.50   0.000     .0005505     .000881
delta_transp_cost |  -.0052441   .0002379   -22.04   0.000    -.0057109   -.0047772
```

Equation 18 estimation

```
. reg ln_p_relative delta_transp_time delta_transp_cost delta_div_dist, noconstant

      Source |       SS       df       MS              Number of obs =    1204
-------------+------------------------------           F(  3,  1201) =  322.02
       Model |  11180.7864     3   3726.9288           Prob > F      =  0.0000
    Residual |  13899.8349  1201  11.5735511           R-squared     =  0.4458
```

```
-------------+------------------------------           Adj R-squared =  0.4444
       Total |  25080.6213  1204  20.8310808           Root MSE      =   3.402

------------------------------------------------------------------------------------
    ln_p_relative |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
------------------+-----------------------------------------------------------------
delta_transp_time |   .0003718   .0000776     4.79   0.000     .0002196    .0005241
delta_transp_cost |  -.0046987   .0002144   -21.91   0.000    -.0051193    -.004278
   delta_div_dist |  -6.362997   .3609147   -17.63   0.000     -7.07109   -5.654903
```

Equation 19 estimation

```
. reg ln_p_relative delta_transp_time delta_transp_cost delta_div_dist hint2 hint3, noconstant

      Source |       SS       df       MS              Number of obs =    1204
-------------+------------------------------           F(  5,  1199) =  210.66
       Model |   11729.213     5  2345.84261           Prob > F      =  0.0000
    Residual |  13351.4082  1199   11.135453           R-squared     =  0.4677
-------------+------------------------------           Adj R-squared =  0.4654
       Total |  25080.6213  1204  20.8310808           Root MSE      =   3.337

------------------------------------------------------------------------------------
    ln_p_relative |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
------------------+-----------------------------------------------------------------
delta_transp_time |   .0009267   .0001418     6.54   0.000     .0006486    .0012048
delta_transp_cost |  -.0061618   .0003467   -17.77   0.000     -.006842   -.0054815
   delta_div_dist |  -6.517115   .3626646   -17.97   0.000    -7.228643   -5.805588
            hint2 |  -2.361559   .3471954    -6.80   0.000    -3.042737   -1.680381
            hint3 |  -2.613011   1.139102    -2.29   0.022    -4.847867   -.3781562
```

Equation 20 estimation

```
. reg ln_p_relative delta_transp_time delta_transp_cost delta_div_dist hint2 hint3
same_country, noconstant

      Source |       SS       df       MS              Number of obs =    1204
-------------+------------------------------           F(  6,  1198) =  186.29
       Model |  12105.6634     6  2017.61057           Prob > F      =  0.0000
    Residual |  12974.9578  1198  10.8305157           R-squared     =  0.4827
-------------+------------------------------           Adj R-squared =  0.4801
       Total |  25080.6213  1204  20.8310808           Root MSE      =   3.291

------------------------------------------------------------------------------------
    ln_p_relative |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
------------------+-----------------------------------------------------------------
delta_transp_time |   .0009933   .0001403     7.08   0.000     .0007181    .0012685
delta_transp_cost |  -.0059556   .0003437   -17.33   0.000      -.00663   -.0052813
   delta_div_dist |  -5.667724   .3855911   -14.70   0.000    -6.424233   -4.911215
```

```
         hint2 |  -2.940255      .3562    -8.25   0.000    -3.639101    -2.24141
         hint3 |  -3.514709   1.133761    -3.10   0.002    -5.739086   -1.290332
  same_country |   1.501664   .2547085     5.90   0.000     1.001939    2.001388
```

Equation 21 estimation

```
. reg ln_p_relative delta_transp_time delta_transp_cost delta_div_dist hint2 hint3 p_owner2
p_owner3 same_country, noconstant

      Source |       SS       df       MS              Number of obs =    1204
-------------+------------------------------           F(  8,  1196) =  150.31
       Model |  12574.0563     8  1571.75704           Prob > F      =  0.0000
    Residual |   12506.565  1196  10.4569941           R-squared     =  0.5013
-------------+------------------------------           Adj R-squared =  0.4980
       Total |  25080.6213  1204  20.8310808           Root MSE      =  3.2337

------------------------------------------------------------------------------------
    ln_p_relative |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
------------------+-----------------------------------------------------------------
delta_transp_time |   .0008416   .0001421     5.92   0.000     .0005628    .0011204
delta_transp_cost |  -.0055046   .0003448   -15.97   0.000     -.006181   -.0048281
   delta_div_dist |  -8.684295   .6530506   -13.30   0.000    -9.965547   -7.403043
            hint2 |  -2.992391   .3501341    -8.55   0.000    -3.679337   -2.305446
            hint3 |  -2.979601   1.118354    -2.66   0.008    -5.173755   -.7854464
         p_owner2 |  -3.021263   .5239493    -5.77   0.000    -4.049225   -1.993301
         p_owner3 |   .4605613   .2267446     2.03   0.042        .0157    .9054227
     same_country |   1.444617   .2504867     5.77   0.000     .9531743    1.936059
```

Equation 22 estimation

```
. reg ln_p_relative delta_transp_cost delta_div_dist hint2 hint3 p_owner2 p_owner3
same_country, noconstant

      Source |       SS       df       MS              Number of obs =    1204
-------------+------------------------------           F(  7,  1197) =  162.15
       Model |  12207.2408     7  1743.89155           Prob > F      =  0.0000
    Residual |  12873.3804  1197  10.7547038           R-squared     =  0.4867
-------------+------------------------------           Adj R-squared =  0.4837
       Total |  25080.6213  1204  20.8310808           Root MSE      =  3.2794

------------------------------------------------------------------------------------
    ln_p_relative |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
------------------+-----------------------------------------------------------------
delta_transp_cost |  -.0037773   .0001865   -20.25   0.000    -.0041433   -.0034114
   delta_div_dist |  -9.330391   .6529761   -14.29   0.000     -10.6115   -8.049286
            hint2 |  -1.607543   .2643025    -6.08   0.000    -2.126091   -1.088996
            hint3 |   2.036292   .7407287     2.75   0.006      .583021    3.489563
         p_owner2 |   -3.15778    .530841    -5.95   0.000    -4.199263   -2.116298
```

```
     p_owner3 |   .7611443   .2241157     3.40   0.001      .321441    1.200848
 same_country |   1.314529   .2530489     5.19   0.000     .8180608    1.810998
```

Equation 23 estimation

```
. reg ln_p_relative delta_transp_time delta_transp_cost delta_div_dist hint2 hint3 delta_port
> _cr_congestion delta_thc delta_portcranes delta_port_depth delta_port_berths, noconstant

      Source |       SS       df       MS              Number of obs =    1204
-------------+------------------------------           F( 10,  1194) =  134.72
       Model |  13296.4124    10  1329.64124           Prob > F      =  0.0000
    Residual |  11784.2089  1194  9.86952166           R-squared     =  0.5301
-------------+------------------------------           Adj R-squared =  0.5262
       Total |  25080.6213  1204  20.8310808           Root MSE      =  3.1416

------------------------------------------------------------------------------------------
           ln_p_relative |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------------------+----------------------------------------------------------------
       delta_transp_time |   .0005919    .000143     4.14   0.000     .0003113    .0008726
       delta_transp_cost |  -.0051202   .0003565   -14.36   0.000    -.0058196   -.0044207
          delta_div_dist |  -5.103616   .6764908    -7.54   0.000    -6.430859   -3.776373
                   hint2 |  -2.456698     .33895    -7.25   0.000    -3.121702   -1.791694
                   hint3 |  -.4535912   1.121324    -0.40   0.686    -2.653576    1.746394
delta_port_cr_congestion |  -2.341858   1.620769    -1.44   0.149    -5.521732    .8380148
               delta_thc |   1.019093   2.336981     0.44   0.663    -3.565954     5.60414
        delta_portcranes |   .8663058   .5285288     1.64   0.101    -.1706427    1.903254
        delta_port_depth |  -2.435059   .8794499    -2.77   0.006    -4.160498   -.7096198
       delta_port_berths |  -1.248783   .6391512    -1.95   0.051    -2.502768    .0052011
```

Variance Inflation Factor Analysis

We began the Variance Inflation Factor analysis with one dependent and one independent variable. The independent variables tested are shown in the column headers of Table XII while the dependent variables are shown in the row headers of the table.

The VIF is only above 10 on one occasion, with the introduction of the difference between port berths in the last estimation. This signals very high correlation, as the R-square of the estimation is almost unit. The independent variables in the estimation can be used to predict the values that the dependent variable will take. Adding the variable port berths into our multinomial logit model will not improve our estimation as a result.

High values for the VIF also occur for the Crane Congestion, Terminal Handling Charges and Port Depth (Draft) variables. Although the VIF is not higher than 10, it is still sufficiently large to raise some questions as to the amount of information that the variables could add to the multinomial logit estimations. One particular concern was that all the variables mentioned are specific to the port they are related to. Thus, the variation of one of the factors would trigger the variation of the others and would make it difficult to separate the influence of one port related factor over the others'.

The Port Depth (9) and Port Berth (10) variables were the first two to be discarded from the final specification of the multinomial logit model. Next, we turned our attention to the Crane Congestion (8) and Terminal Handling Charge (11) variables. If analysed individually, they produce a relatively low VIF. When the Crane Congestion variable is introduced as an independent variable in estimation 12, the VIF soars to 7.45. Furthermore, the t-statistic of the Crane Congestion is very high, which signifies that the variables has a great deal of importance in explaining the values of the dependent variable. Furthermore, both in estimations 8 and 11, the factors with most influence are the Maritime diversion distance (ΔMm), port ownership binary variables and hinterland modes. The decision was made that both the variables would be excluded from the final multinomial logit specification. Adding both variables was not expected to significantly help the estimation.

Table XII: Variance Inflation Factor analysis results

			Independent variables										Regression information				
Nr.	Dependent variable		Const.	ΔCm	ΔTm	ΔMm	D Rail	D Barge	D Private (S comp)	D Private (operator)	D in country	ΔCrane Congestion	Obs.	F-test	R-square	Adj. R-square	VIF
1	ΔTm	Coef.	1230.40	1.57									2924	972.12	0.25	0.25	1.33
		t-stat	46.47**	31.18**													
2	ΔMm	Coef.	-0.24	0.00	0.00								2924	29.68	0.02	0.02	1.02
		t-stat	-45.62**	-7.05**	6.21**												
3	D Rail	Coef.	0.25	0.00	0.00	-0.07							2924	449.97	0.32	0.32	1.46
		t-stat	18.13**	-34.34**	28.30**	-1.87											
4	D Barge	Coef.	-0.05	0.00	0.00	0.03							2924	779.31	0.44	0.44	1.80
		t-stat	-16.72**	-26.40**	47.33**	3.75**											
5	D Private (S comp)	Coef.	-0.20	0.00	0.00	-1.43	0.02	0.10					2924	2214.61	0.79	0.79	4.79
		t-stat	-36.39**	0.80	2.96**	-104.28**	1.66	2.33*									
6	D Private (operator)	Coef.	0.27	0.00	0.00	0.57	0.08	0.58					2924	119.12	0.17	0.17	1.20
		t-stat	20.58**	0.23	1.96*	17.43**	3.24**	5.69**									
7	D in country	Coef.	0.16	0.00	0.00	-0.32	-0.02	0.44	-0.02	-0.07			2924	55.31	0.12	0.12	1.13
		t-stat	9.52**	-4.81**	-4.08**	-4.41**	-0.82	4.45**	-0.36	-3.63**							
8	ΔCrane Congestion	Coef.	-0.46	0.00	0.00	-1.07	0.10	0.68	-0.84	0.04	-0.01		2924	256.40	0.41	0.41	1.70
		t-stat	-57.98**	3.89**	-6.33**	-31.14**	9.24**	14.35**	-40.31**	4.07**	-1.07						
9	ΔPort Depth	Coef.	-0.22	0.00	0.00	-0.21	-0.05	-0.33	0.20	0.33	0.00		2924	1767.78	0.82	0.82	5.83
		t-stat	-15.22**	-7.35**	13.70**	-15.22**	-12.23**	-17.59**	23.71**	95.98**	0.00						
10	ΔPort Berths	Coef.	-0.36	0.00	-0.00	0.53	0.02	0.18	3.20	0.19	0.02		2924	34390.13	0.98	0.98	95.24
		t-stat	-78.49**	-0.70	-1.15	26.62**	4.07**	6.73**	262.91**	38.79**	5.01**						
11	ΔTHC	Coef.	0.36	-0.00	0.00	0.54	-0.05	-0.37	0.14	-0.03	-0.02		2924	246.71	0.40	0.40	1.67
		t-stat	81.08**	-1.67	2.32*	27.60**	-8.36**	-13.90**	12.17**	-7.61**	-5.13**						
12	ΔTHC	Coef.	0.13	0.00	0.00	0.00	0.00	-0.03	-0.27	-0.02	-0.03	-0.50	2924	2096.24	0.87	0.87	7.45
		t-stat	43.19**	3.70**	-6.81**	0.32	-0.47	-2.57*	-39.46**	-8.48**	-12.82**	-100.36**					

* significant at 5% significance level

** significant at 1% significance level