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The impact of the expanded Panama Canal on port range choice for cargo flows from the U.S. to Europe

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ABSTRACT

The works to double the capacity of the Panama Canal were completed in 2016. This may have significant implications on the maritime flows of goods, both locally and on international shipping routes between the US, Asia and Europe. This paper examines the impact of the expanded Panama Canal on potential shifts of cargo flows from one port region to another in either the US or Europe via different case studies.

The analysis uses a model designed for calculating the generalised cost of transporting a container from origin to destination. This model has been extended with more detailed geographical coverage for the US and additional functionalities.

From the different performed case studies, before and after the expansion of the Panama Canal, for cargo flows form the US to Europe, it can be concluded that there is an effect of the new Panama Canal on the port range selection, in both the US and even, to a lesser extent, also in Europe.

This article is a revised and expanded version of a paper entitled Impact of the new Panama Canal on the competitiveness of the Hamburg - Le Havre range ports presented at the 44th European Transport Conference 2016, 05-07 October, 2016, Barcelona, Spain.

Keywords: Maritime logistics chains, ports, hinterland transportation, container ships, Panama Canal expansion

1. INTRODUCTION

The Panama Canal is an important connection for maritime trade lines on the East-West and North-South routes of the American continent due to its unique geographical position between the Atlantic and Pacific oceans. The Canal is 81 km long and enables vessels to benefit from large savings in time and distance when compared to alternative routes via the Strait of Magellan.

The expansion of the Panama Canal was completed in 2016. In particular, new locks have been built and existing channels have been deepened in order to allow for the passage of larger vessels. Before the expansion project, the Canal was suitable for container vessels up to 4,400 TEU. Since 2016, after a considerable investment project, estimated at between 5.4 to 6.22 billion dollars[1], 13,000 TEU vessels can pass through the Canal. (SRM, 2016)

This expansion may have significant implications on the maritime flows of goods, both locally in the US, and on international container loops between the US, Asia and Europe. On the cargo flows between Asia and the US, some effects are already being observed. Imports through the West Coast ports are decreasing, while the ones via the East coast are increasing. Market Waves (2017) reports that the Canal expansion's manifold impacts on US trucking are already starting to be felt. Large shifts in freight from the West Coast to the East Coast will lessen demand for West Coast intermodal, rail, and longhaul capacity.

Based on data from the Panama Canal Authority (2012,2016, 2019) and Quijano (2017), the transit throughput evolution of the Panama Canal two years before the opening of the expanded Panama Canal (EPC) till three years after was determined. Based on this data, it can be concluded that the total transit throughput via the Panama Canal grew from 220 million long tonnes[2] in the pre-expansion period to 255 million long tonnes in the post-expansion period, which is an increase by 12%. The data also shows that the transit volumes going from the US and the Canadian West Coast to Europe are relatively small (4% before the expansion, to 5% after the expansion) compared to the total transit volume. However, the absolute volume has gone up from 9.8 million long tonnes to 12.5 million long tonnes, which is an increase by 16%.

This leads to the fundamental question whether the expansion of the Panama Canal could also impact on the structure of the container loops from the US to Europe, and due to these changes also have an impact on the selection of port regions in both the US and even Europe. This means that the Panama Canal not only impacts on the ports in the US but possibly also in Europe.

[1] Depending on the source, Wall Street Journal (2016) reports 5.4 billion US$, while SRM (2016) claims a figure of 6.22 billion US$.
[2] A long tonne is defined as exactly 2,240 pounds, which is 1.016 metric tons

This research examines the hypothesis that the EPC may induce new logistics chains from the US to Europe, that are currently passing via US East Coast ports, to shift to US West Coast ports. Furthermore, this might imply that instead of sailing to or from European Hamburg – Le Havre (HLH) range ports, ships now could start using Mediterranean (MED) Ports.

In the developed case study, the loops from the US to Europe before the expansion, both in ship size and number of vessels, for the container loops of CMA-CGM[3] and are given in table 1[4]. Table 1 shows that until the expansion, two CMA-CGM container loops from the US to Europe went from the US East Coast ports (e.g. New York, Savannah, etc.) to HLH range ports in Europe. There was one loop, with six vessels, calling at the MED ports in Europe. There were no loops from the US West Coast ports to Europe via the Panama Canal.

Table 1: Container loops of CMA-CGM in 2016 from the US to Europe before the expansion of the Panama Canal

	Hamburg – Le Havre			**Mediterranean range**		
	# loops	Average vessel size in TEU	# vessels	# loops	Average vessel size in TEU	# vessels
US East Coast	2	6,000	12	1	6,000	6
US West Coast	n/a	n/a	n/a	n/a	n/a	n/a

Source: Based on data CMA-CGM (2016)

The expansion of the Panama Canal enables 13,000 TEU vessels to sail from the US West Coast ports through the Panama Canal to Europe, calling at either the HLH or the MED range. In Figure 1, the solid lines represent the transport chain before the expansion, while the dotted lines show the potential new transport chains from the US to Europe.

Figure 1: The cargo flows from the US to Europe via the Panama Canal
Source: Own composition

Therefore, if cargo flows from the West of the US are potentially redirected from East Coast to West Coast ports, a new maritime supply chain can be formed to either the HLH range or the MED range in Europe. It is the purpose of this paper to research this latter effect.

In summary, the following research question will be analysed in this paper:

What is the potential effect of the expansion of the Panama Canal for port range choice, both in the U.S and Europe, for cargo flows from the US to Europe?

In order to answer this question, a generalised cost simulation model was built. From each point of origin in the US (state level) to Europe (NUTS-2 regions[5]), the generalised chain

[3] CMA-CGM is the third largest container shipping company in the world in 2017 behind Maersk and MSC. Its loop structures and their evolution are best documented.
[4] Only CMA-CGM, in contrast to Maersk and MSC, publishes this information via their website.
[5] NUTS-2 areas in Europe are basic regions for the application of regional policies.

costs are calculated for the container loops existing before the expansion and for potential new ones.

Not all US cargo flows to Europe are eligible for re-shifting. For example, cargo originating from New York with a destination in Europe will always go via the US East Coast ports. For the cargo flows originating between the Mid-West and the West of the US, it needs to be investigated whether the cargo flows to Europe are eligible for a shift from the East Coast to the West Coast and/or from the HLH range to the MED ports.

This paper is structured as follows. The following section contains a literature review. Section 3 explains the applied methodology in detail. Section 4 presents the scenario analysis and the empirical results of the case study. Finally, section 5 draws conclusions.

2. LITERATURE REVIEW

The literature review is built up from two parts. Firstly, an overview is given on the main changes in the maritime and port sector, as observed by academia. Secondly, the recent development of the extended Panama Canal is given.

2.1 Main developments in the maritime and port sector

The maritime and port sector is continuously changing. This has become particularly noticeable in the shift in competition that has taken place in recent years. Whereas in the past, shipowners and ports used to compete with one another, the competitive struggle is now increasingly unfolding at the level of logistics chains (Meersman et al., 2010).

Carbone, V. & De Martino, M. (2003), Song& Panayides (2008) and Pettit & Beresford (2009), among others, highlight the changing role of a port which has become a node in a large supply chain network. All of this research concludes that in order for ports to stay competitive, they need to be integrated in the global supply chains.

Next to the changing role of ports, also further integration of ports in the hinterland is being observed. Notteboom & Rodrigue (2005) conceptualize this complex inland penetration of ports as port regionalisation. van Hassel et al (2016) show that the hinterland cost of the transport chain becomes more dominant in the total transport chain.

The above implies that the expansion of the Panama Canal could influence the route of logistics chains, and it may make certain chains connecting particular ports more attractive. Therefore, a maritime supply chain has to be analysed, which includes maritime transport, ports and hinterland transport.

With respect to the impact of the expansion of the Panama Canal of possible shifts on the route of logistics chains, similar rerouting research has also been done for the Arctic route.

Furuichi & Otsuka (2015) and Pruyn (2016) for instance indicate the impact of the possible opening of the artic route on a shift in cargo flows from Asia to Europe. Conceptual as well as impact lessons from those studies can be used in this paper.

2.2 The expanded Panama Canal

The main body of the literature review deals with the recent developments related to the EPC. The references below are presented in chronological order, as that sequence also shows how the scientific contributions have built on each other, and refined the applications and analyses with respect to the Panama Canal potential.

Ungo and Sabonge (2012) build an analytical tool to analyse the competitive position of the Panama Canal compared to other maritime supply chains. Ungo and De Ducreux (2014) analyse the impact of the expansion of the Panama Canal from a generalised cost perspective for a cargo route going from Asia to the US East Coast. This study shows that the competitiveness of the EPC route improves due to enhanced economies of scale. The type of goods and the different routes of a supply chain are also important factors in the analysis.

Veldman et al. (2014) study the effect of deploying larger vessels on the trade routes between Asia and the US. The authors analyse different routes, such as those via the Suez Canal (SCR), the land bridge route (via the US West Coast ports), the EPC and the Gran Canal Interoceánico de Nicaragua (GCIN). From this analysis, it is expected that in 2030, the GCIN will have been operational for some years and that the combined market share of the GCIN and the EPC is expected to reach a 41% share of the total container shipping capacity employed on the North America - East Asia trade route.

Rodrigue and Notteboom (2015) argue that the most important impact of the EPC is on the trade relation between Asia and the US, and that the EPC will accommodate the trade relation between Asia and the US East Coast ports.

Rodrigue and Asaf (2015) examine the role of the possible emergence of transhipment hubs in the Caribbean due to the expansion of the Panama Canal. The authors argue that the transhipment function in the Caribbean will increase in two phases. The first phase would favour the continuation of the existing configuration of direct services to the US East Coast. The second phase would attract new new-Panamax ships of 13,500 TEU that cannot be handled efficiently by most East Coast ports. This could foster substantial growth in transhipment activities in the Caribbean.

Ducruet (2016) shows the key role of the world's two interoceanic canals: the Suez Canal and the Panama Canal. He measures that role both in terms of the geographic coverage and the network-topological properties of canal-dependent flows. His findings show that certain areas, such as Asia, Europe, and North America, remain more dependent on the Panama Canal than others.

With regard to the specific impacts of the EPC, Martinez et al. (2016) show that US West Coast shipments often have lower transit times but higher freight charges than US East Coast shipments. Their coast choice model shows that if the Panama Canal expansion generates significant transit time savings on shipments from Asia, there will be major shifts in traffic from US West to East Coast ports. Liu et al. (2016) apply game theory to assess the power relationship between the various supply chain players after the Canal's enlargement. The paper shows that the fact that larger ships can pass through the Panama Canal will increase the US East Coast players' market power while damaging that of the US West Coast players.

Bhadury (2016) shows that the Panama Canal expansion will impact on the growth in throughput of the US East Coast ports. The ports of Newark / New York, Norfolk, and Charleston are the ones that are likely to see the highest amount of growth in the coming decade. The ports of Houston, Miami, and Savannah are also likely to see an increased cargo traffic, but less than the three ports named above. As for the remaining other US East Coast ports, growth or lack thereof will be influenced primarily by port-specific factors.

Due to the expansion of the Panama Canal, many ports on the Atlantic side of the Canal rushed to make plans to dredge and increase their water depth. Doing this is not such an easy task in the United States (Bell, 2016). The first step is to petition the U.S. Army Corps of Engineers, which could take several years. In addition to the lengthy process of paperwork, there is the issue of funding. The majority of ports are state-owned in one way or another, which means they receive partial funding from the State and Federal Governments for projects such as dredging. However, due to the expense, other sources of private revenue must be found to complement the public funds received. The Federal Government alone spent $320 million in five years on dredging the East coast and the Gulf of Mexico in the period 2009 and 2014 (SRM, 2016). This means that, for any analysis for the distant future, the current-day situation with respect to vessel size limitations of the U.S. East Coast ports is to be used.

Pagano et al. (2016) study the effects and impact of the new Panama Canal on Panama's maritime cluster. From their work, it can be concluded that the Canal and the ports can be identified as driver industries. Based on their analysis, they conclude that cluster economies and network effects will expand over three times with the new locks in place by 2025.

The research conducted in this paper capitalizes on the above-mentioned findings in the literature. This research goes further, in both its scope and its approach compared to the existing literature. It does so in scope, where possible port call changes on both sides (U.S. as well as Europe) of the transport chain as a consequence of an EPC are taken into account. Also, this research focuses on the impact on cargo flows going from the US to Europe, which was not researched in the literature so far. In terms of approach, this paper applies a chain cost simulation model, which includes both the maritime, port and land components.

3. METHODOLOGY AND MODELLING APPROACH

The method applied is a maritime supply Chain Cost Model. An initial version of this model was proposed by van Hassel et al. (2016b) and for the purpose of this paper, this model has been expanded and adapted in order to deal with the specific research questions. Section 3.1 provides a brief general overview of the model and its components. The input parameters are given in section 3.2. Subsequently, section 3.3 looks at some of the adaptations to the base model.

This approach was chosen as it allows not only calculating the generalised cost for a total logistics chain, in which ports play a vital role, but also building different scenarios, with and without the EPC. Other methods, mentioned in the literature review, did not have this ability, and therefore this model is used to address to proposed research questions.

The main goal of this research is to determine the effect the EPC has on port range selection, which implies that port selection should play an important in the model. With respect to port choice, Nazemzadeh & Vanelslander (2015) indicate that there are five main port selection criteria, which are, ranked in order of importance: port cost, quality of hinterland connection, geographical location, port productivity and port capacity. All of these elements are incorporated in the model and all of them will be reflected in the total generalized chain cost.

3.1 Overview of the base model

The purpose of the base Chain Cost Model is to calculate the generalised chain cost per TEU from a selected point of origin in the hinterland, via a predefined, user determined, container loop, to a destination point in another hinterland. This container loop determines the maritime leg of the supply chain. Figure 2 provides a general overview of the original model (van Hassel et al., 2016b).

Figure 2. Conceptual representation of the Chain Cost Model
Source: van Hassel et al. (2016b)

In the Chain Cost Model, different world regions, here defined as aggregated hinterlands, are connected via a route along ports (bold lines in Figure 3). The aggregated hinterlands are defined as a summation of different smaller geographical areas, which in Europe correspond to NUTS-2 areas. Each aggregated hinterland is served by at least one and usually several ports. Each port is built up of a set of terminals, all of which have their own set of characteristics. From each port terminal, the hinterland connections via the three main hinterland modes (road, rail and inland waterways (if applicable)) to all the disaggregated hinterland regions are incorporated into the model. (van Hassel et al., 2016b)

In the model, a logistics chain is defined as a route from a specific hinterland region (*i*) to another hinterland region (*j*). A chain therefore has a beginning and an end. The region where the origin of the chain is located situated is defined as the aggregated *from*-hinterland (*Y*), whereas the location of the end of the chain is referred to as the aggregated *to*-hinterland (Z) (van Hassel et al., 2016b)

For all these different logistics chains, the generalised costs are calculated. The generalised cost approach is used in order to determine the competiveness of a port (region) in a container loop and to determine which transport chain has, between origin i and destination j, the lowest generalised chain cost. The shipper's preferences for a logistics chain, including the port choice, are influenced to a large extent by these generalised costs. These include the direct out-of-pocket and time cost, but also the reliability, flexibility of a transport chain and even the quality of a port information system can be part of the generalised cost. However, these later aspects are more difficult to quantify than the out-of-pocket cost and the time cost. The initial Chain Cost Model incorporates the most important decision criteria for shippers, forwarders and shipping companies are. These are: out-of-pocket cost (for the total transport chain), time (also for the total transport chain), port infrastructure[6] (which is expressed in the number of container cranes, maximum draughts at terminals, quay wall length, which all relate to the port productivity and capacity) and port location (which relates to the geographical location of the port). The generalised cost between origin i and destination j ($GC_{i,j}$) can be calculated with the following formula:

$$GC_{i,j} = OPC_{i,j} + T_{i,j}.VoT_k \quad (1)$$

In which $OPC_{i,j}$ are the out-of-pocket costs for a transport chain between origin i in aggregated hinterland Y and destination j in aggregated hinterland Z in EUR/TEU. $T_{i,j}$ is the total transport time between origin i and destination j in days. VoT_k is the value of time of product type k in EUR/day. In this research, the average value of a container load is taken between the US and Europe. O'Sullivan (2010) provides estimations for this, and these values are indexed to 2016 values. In this research, a yearly depreciation rate of 10% per year is used, to calculate the daily cargo depreciation.

An important element of the generalised cost is the transport time for the entire transport chain, which is therefore incorporated in the model. This means that the transport time from a hinterland region (including a dwell time at an inland terminal for rail or IWT) to a port, the dwell time of a container at a deep-sea port, the maritime transport and the reverse port and land transport times at the destination hinterland are taken into account. This means that a change in a loop structure will impact on the generalised cost of the total logistics chain (including the transport time).

In the generalised cost formula, $OPC_{i,j}$ is built up from different chain cost elements: hinterland transport in the origin hinterland ($OPC_{Hint,i,y}$), the port-related cost in the origin hinterland ($OPC_{Port,i,y}$), the maritime transport cost between the port in the origin hinterland Y

[6] Where the port cost relates to the direct port calling cost and the cost and time of the hinterland transport, related to the quality of the hinterland connections of the port.

and destination hinterland Z ($OPC_{Mar,Y,Z}$), the port-related cost in the destination hinterland ($OPC_{Port,j}$) and the hinterland cost from the destination port to the final destination ($OPC_{Hint,j}$).

$$OPC_{i,j} = OPC_{\text{Hint,i,y}} + OPC_{\text{Port,i,y}} + OPC_{\text{Mar,y,Z}} + OPC_{\text{Port,j,Z}} + OPC_{\text{Hint,j,Z}} \quad (2)$$

Based on this approach, the first approximation of the captive hinterland distribution based on the lowest generalised costs, for both the ports in the origin and destination hinterland, can be calculated using this model.

For each mode of hinterland transport, the cost functions are built in the model. These cost functions are explained in van Hassel et al (2016a). Based on these cost functions, it is possible to determine the hinterland competitiveness of each port. For instance, the major container ports in the HLH range can use all three modes, while the ports in the MED region lack IWT. These effects are incorporated in the used model.

With respect to the ports in the model, the different involved cost factors are taken into account. These encompass port dues, pilotage dues, the use of tug boats and container handling. On top of that, also the physical parameters of the ports are built in the model, such as the quay wall length, the number of container cranes, and the draught limitations to the port. The process of handling a container vessel at a port is modelled as different queues, using queueing theory. Therefore, based on the actual throughput of a port, the total handling time and cost can be calculated. For a more detailed description of this part of the model, reference is made to van Hassel et al. (2016a).

The base version of the model has also been used for a research project about nearshoring strategies for large European shippers (Neyens et al., 2016). In this project, four different maritime supply chains were analysed for two large shippers, which acts as a good validation effort with reality. The results of the calculated supply chain cost turned out to be very much in line with was observed in reality by those shippers.

3.2 Input parameters

The input parameters in the Chain Cost Model can be grouped into three categories. Firstly, input is needed to form container loop. In the model, an actual loop can be built by using data obtained from the websites of the concerned container lines. In the Chain Cost Model, it is possible to build a container loop for which a database of 70 different ports can be used. Also, a specific vessel needs to be selected that is deployed on this specific loop. The main standard input parameters related to the ship are a sailing speed of 22 knots and a capacity utilization of 80%. Secondly, there is the input data related to the ports. As a default setting, the handling rate of the container cranes is set at 30 moves per hour for the HLH range and the US ports and at 25 moves per hour for the MED ports[7]. All other input parameters are taken from port and terminal websites and other sources such as Drewry (2015) for the terminal throughputs. Thirdly, there is the input related to the hinterland transport modes. The main cost factors can be seen in van Hassel et al. (2016a), while the capacity utilization of inland vessels and trains is assumed to be 80%.

3.3 Adjustments to the base model

The focus of this article is on the potential shift of cargo flows from the US to Europe due to the enlargement of the Panama Canal. Specifically, flows originating mainly in the western part of the US which traditionally were transported by train to the US East Coast ports will be considered. The fact that larger ships can pass through the EPC may generate economies of scale on the maritime leg, which may make it less expensive to ship cargo from US West Coast ports to Europe. van Hassel et al. (2016b) already included six main container ports in the MED area in the Chain Cost Model: Koper, Marseille, Algeciras, Valencia, Barcelona and Genoa. In order to perform the required analysis, the ports on the West Coast of the US must also be included. The following ports have therefore been added to the model for this paper: Seattle, Tacoma, Portland (Oregon), Oakland, Los Angeles and Long Beach.

For each port, a new set of data was collected, which consists of the following elements: technical data related to maritime access to the port on the one hand, and terminal infrastructure characteristics on the other. Also the terminal throughput, terminal equipment and port-entering cost parameters are included. Finally, also the hinterland data related to the distance (for each US port to the each US mainland State) and the hinterland cost were collected.

The rail distances are based on Open Street Map Data (OpenStreetMap, 2015) for the US. The distance data from each port terminal to each rail terminal has been determined using a shortest path algorithm over the rail networks. Both the distances via road from port terminals and the distance from a rail terminal to the centroid of a US state region have been determined by means of the Google Maps algorithm.

The cost data for the US hinterland modes have been taken from the American Transportation Research Institute (ATRI, 2015) which provides figures on the operational cost of trucking in the US. The rail cost structure of Europe has also been used for the US. The cost elements have been scaled according to data taken from Association of American Railroads (2016) to obtain the US cost. As such, it is possible to calculate the generalised hinterland cost from a specific state to a port.

[7] JOC (2014) states that the berth productivity in the Mediterranean region (Algeciras (76 moves per hour per vessel) and Barcelona (71)) is lower than for the Hamburg – Le Havre range (Rotterdam (86) and Hamburg (81)).

The transit cost function of passing the Panama Canal has also been incorporated. The cost elements have been taken from Verbueken (2014) and updated to 2016 values by using the official tariffs published by the Panama Canal Authority (2016). Using this cost function, both the transit cost of current ship types and of the larger ones can be calculated.

In addition to adding more data into the model, structural modifications and improvements have been made to the Chain Cost Model version of van Hassel et al. (2016b). The first one is the introduction of truck-driver waiting and resting times, which differ between the EU and the US. The regimes are taken from EC (2016) for Europe and FMCSA (2016) for the US. The reason for adding the driving and resting times is to fine-tune the total transport time. The effects of driving and resting times become more important when long haulage from seaports is considered.

The second major structural improvement is fitting the hinterland model of Europe. Based on data provided by the Port of Antwerp, the modal split figures per NUTS-2 region in Europe are incorporated. In the original Chain Cost Model of van Hassel (2016b), a logit-type model was used to calculate the modal split from a specific terminal to a hinterland region. With the provided model split data and the implemented new driving and resting times for road transport, a new fit has been made to better align the calculated modal split with the observed one. By doing this, it also becomes possible to analyse effects of changing input parameters related to the hinterland cost on the modal split.

4. SCENARIO ANALYSIS AND EMPIRICAL RESULTS

In order to study the impact of the expansion of the Panama Canal on the possible changes in the structure of the container loops between the US and Europe and as a result on the port range selection, two different scenarios have been developed: one for the former situation in which the Panama Canal has not been expanded (scenario 1), and one for the new situation where the Canal has been expanded (scenario 2). Each scenario consists of a number of different cases. The reason to use this case study approach is that approximately 12,000 different origin-destination pairs can be formed between the US and Europe. In order to maintain the overview in this large number of cases, only those which give the most information about the effect of the expansion of the Panama Canal will be used. The overview of the scenarios is presented in Table 2.

Table 2: Developed scenarios

	Panama Canal	Origin	US port range(s)	Destination	EU port ranges
Scenario 1 Case_A	Old situation	New York State	EAST Coast	Europe	HLH / MED
Scenario 1 Case_B	Old situation	California	EAST Coast	Europe	HLH / MED
Scenario 2 Case_A	New situation	California	WEST Coast	Europe	HLH / MED
Scenario 2 Case_B	New situation	Texas	EAST / WEST Coast	Europe	HLH / MED
Scenario 2 Case_C	New situation	US	EAST / WEST Coast	Munich	HLH / MED

In the first scenario, there are two cases. In the first case, scenario 1A, the origin of the transport chain is in New York State, while the destination of the chain is the whole of Europe. In this scenario, a US East Coast port (New York) is used, while in Europe, two possible port ranges can be used: HLH or MED. This means that the competition between these two port ranges can be examined. In scenario 1B, the origin of the cargo flows is the State of California and the destination is the same as in scenario 1A. In this case, the hinterland transport component from California to the US East Coast is included in the analysis.

For the second scenario, a new container loop via the EPC has been analysed. This scenario has three different cases. In the first case study, scenario 2A, the origin of the cargo flows is in California, but now the US West Coast ports (Los Angeles or Long Beach) are used. The second case, scenario 2B, has Texas in the US as an origin, with a destination in Europe. For these cargo flows, an analysis is done for each possible port combination (East Coast US – HLH, East Coast US – MED, West Coast US – HLH and West Coast US – MED). In the last case, scenario 2C, the origin of the transport chain is the whole of the US and the destination is Munich. An analysis is again done for each possible port combination (East Coast US – HLH, East Coast US – MED, West Coast US – HLH and West Coast US – MED) for these cargo flows.

4.1 Scenario 1: The pre-expansion situation

The first scenario analyses container flows from New York State and California to Europe during the period before the expansion of the Panama Canal. All flows are shipped from East Coast ports.

4.1.1 Case 1A: New York State – Europe

To calculate the generalised costs when the HLH ports are called at, the CMA-CGM Liberty Bridge loop 2 is used[8]. Ships with an average capacity of 6,000 TEU are being deployed on this loop. For the calculations, the main standard input parameters are used as described in

[8] The Liberty Bridge 2 service will be suspended in order to adjust the capacity of CMA-CGM on the Transatlantic trade. (CMA-CGM, 2016)

section 3.2. The loop calling pattern is as follows: Miami - Savannah - New York - Antwerp - Bremerhaven - Rotterdam - Le Havre - New York - Norfolk - Miami. When the MED ports are used, the CMA-CGM Amerigo loop is taken. Again, ships with an average slot capacity of 6,000 TEU are used. The loop calling pattern is as follows: New York – Norfolk – Savannah - Miami – Algeciras - Valencia – Malta (Free port) – Genoa – Marseille (Fos) – Barcelona – Valencia – New York.

Figure 3 shows the European hinterland division based on the generalised cost of transporting from New York State to the different NUTS-2 regions in Europe. These cargo flows can either go via HLH or via MED. For each NUTS-2 region, it is determined which port, in the respective port ranges, will lead to the lowest generalised chain cost. If the generalised costs to a NUTS-2 region are the lowest via a port in HLH, then those regions are marked with plusses. When a chain has the lowest generalised costs via a port in MED, then the NUTS-2 region is marked with dots. If the generalised cost difference between the two port regions is smaller than 10%, these NUTS-2 regions are marked with diagonal lines. The latter zones can be interpreted as the competitive margin between the two port ranges in Europe. The zones with plusses and dots can be considered the captive hinterland of the HLH respectively MED.

Figure 3: European hinterland split (New York – Europe) using U.S. East Coast ports

From Figure 3, it can be concluded that in this case, the captive hinterland of the HLH ports contains most of Northern Europe. The captive hinterland of the MED ports is limited to the Iberian peninsula, Italy and a small part of Greece. The competitive margin between the two port ranges goes from West to East in Europe. The further eastwards in Europe, the wider the competitive margin becomes. One major city located in the competitive margin is Munich. Table 3 gives a detailed calculation of the generalised chain cost of transporting between New York State and Munich via the ports of Antwerp and Genoa.

Table 3: Total generalised chain costs from New York State to Munich (Germany)

Chain cost elements		via NY - ANT	via NY - GENOA
Hinterland US	[EUR/TEU]	298.95	298.95
Port US	[EUR/TEU]	517.81	517.81
Maritime	[EUR/TEU]	283.82	449.17
Port Europe	[EUR/TEU]	233.98	194.54
Hinterland Europe	[EUR/TEU]	754.96	629.04
Total gen. chain cost	[EUR/TEU]	2,089.51	2,089.50

From Table 3, it can be observed that the difference in generalised cost for chains between New York and Munich going via either Antwerp (HLH) or Genoa (MED) is very small (0.1%). The calculations show that the maritime costs from New York State to Munich via Genoa are much larger than via Antwerp, due to the larger maritime distance between the ports of New York and Genoa. The higher maritime costs via Genoa are however compensated for by lower hinterland costs from Genoa to Munich and lower port costs in Genoa.

4.1.2 Case 1B: California – Europe

In the second case under scenario 1, cargo flows originate in California. The same two existing container loops as in section 4.1.1 are used in the analysis.

From Figure 4, it can be concluded that the competitive margin (areas with diagonal lines) between the two port ranges becomes larger as compared to scenario 1A. This is due to the fact that in this case, a large US hinterland cost component also has to be included. This cost component is added to cargo flows that go via HLH and MED ports. This means that the relative cost difference, in percentages, between the two port regions becomes smaller. Another effect is that another US East Coast port is used. From the included ports, Savannah is the port that will lead to the lowest generalised chain cost for cargo flows from California to Europe. Thus, the size of the captive hinterland and the competitive margin of the HLH and the MED ports is impacted on by the hinterland component and the port choice in the US.

Figure 4: European hinterland split (California – Europe) using East Coast ports

Table 4 shows the detailed chain cost from California to Munich, via HLH (Antwerp) or MED (Genoa).

Table 4: Total generalised chain costs from California to Munich (Germany)

Chain cost elements		via SAV - ANT	via SAV - GEN
Hinterland US	[EUR/TEU]	975.79	975.79
Port US	[EUR/TEU]	550.49	550.49
Maritime	[EUR/TEU]	311.17	416.04
Port Europe	[EUR/TEU]	233.98	194.54
Hinterland Europe	[EUR/TEU]	754.96	629.04
Total gen. chain cost	[EUR/TEU]	2,826.38	2,765.90

The cost of going via Savannah and Antwerp is 2.1% higher than via Savannah and Genoa. The maritime cost for the chain going to the MED region is lower than in scenario 1A. The reason is that the calling sequence of ports in the US is different compared to the loop going to the HLH range. Using the port of Savannah, which is called at after New York, makes the maritime distance smaller, resulting in a lower generalised maritime cost.

4.2 Scenario 2: The EPC situation

In the second scenario, the impact of the EPC is analysed. Three different cases are used to illustrate this.

4.2.1 Case 2A: California – Europe

The first case under scenario 2 is a new loop via the US West Coast to the HLH with the following ports of call: Los Angeles - Oakland - Seattle - Long Beach – Antwerp – Bremerhaven – Rotterdam – Le Havre – Los Angeles. The second alternative is a new loop via the US West Coast to the MED, calling in the following ports: Los Angeles - Oakland - Seattle - Long Beach - Sines - Barcelona - Marseilles - Genoa - Los Angeles. As the EPC can handle 13,000 TEU vessels, compared to 6,000 TEU vessels before its expansion, it is assumed that 13,000 TEU vessels with a capacity utilisation of 80% are used in this loop.

Figure 5: European hinterland split for cargo flows between Europe and California using new loops via EPC

Comparing Figures 4 and 5 shows that the differences in hinterland split between the HLH range and the MED range are very small. This means that if new loops to both HLH and to MED were to emerge, the balance between the European port regions would remain almost the same. The captive hinterland of the MED ports increases slightly in Northern Italy and Southern Switzerland.

Table 5 shows the detailed chain cost from California to Munich, via Antwerp and Genoa.

Table 5 : Total generalised chain costs from California to Munich (Germany) using the EPC

Chain cost elements		via LA - ANT (EPC)	via LA – GEN (EPC)
Hinterland US	[EUR/TEU]	369.55	369.55
Port US	[EUR/TEU]	439.98	439.98
Maritime	[EUR/TEU]	529.77	584.43
Port Europe	[EUR/TEU]	225.23	189.52
Hinterland Europe	[EUR/TEU]	754.96	629.04
Total gen. chain cost	[EUR/TEU]	2,319.49	2,212.52

If Table 5 is compared to Table 4, it can also be observed that the port costs per TEU in Europe are reduced by 4% due to the deployment of large container vessels.

The difference in chain cost for cargo flows going via the US West Coast to the HLH and MED, results in larger differences between the two European port regions (4.6%) than in the original situation (via the US East Coast ports). This larger difference is explained by the fact that by using the expanded Panama Canal, the maritime cost to Antwerp increases more than to Genoa.

4.2.2 Case 2B: Texas – Europe

The second case under scenario 2 considers the cargo flow between Texas and Europe. Four different cargo flows are analysed, since there are two port ranges in both the US and in Europe. For that reason, the NUTS-2 regions in Europe are marked for each of the possible port range combinations. The results can be found in Figure 6.

The hinterland regions in Europe that have the lowest generalised chain cost via the HLH, regardless of whether the US East or West Coast ports are used, are marked with plusses. The areas with dots are those areas which have the lowest generalised chain cost via MED, regardless of whether the US East or West Coast ports are used.

From Figure 6, it can be concluded that there is a large competitive margin in both the US (East vs West) and in Europe (HLH vs MED). This competitive margin is marked with the different diagonal lines. The northern part of this competitive margin, which is marked with the single diagonal lines from top left to bottom right, are regions for which the combination US West Coast – MED ports is always too expensive to be chosen. The same applies to the regions with single diagonal lines (top right to bottom left) where the cargo flow via the US West Coast– HLH is not included. The regions with double diagonal lines are those regions for which there is no preference for port region (less than 10% cost difference). The total competitive margin is almost similar to that for cargo flows coming from California (Figure 4).

Figure 6: European hinterland split for cargo flows between Europe and Texas via the east Coast or via the West Coast using new loops via EPC

Table 6 gives a more detailed calculation for the different chains going from Texas to Munich. It is clear that the lowest costs are for the situation in which the cargo is transported over land to Savannah and from there via Genoa to Munich. The option of using LA and the EPC is always more expensive in this specific case. However, the differences are small. The hinterland cost in the US is almost the same, independent of whether a West Coast or an East Coast port is used. Port costs in Savannah are higher than in LA, but this difference is compensated for by a shorter maritime distance and, as a consequence, lower maritime costs.

Table 6: Total generalised chain costs from Texas (US) to Munich (Germany)

Chain cost elements		via SAV - ANT	via SAV - GEN	via LA - ANT (EPC)	via LA - GEN (EPC)
Hinterland US	[EUR/TEU]	600.56	600.56	615.61	615.61
Port US	[EUR/TEU]	550.49	550.49	439.98	439.98
Maritime	[EUR/TEU]	311.17	416.04	529.77	584.43
Port Europe	[EUR/TEU]	233.98	194.54	225.23	189.52
Hinterland Europe	[EUR/TEU]	754.96	629.04	754.96	629.04
Total gen. chain cost	[EUR/TEU]	2,451.15	2,390.67	2,565.55	2,458.58

4.2.3 Case 2C: US – Munich

In this third case under scenario 2, the whole of the US is used as the origin of the cargo, with a destination in Munich. Whether the flows to Munich pass through the East Coast or West Coast ports in the US and through the HLH or MED ports in Europe will depend upon where they originate in the US. Figure 7 shows the results of the comparison of the general cost calculations for the four possible combinations (East Coast - HLH, East Coast - MED, West Coast - HLH, West Coast – MED) for every state.

Figure 7: US hinterland split for cargo flows with destination Munich

The US hinterland areas which have the lowest generalised cost to Munich via the US West Coast ports and the Panama Canal, regardless of whether the HLH or the MED is used, are marked with plusses. The regions with dots are those which use the US East Coast ports, regardless of whether the HLH or MED regions are used. The regions that are marked with diagonal lines are those regions for which the generalised chain costs, for all four possible chains, differ by less than 10%. The regions with horizontal lines are those regions for which three possible chain costs differ by less than 10% (excluding the US West Coast – HLH which differs by more than 10%).

From Figure 7, it can be concluded that for the US East Coast to the Mid-West, there is a large area for which the US East Coast ports are used. This part of the US hinterland (darker-shaded) will not be influenced by the EPC. The ligther shaded hinterland will exclusively make use of the US West Coast ports. For the cargo flows to Europe, it can be observed from section 4.2.1 that the captive hinterland of the MED ports increases slightly for cargo flows originating on the US West Coast. With respect to the other regions, there is a large area, running from North to South, for which it is not really clear whether the US West or the East Coast ports should be used. This is illustrated for the case from Texas to Europe (figure 7).

5. DISCUSION AND CONCLUSIONS

The expansion of the Panama Canal allows for the deployment of larger ships. It is expected that this will have an impact on the East and West Coast ports in the US for the traffic with Asia. The purpose of this article was to analyse the effects of the EPC on port choice, not only in the US but also in Europe, for cargo flows between the US and Europe. This possible impact of the EPC on other port regions than the U.S, has not yet been researched in the academic literature. Therefore, the following research question was formulated:

What is the potential effect of the expansion of the Panama Canal for port range choice, both in the U.S and Europe, for cargo flows from the US to Europe?

Based on the performed analysis, it can be concluded that the EPC has an impact on the port range choice, for certain cargo flows between the US and Europe.

Where in the past, only the East Coast ports were used for the US - Europe trade, deploying relatively smaller container ships, it now becomes more efficient (i.e. cheaper in terms of generalised costs) for a number of regions in the West of the US to sail with larger ships via the West Coast ports such as Los Angeles or Long Beach and the Panama Canal to Europe.

By comparing the generalised costs per TEU of the entire chain, it is clear that for the cargo flows to Northern Europe, the HLH ports are favoured, regardless of the origin in the US, while for the destinations in Southern Europe, the MED ports are preferred, also regardless of the origin in the US. For these cargo flows, there is no effect of the EPC on the competition between the different port ranges.

However, there is a range from West to East in the middle of Europe where using the HLH or the MED ports for container traffic to/from the US results in very small differences in the generalised cost per TEU of the total transport chain. This is labelled as the competitive margin between the HLH and the MED ports, because a small change in one or more of the generalised cost components may result in a shift of one port range to another. Due to the introduction of the EPC, the competitive margin between the HLH and the MED ports will decrease for cargo flows from the US West Coast states to Europe using West Coast ports. This means that the captive hinterland of the Mediterranean ports for these cargo flows using the US West Coast ports will increase slightly due to the expansion of the Panama Canal. As a result, the port range selection in Europe will be affected.

This is illustrated by detailed calculations for cargo flows from New York State, California and Texas to Munich (Germany). Due to the reduction of generalised hinterland costs per TEU in the US and the use of larger vessels, the total generalised chain costs per TEU will decrease for container flows that go via the US West Coast ports to Europe, compared to transport chains that originate in the West of the US and go via the US East Coast ports to Europe. For these specific cargo flows, the MED ports in Europe will expand their catchment area slightly, at the expense of the cargo flows going via the US East Coast ports and HLH.

For the detailed calculation of cargo flows which originate in the US and have a destination in Munich, it can be concluded that there is a large area, ranging from the US East Coast to the Mid-West, for which the use of US East Coast will always be the preferred port region (in terms of the lowest generalised costs per TEU) to transport cargo to the centre of Europe. These regions are not affected by the expansion of the EPC. The regions in the US that are clearly affected are those that are located close to the US West Coast ports (California, Nevada, Utah, Arizona, Oregon and Washington state). There is also a range of states (from North to South in the middle of the US) for which it makes not much difference in terms of generalised costs per TEU whether an East Coast or a West Coast port is chosen.

If a more detailed calculation is made for cargo flows going from Texas to Munich, the generalised chain costs per TEU for cargo flows going via the US East/West Coast and via the HLH or MED ports are almost identical. This means that due to the expansion of the Panama Canal, more competition can be expected between the US East and West Coast ports, also for cargo flows from the U.S. to Europe. In the literature, it was found that there is a shift possible from US West coast ports to East Coast ports for cargo flows from the US to Asia.

From this research, it can be concluded that an opposite, but smaller, shift is expected for cargo flows from the US to Europe.

The research shows that the investment in the EPC could impact on the structure of the container loops between the US and Europe and as a result impact on the competition between the different port ranges in the US and even in Europe. This means that port range competition will also be affected by infrastructure developments far away from the location of a port range (even as far as in another continent). However, from the research, it can be concluded that the impact of the EPC on the competition between two port ranges in Europe is smaller than it is in the US. This means that the effect of such an investment is less profound in port regions that are geographically further away.

Another important research finding is that both the ports and the hinterland transport modes in both the US and Europe are affected. Due to the potential shift of the identified cargo flows to other port regions, the hinterland operators might experience more competition. This competition could come from other hinterland transport modes. For example, trucking companies could expect more competition if certain cargo flows are diverted to another port with good hinterland connections to the rail or barge network.

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