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Chapter 7. Port competition in contestable hinterlands: The case of preferential relationships and barrier effects in Central Europe

In Ducruet, C. and Notteboom, T. (ed.) "*Port systems: spatial-economic perspectives on the co-development of seaports*"

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Abstract

This chapter analyses port competition from a hinterland perspective. It focuses on a set of countries of Central Europe for which there is not a clear geographical advantage of one port over another. Such contestable hinterlands seem particularly relevant for an appreciation of factors that can tip the balance in favor of certain port alternatives, minimizing the statistical noise induced by distance effects. With the expansion of the European Union towards the East and the subsequent development of East-West transport links, such as the Rhein-Main-Danube canal, increased competition between ports can be expected. This paper tests this idea for different industries, by using a spatial interaction model on data on container shipments to the United States. Sailing frequency is used as a measure of port attractiveness and truck drive time as geographical separation. We also identify preferential ties between source countries and ports and barrier effects in the organization of hinterlands. Against expectations, the results highlight the path dependence in the North-South organization of hinterlands, with a persistent split between Switzerland, mostly oriented towards Rotterdam and Antwerp, and the other countries of Central Europe, historically tied to German ports, while Mediterranean ports are largely disregarded.

Introduction: Path dependence and change in the hinterlands

In deep-sea transport chains, inland drayage represents only a small part of the overall distance but a high share of the costs. Thus, it is critical for competitiveness across the port systems. Agents involved in port choice, such as shippers, freight forwarders, and shipping companies often organize themselves to minimize such cost, which implies choosing the closest or best-connected port alternatives. Of course, inland transport costs cannot be viewed

in isolation since they are part of broader chains, including other segments such as shipping which has proven to be volatile (Ducruet and Notteboom, 2022). Moreover, factors related to time, such as reliability, frequency and speed, are crucial for many industries and may limit the propensity of agents to systematically choose the cheapest route, often associated to the closest port alternative.

Overall, it seems that changes in inland routes are slower than changes in maritime routes. Braudel's writings on the early days of European capitalism provided examples on how quickly ships responded to sudden changes in demand: "*In 1725 [...], small English ships literally flocked to load any available freight in Amsterdam and other ports of the United Provinces¹. They offered their services, for trips as far as the Mediterranean, [...]*" (Braudel, 1992, p.368). By contrast, road transport changes at a slow pace because it is affected by the inertia of commercial relationships, with certain routes generating most of trade volumes and inducing virtuous effects such as a better utilization of capacities and competition. The roads used by horse-drawn carriages relied on inns and halts, in which innkeepers acted as freight forwarders. This inspired Braudel to maintain "*only traffic along trunk routes really 'paid'. Everything else, the ordinary, everyday, unspectacular traffic was left to anyone who was prepared to countenance the very modest reward it brought*" (Braudel, 1992, p. 349-350). Many of these trunk routes are organized South-North, between the port-cities of Venice and Genoa to Antwerp and the United Provinces, running through Switzerland.

In Europe, despite the development of the intra-regional trade routes, port hinterlands may have been probably very limited in scope in the early days of capitalism. Although maritime trade was intense in the Mediterranean and the Atlantic [realms](#), most of the cargo was hardly moved beyond the limits of port cities. An important change took place from the 18th-19th centuries, with the development of steam [engines](#), and especially rail transport (Vance, 1985). The so-called "*transportation revolution*" (*ibid*, p. 12) may have been crucial for the opening of inland markets for maritime trade, and the subsequent development of port competition. In this respect, early research of the 19th century suggested that Antwerp and Hamburg were already preferred by French shippers over Le Havre for their exports of refined sugar, cotton cloths, fabrics, and for their imports of raw cotton and wood (Simonin, 1878, p. 251).

Later, Morgan (1948) studied this competitive dimension from a hinterland perspective, by mapping the catchment areas of the ports of Hamburg and Bremen during the inter-war period. Despite the extensive development of railways and waterways, inland distance remains a major obstacle to hinterland expansion. In these maps, each hinterland is divided into two zones: a "*basic hinterland*" which is mostly captive and concerns all types of navigation, and "*competition margins*" which concern almost mostly liner shipping (operating on a regular schedule), involving cargo of higher value. The competition margins of Hamburg and Bremen [encompass](#) Southern Germany and the landlocked countries of Central Europe (Switzerland, Czechoslovakia, Austria and Hungary): "*the fringing tributary regions are less exclusively the preserve of Hamburg; lying most remotely from the port they are an index of*

¹ Braudel cites Dickson (1967, pp. 506).

its attractive power [...]” (Morgan, 1948, p.50). It also **underscores** the larger geographical scope of Bremen’s influence: *“The fringing territories [of Bremen] are relatively much more extensive than those for Hamburg”* (*Ibid.*). There are references to previous delineations (“economic watershed”, *Ibid.*, p. 48) between the hinterlands of German ports on **the** one hand, and the hinterlands of Dutch and Belgian ports, on the other side: *“the line joins Cheb (Eger) in Czechoslovakia and Hamm [in Germany, next to Dortmund] [...]. Here is the critical area of competition between the German ports and Rotterdam and Antwerp: across this watershed, largely by the operation of the [...] special rates on the railways, Hamburg and Bremen have been most successful in extending their hinterlands to the south-west towards Frankfurt-am-main, Mainz, Mannheim, and Basle.”* (*Ibid.*). Although there are multiple references in the paper to the geographical limits of hinterlands, Morgan concludes that these cannot be considered as boundaries, but rather as gradients: *“Outwards from the port we move into zones of diminishing magnitudes, where overlap with the fringes of other hinterlands – Amsterdam, Rotterdam, Antwerp, Marseilles, Genoa, [...] – becomes more and more complicated.”* (*ibid.*, p. 50). The factors behind the unequal attractiveness of ports come from the variety and frequency of liner sailings, *“geographical advantage, politico-economic manipulation, or commercial organization”*. To illustrate the differences in commercial organization, Morgan draws maps of two commodities: raw cotton imported from the US, and widely distributed in Central Europe mainly from Bremerhaven, and Machinery and Plant, dominated by Hamburg. With regard to the latter, *“This product, of high value in relation to its bulk, seeks more for the most convenient port and less for the nearest”* (*ibid.*, p. 54). These maps illustrate how individual commodities frequently do not conform to a general hinterland pattern. The reasons invoked for these variations relate to special marketing arrangements, the nature of the commodity, or the nature of the shipping services using a port. At that time, Central Europe appears as a particularly contested area, not just between German ports, but also involving Rotterdam, Antwerp and, although to a minor extent, Polish and Mediterranean ports.

This chapter revisits Morgan’s narrative on port competition in Central Europe in the current era. Central Europe is a particularly interesting ground for the study of port competition since there is not a major geographical advantage of one port over another. With the development of intermodality and the extension of the European common market towards the East, these hinterlands are expected to become **increasingly** contestable. To what extent **does** the current situation of the hinterlands of Central Europe differ from the one depicted by Morgan? Did the hinterlands of Central Europe become *“more complicated”* (Morgan, 1948, p. 50) with a higher number of ports (ex. Poland, Mediterranean) vying for the same markets? Are the German ports, on **the** one hand, and Rotterdam and Antwerp, on the other hand, still competing for the same common hinterland? Or are there distinct competition spaces for both sets of ports? Moreover, the use of containers has considerably standardized the ways in which the different commodities are handled at ports. Did it erase the specificities of hinterlands for different commodity types? To shed light **on** these questions, this chapter examines the current organization of hinterlands in Central Europe, using disaggregated data on the container shipments bound to the United States. Following Morgan, we use maps to visualize the hinterlands in Central Europe. Then we identify preferential relationships and

barrier effects using the residuals of a spatial interaction model. **To the best of our knowledge, this is the first time that such an approach is applied to the study of port systems, as a tool to visualize trade corridors and obstacles to hinterland expansion.** We discuss these patterns with regard to the improvements in transport infrastructure, within the framework of the Trans-European Transport Network (TEN-T) policy. How have infrastructure improvements on the East-West routes affected hinterlands in Central Europe? Has this driven to more competition? The comparison of the modeling results for different commodity types should allow to measure how much the hinterlands have been standardized (or not) by containerization.

The remainder of the chapter is organized as follows. The second part presents a literature review related to port competition and contested hinterlands. Then we present the data and method. The fourth part presents the results of our analysis. The fifth part provides a discussion and conclusions.

Literature review

Within port geography, a large amount of research has been carried out on port hinterlands, **in the light of** their critical importance in the competitiveness of intermodal supply chains. For a more general review on port hinterlands, we refer to the recent works of Skodopoulos and Boile (2020) and Guerrero (2021) in port geography and Martinez-Moya and Feo-Valero (2017) from an economic perspective on port choice.

Within the field of port hinterland studies, this paper seeks to understand the specific situation in which a landlocked region is served by several competing ports. Similar cases have received attention from scholars in other geographical contexts, such as for example in France (Charlier and Thomas, 1983), Spain (Moura et al, 2017), Italy (Acciaro et al, 2017), the United States (Monios and Lambert, 2013), South Africa (Fraser and Notteboom, 2012) or the Greater Mekong Subregion (Kosuge et al, 2021). Central Europe is a rather unique **domain** of study given the border-crossing issues and the number of countries involved, as well as the recent changes in transport infrastructure. This type of situation has been analyzed by a few case studies. These include the case of Austria (De Langen, 2007), of the Czech Republic (Rodrigue and Kolar, 2016, Kolar et al, 2018) as well as some broader geographic contexts (Kashiha et al, 2016, 2017).

There are also more classical port-centric approaches citing the case of Central European countries as contestable hinterlands from the perspective of Benelux (Notteboom, 2010, Meersman et al, 2013) or German ports (Biermann et al., 2015, Biermann and Wedemeier, 2016). Also, there are studies comparing several ports or port systems, and highlighting complementary effects, such as Notteboom (2016). These studies are similar to Morgan's (1952) as they consider contestable hinterlands in Central Europe as competition margins for the main gateways, and discuss how market changes and public policies favor certain ports or port systems.

From a theoretical perspective, Central Europe is a particularly interesting ground for the study of port regionalization. As suggested by Noteboom and Rodrigue (2005),

containerization and the development of intermodalism push the development of hinterlands beyond the usual **territory** of influence of ports. The driver of this phase is expected to be market based, and largely beyond the control of port authorities (*ibid*). These restrictive assumptions were somewhat relaxed by subsequent studies, in the sense that stakeholders of ports and public authorities may also be critical in port regionalization (Rimmer and Comtois, 2009, Monios and Wilmsmeier, 2012). This seems to be **the** case of the countries of Central Europe, where port handling operators, as well as shipping lines, play active roles (Rodrigue and Kolar, 2016). Both types of operators have developed networks of terminals and rail shuttle services, within a European context of rail liberalization (Debrie and Gouvernal, 2006). For example Metrans, which is affiliated with the port terminal operator of Hamburg HHLA, is one of the major intermodal players in Central Europe (see figure 1). From the perspective of ports (port authorities and other stakeholders involved in the development of ports), investing in inland connections and inland terminals appear as a way to build loyal business relationships. **Conversely**, the public authorities, logistic companies and shippers from inland regions seek to diversify their maritime outlets, to avoid being captive of a specific port, and to have more routing options (Notteboom, 2010).

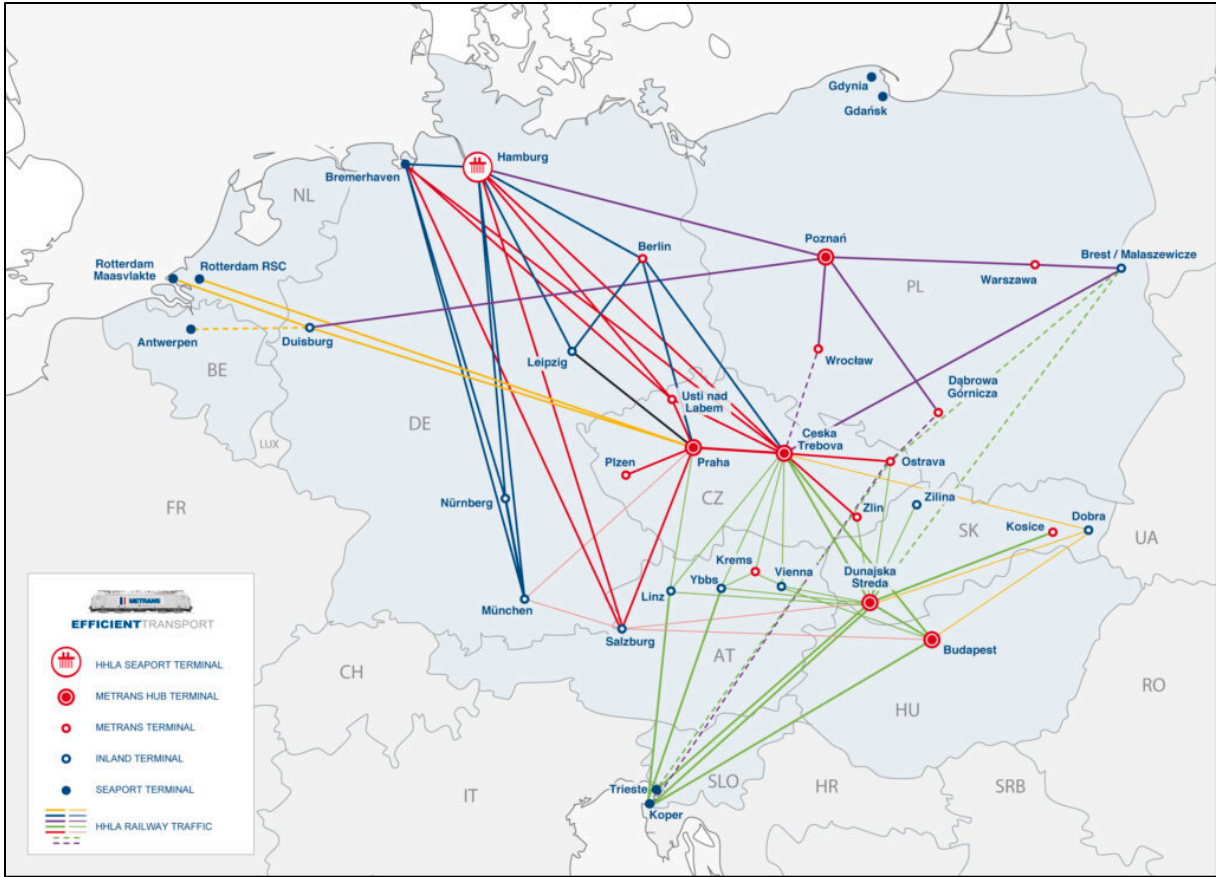


FIGURE 1. METRANS NETWORK OF RAIL SERVICES (SOURCE: RETRIEVED FROM THE FIRM’S WEBSITE, 2020)

The development of the intermodal transport network linking major European gateways to the countries of Central Europe is still under construction (Sdoukopoulos and Boile, 2021) and there is uncertainty on how the port choice of these landlocked countries will evolve in the next decades (Rodrigue and Kolar, 2016). It has been shown that better transport connections

contribute to expand the hinterlands of ports (Meersman et al, 2009, Guerrero, 2019). But the effects of infrastructure improvements on hinterlands are not immediate. The case of Austrian shippers, strongly tied to German ports, despite the improvement of waterway connections to Rotterdam through the Rhein-Main-Danube canal, provides a good illustration of this inertia (De Langen, 2007).

Of course, despite the containerization and the standardization of the ways in which goods are moved, sector specificities remain (Martinez-Moya and Feo-Valero, 2017, 2022). The sensitivity of shippers to inland distance and to port performance may differ from one industry to another (Guerrero and Thill, 2021). Although there is some research on these differences, there is little evidence on the variations in the port choice of landlocked countries for different industries. The present work seeks to fill this void with a systematic analysis of the differences in landlocked hinterlands for different commodity types. To characterize hinterlands we use spatial interaction models, a proven means for measuring how inland distance and port characteristics affect trade flows. This approach is complemented by the visualization of barrier effects and preferential relationships, using the model outliers. This technique has been used in other domains such migrations or trade (Grasland, 1994, Rietveld, 2012) but it is new within the field of port geography and hinterland studies. This scarcity of quantitative measurements of barrier effects and preferential relationships in port hinterlands may stem from the lack of coherent multi-country hinterland data despite a few exceptions (Kashiha et al, 2016). To the best of our knowledge, the only comprehensive container trade database that span multiple countries are the customs data and bills of lading of the United States, disseminated through several data providers.

Data

Data source

Data used in this study encompass waterborne containerized shipments from locationally verified physical sources in the five land-locked Central European countries of Switzerland, Austria, Hungary, Czech Republic, and Slovakia, that were imported by the United States during the month of October 2006. They are derived from raw data comprised of information submitted through both the former U.S. Customs and Border Protection Automated Manifest System (AMS) and manifests submitted by shipping parties at the ports. The raw data were corrected for mistakes in entry/missing records and then packaged with proprietary data fields by data vendor PIERS, which provides the data product for commercial sale (PIERS/UBM Global/JOC Group, Inc., 2007). These data provide various attributes of the shipment of each bill of lading, including the shipper company name and address, commodity type based on the Harmonized Commodity Description and Coding System (HS), quantity (twenty-foot-equivalent-unit -TEU, value and weight), forwarding port, US port of entry, and some others.

As indicated in Kashiha and Thill (2013), data items were extensively verified with machine-learning algorithms and manual methods. In particular, the physical source of each shipment was verified and adjusted as needed through thorough market intelligence processes. Indeed, a

common issue that was discovered is that many bills of lading that clearly were sourced from land-locked countries (such as the five countries that are the focus of our attention in this chapter) had the country of origin coded as the country where the main forwarding port was located, such as Belgium (port of Antwerp), or the Netherlands (port of Rotterdam), or Germany (ports of Hamburg or Bremerhaven). Hence, the generated dataset is unique in its geographic and logistical detail, and **it also stands out by** its accuracy. The period of October 2006 is an important timeframe as it provides a solid baseline right before the Great Recession of 2008 that resulted in a major downturn in international trade and a restructuring of trade and logistical relationships.

Data description

A full description of the dataset of bills of lading on which our study draws is provided in Kashiha and Thill (2013). As shown in Table 1, in Central Europe, the largest exporters are Austria and Switzerland, each of them sourcing one third of the region's volumes. The Czech Republic contributes 19% of the volumes, and Hungary and Slovakia 10% each.

Table 1 shows also that the trade of Central European countries to the U.S. is moved through a limited number of ports; 7 ports handle 97% of TEU volumes. The main ports are located mainly in the Northern Range. Bremerhaven concentrates about half the total (52%), Rotterdam a fifth (21%) and Antwerp (12%) and Hamburg (10%) about a tenth each. The volumes moved by the Mediterranean ports are smaller by one order of magnitude, about 1% and less than 120 containers each. All the other ports (such as Fos, Felixstowe, Barcelona, or Gioia Tauro) together account for 3% of the total.

TABLE 1 : CONTAINERIZED EXPORTS OF THE COUNTRIES IN CENTRAL EUROPE TO THE U.S. BREAKDOWN BY PORT AND COUNTRY. SOURCE: PIERS (OCTOBER 2006)

Port	TEUs	%	Country	TEUs	%
Bremerhaven	5 746	52%	Austria	3 402	31%
Rotterdam	2 308	21%	Switzerland	3 339	30%
Antwerp	1 309	12%	Czech Republic	2 157	19%
Hamburg	1 129	10%	Hungary	1 109	10%
Genoa	113	1%	Slovakia	1 106	10%
La Spezia	110	1%	All 5 countries	11 113	100%
Le Havre	60	<1%			
Others	338	3%			
All ports	11 113	100%			

Figure 2 depicts how the exports of Central European countries to the U.S. are distributed between the ports. For four of the five countries in Central Europe, Bremerhaven is, by far, the main port of export to the US. The only exception is Switzerland, whose trade goes through Rotterdam and Antwerp. Ports like Hamburg, Rotterdam and Antwerp often act as secondary options for Austria, Czech Republic, Slovakia and Hungary. In general, Rotterdam and Antwerp attract the Western countries while Hamburg is preferred by the Eastern ones. Finally, other ports such as La Spezia and Genoa in the Mediterranean, or Le Havre in the Northern Range only play minor roles in the trade between Central Europe and the US. Detailed traffic volumes are reported in Table 2.

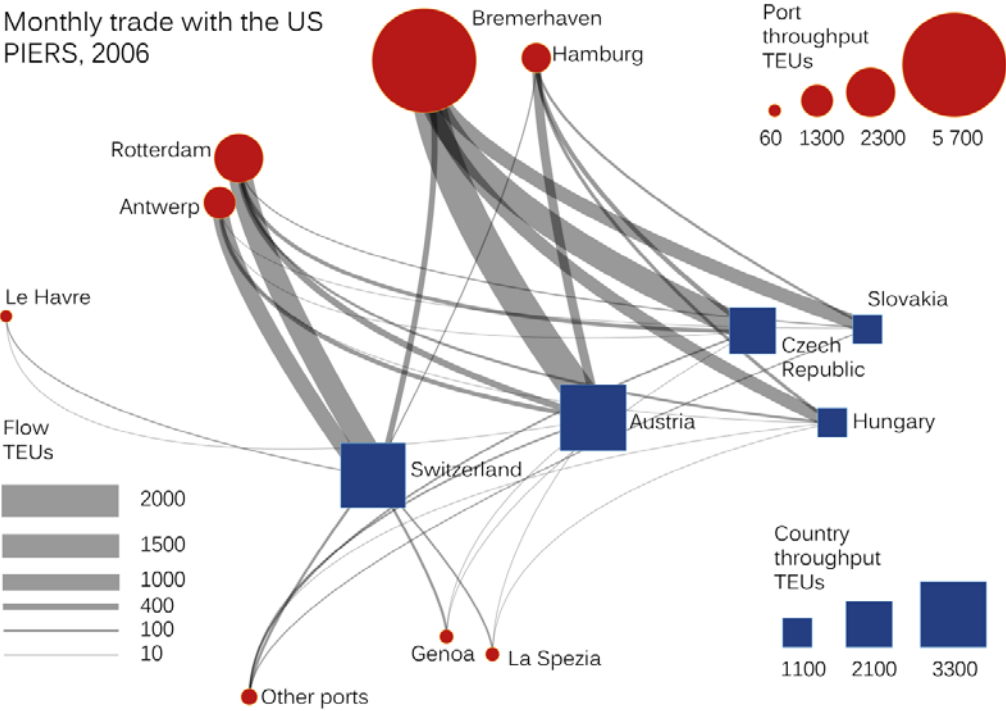


FIGURE 2 : VISUALIZATION OF THE MAIN COUNTRY-PORT PAIRS (97% OF THE TOTAL). SOURCE: PIERS (OCTOBER 2006)

TABLE 2 : SHARE OF CONTAINERIZED EXPORTS OF CENTRAL EUROPEAN COUNTRIES TO THE U.S., BROKEN DOWN BY FORWARDING PORT. TOTALS MAY NOT ADD UP TO 100% DUE TO ROUNDING ERRORS. SOURCE: PIERS (OCTOBER 2006)

Ports	Czech				
	Austria	Switzerland	Republic	Hungary	Slovakia
Bremerhaven	62	11	74	74	80
Rotterdam	12	45	11	11	4
Antwerp	8	31	0	0	0
Hamburg	17	1	11	14	12
Genoa	0	3	0	0	0
La Spezia	0	3	0	1	0
Le Havre	0	2	0	0	0
Others	2	4	0	1	0
Total (%)	100	100	100	100	100

Bilateral trade of Central Europe (Table 3) is quite concentrated, as over two thirds (65%) of all exports encompass 5 categories only. Base metals, machinery & mechanical appliances, handicrafts/pearls/semi/precious stones/metals, plastics & rubber, and chemicals products dominate the trade volumes. Significant variations exist between countries, however. For instance, trade in chemicals and in plastics and rubber products disproportionately originates from Switzerland (about 70 and 50%, respectively), while Hungary sources about 40% of all transportation equipment exported to the U.S.

TABLE 3 : CONTAINERIZED EXPORTS OF CENTRAL EUROPEAN COUNTRIES TO THE U.S. BREAKDOWN BY TYPE OF COMMODITY. TYPOLOGY BUILT FROM HS CATEGORIES. DISPROPORTIONATELY LARGE FLOWS ARE MARKED IN BOLD.

SOURCE: PIERS (OCTOBER 2006)

Commodity	Austria	Switzerland	Czech Republic	Hungary	Slovakia	Total TEUs	%
Base Metals & Articles							
Thereof	778	547	250	160	204	1 940	18%
Machinery & Mechanical Appliances	574	560	283	184	131	1 732	16%
Handicrafts, Pearls, semi/Precious stones, Metals	255	137	308	254	426	1 379	12%
Plastics & Rubber	189	520	261	21	65	1 056	10%
Chemical Products	179	690	96	59	15	1 039	9%
Articles Of Stone, Plaster, Cement, Asbestos	173	117	293	62	165	811	7%
Prepared Foodstuffs	150	259	259	88	3	760	7%
Wood & Pulp Products	379	145	47	6	7	583	5%
Transportation Equipment	220	44	72	201	2	540	5%
Wood & Wood Products	185	56	123	15	33	412	4%
Textiles & Textile Articles	188	49	48	21	18	325	3%
Others	132	215	115	37	37	536	5%
Total	3 402	3 339	2 157	1 109	1 106	11 113	100%

Method

To better understand the preferred forwarding port pathways of containerized export from the five Central European countries under study to the U.S., we compare the departure between actual freight flows to ports as evidenced by the PIERS bill of landing data set and the flows predicted by spatial interaction models. This research approach shares similarities with the approach used by Tiller and Thill (2017), although they differ in meaningful respects. Spatial interaction models are important benchmarks for the assessment of how a territorial system operates (Ullman, 1980) and how functional relationships manifested by commodity flows may depart from a certain norm (Plane, 1984). Hence, the analysis will focus here on the residuals from spatial interaction models. In particular, these residuals will be used to identify preferential relationships between source countries and ports on the one hand, and barrier effects, on the other hand.

Spatial interaction models have been a mainstay of analysis in geography, spatial science, logistics, transportation and trade for many decades (Wilson, 1971; Haynes and Fotheringham, 1985; Fotheringham and O’Kelly, 1989; Roy and Thill, 2004). In particular, there is a long tradition of use of spatial interaction models to study freight shipping systems in relation to centers of economic activity and significant nodes of the transportation system, such as ports (e.g., Chisholm and O’Sullivan 1973). Spatial interaction models are trip distribution models. We use a prominent member of this family of models, namely the so-called production-constrained spatial interaction model. This model posits that total flows from each origin *i* (here an exporting country) are guaranteed to be fully accounted for, while flows are expressed as a direct function of port *j*’s frequency of shipping services to the U.S. (MDST Transmodal, 2007) as a measure of port attractiveness, and as an inverse power function of the geographical separation (travel time) between country *i* and port *j*. Travel time is taken to be the time of travel by truck as estimated through extensive analysis of data of freight shipping between NUTS-3 regions (Spiekermann and Wegener, 2007) and aggregated to countries. Given that our Central European countries are all land-locked, the friction associated with shipping time is expected to be lower than in other spatial interaction models that include coastal countries.

Preferential relationships and barrier effects

Residuals (or outliers) with respect to the expectation computed by a spatial interaction model provide an image of what is not taken into account by travel time. They provide some approximation of aspects that are hard to measure, such as land affinities and their geographical differences, shared history, and so on. With the production-constrained model, given that we include the frequency of US-bound sailings as an indicator of port attractiveness, we can test other pertinent questions such as whether a port like Rotterdam is able to materialize the potential of improvements in inland waterways with certain countries, such as Austria or Hungary.

TABLE 4 : RESULTS OF THE PRODUCTION CONSTRAINED SPATIAL INTERACTION MODEL FOR ALL COMMODITY TYPES.
SOURCE: PIERS (OCTOBER 2006)

<i>Travel time friction parameter</i>	- 3.10
<i>pseudo R²</i>	28%

The calibration results of the spatial interaction model are reported for the entire dataset in Table 4. We see the goodness-of-fit measure is within an acceptable range and that the parameter representing the magnitude of the friction of travel time is negative, as expected. Residuals of the production-constrained model are discussed below only when they demonstrate a large departure from the expected flow volume, i.e. outside of a 20% margin. Positive outliers (observed flows / predicted flows > 1.2) are depicted in Figure 3, while negative outliers (observed flows / predicted flows < 0.8) are shown in Figure 4.

Figure 3 depicts so-called preferential relationships, which are identified when the observed flows are substantially higher than those predicted by the model on the basis of time distance and vessel frequency. They reveal the presence of two separate groups of relationships. On the one hand, Switzerland has preferential ties with the ports of Rotterdam and Antwerp, and although to a minor extent, to Le Havre, Fos and La Spezia. On the other hand, all the other countries, including Austria are tied to the German ports of Bremerhaven and Hamburg. It is worth noting that the only exception is the preferential tie between Rotterdam and the Czech Republic.

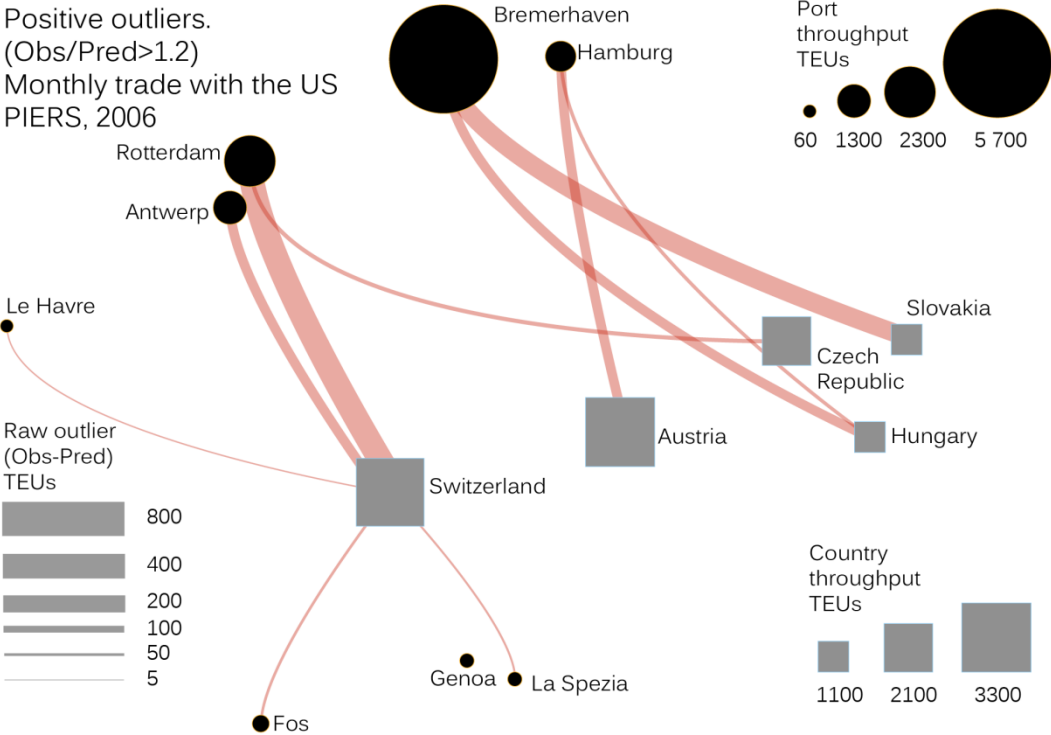


FIGURE 3 : PREFERENTIAL RELATIONSHIPS. SOURCE: PIERS (OCTOBER 2006)

Negative outliers (Figure 4) confirm the results observed previously. The main barriers are, on the one hand, between Rotterdam and Antwerp with Central European countries. On the other hand, there are barriers between Switzerland and the German ports. It is worth noting that a barrier effect exists between the Czech Republic and Hamburg.

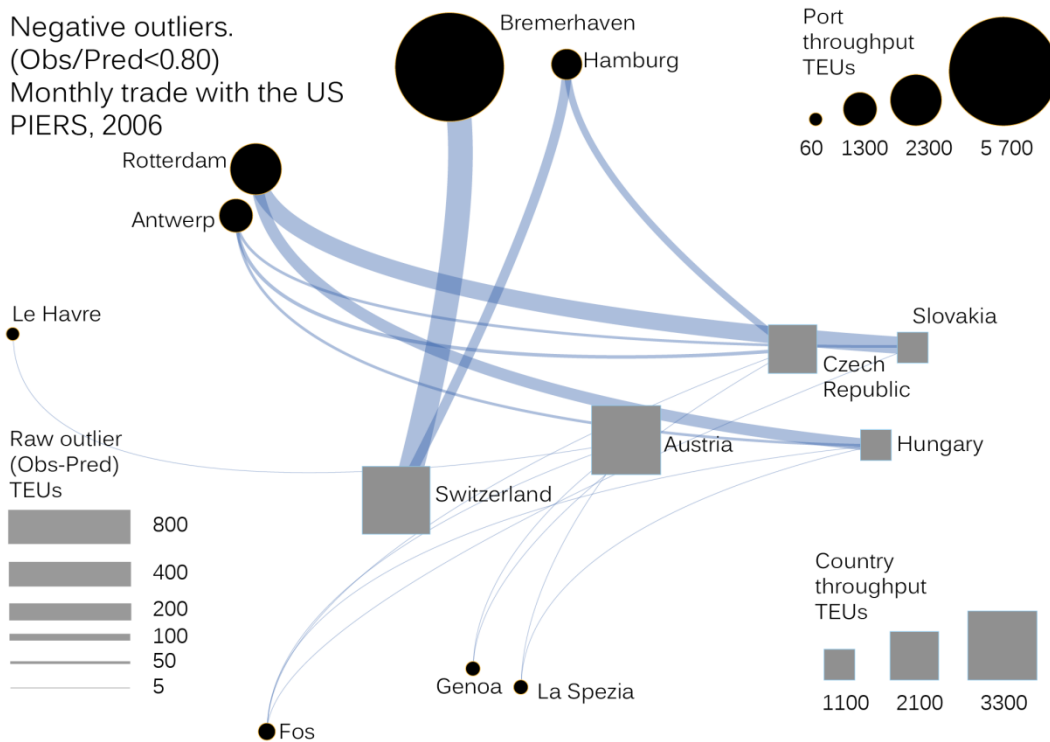


FIGURE 4 : BARRIER EFFECTS. SOURCE: PIERS (OCTOBER 2006)

Some of these results go against expectations. In the relationships with Switzerland, Le Havre and the Mediterranean ports seem to do well with regard to their potential in terms of sailing frequency and time distance. This is an important result, and provides some perspective on the situation of French ports, which are **officially** expected to “reconquer” their hinterlands in Europe (French Senate, 2020). It supports the assumptions of Charlier and Thomas (1983), who suggested that Fos and Le Havre were also competing to attract the Swiss maritime trade.

The preferential relationships and barrier effects also confirm the prevalence of the structures observed by Morgan (1948) in a context that predates containerization. Railway and inland waterway connections may play an important role channeling the flows of Switzerland through Rotterdam and Antwerp, and those of the other Central European countries, through German ports. Another possible explanation of the different port orientation of Switzerland may result from the types of decision makers involved in port choice. Former studies have showed that the influence of freight forwarders on German ports was particularly weak (Ducruet & Van der Horst, 2009). Also, on the land side, Rodrigue & Kolar (2016) highlighted the importance of maritime companies in the organization of land connections of Czech's maritime trade. In Switzerland, however, the influence of freight forwarders in the organization of maritime trade flows is particularly high in comparison to other European countries (Notteboom, 2009). Therefore, shipping lines may have a stronger preference for German ports, and so do freight forwarders for Benelux ports.

The former visualizations provide a synthetic view of the “average hinterlands” in Central Europe. However, port choice behavior may vary considerably depending on the types of cargo. To explore such differences the following section considers several commodity groups.

A tentative explanation based on commodity types

To measure how the hinterlands for specific commodities deviate from the average hinterland, we estimate production-constrained spatial interaction models separately for several commodity types. The model is fitted to the data for seven of the nine commodity types. Table 5 shows that time friction parameter varies greatly, between -0.9 for transportation equipment to -8.0 for handicrafts, pearls, semi-precious stones and metals. Commodity-types generating important volumes such as Base Metals and Articles Thereof and Machinery and Mechanical Appliances, and Plastics & Rubber, exhibit friction values in the average range of 3.2-3.9. The large variations observed in the friction values may stem from the specialization effects of certain ports with respect to world commodity markets, as observed by Morgan (1948).

TABLE 5 : RESULTS OF PRODUCTION CONSTRAINED MODELS BY COMMODITY TYPE. SOURCE: PIERS (OCTOBER 2006)

<i>Production constrained model</i>	<i>Time friction parameter</i>		<i>pseudo R²</i>
Prepared Foodstuffs	- 9.58	●	71%
Machinery & Mechanical Appliances	- 3.24		30%
Articles of Stone, Plaster, Cement, Asbestos	- 4.56		37%
Base Metals & Articles Thereof	- 3.88		63%
Transportation Equipment	- 0.90		58%
Chemical Products	- 2.69		83%
Handicrafts, Pearls, Semi/Precious Stones, Metals	- 8.02		96%
Plastics & Rubber	3.29		38%
Wood & Pulp Products	25.35	●	73%

- The model does not fit the data because the sample is too small

To better characterize the specialization of ports in certain commodity types, we measure it with location coefficients according to

$$\text{Location coefficient} = \frac{\text{Port throughput commodity type} / \text{Total throughput commodity type}}{\text{Port throughput all commodity types} / \text{Total throughput all commodity types}}$$

This location coefficient of a port indicates to what extent the share of this port on a certain commodity type is above or below the share of the port for all types of commodities **combined**. The more the value of the location coefficient exceeds 1, the more the port is specialized on a certain commodity type. A value below one indicates that the port is less specialized on a certain commodity than what can be expected with regard to its throughput.

Table 6 shows the location coefficients of ports with regard to the different commodity types. The main result is that the German ports, on the one hand, and Antwerp and Rotterdam, on the other hand, handle very different types of commodities. While the former are specialized in Transportation Equipment or construction materials (Plaster, Cement, Asbestos), the latter are clearly specialized in chemicals. **In Antwerp and Rotterdam, the petro-chemical and chemical industries are particularly prominent and represent as much as 39% of the overall local value added (Merk and Notteboom, 2009). The concentration of hardware and infrastructure, skilled trade workers and specialized trading companies in the port cities can be expected to be a major draw on throughput in these commodities.**

There are also some differences between both sets of ports, which suggests some kind of complementarity. In Germany, Bremerhaven seems to be rather specialized on commodities of lower value (Semi/precious stones, and metals), while Hamburg seems more specialized on Prepared Foodstuffs. Something similar happens between Antwerp, specialized in plastics & rubber, and Rotterdam, specialized in prepared foodstuffs and wood pulp products. The Mediterranean ports are mostly specialized in chemicals (Chemical products and/or plastics and rubber) and some intermediate inputs (Plaster, Cement, Asbestos and Base Metals & Articles Thereof).

TABLE 6 : LOCATION COEFFICIENTS OF PORTS ON COMMODITY TYPES. SOURCE: PIERS (OCTOBER 2006)

	Machinery & Mechanical Appliances	Articles Of Stone, Plaster, Cement, Asbestos	Transportation Equipment	Base Metals & Articles Thereof	Prepared Foodstuffs	Chemical Products	Plastics & Rubber	Handicrafts, Pearls, semi/Precious stones, metals	Wood Pulp Products
Bremerhaven	1.03	1.13	1.14	1.02	0.91	<u>0.52</u>	<u>0.85</u>	1.39	0.81
Hamburg	0.96	1.74	2.88	0.90	1.32	<u>0.79</u>	<u>0.57</u>	<u>0.32</u>	1.25
Rotterdam	1.06	<u>0.61</u>	<u>0.28</u>	0.93	1.09	1.39	0.99	<u>0.33</u>	1.39
Antwerp	0.99	<u>0.20</u>	<u>0.16</u>	0.82	0.82	2.24	1.28	0.99	0.95
Genoa				2.51			3.21		
La Spezia		5.57				3.04			

Fos						2.33	4.81		
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Discussion and conclusions

In this chapter, we studied how the shipments of containers from Central European countries to the US are handled by the different ports. This land-locked space is highly contested by several ports and this happens in ways that are heterogeneous between countries. Through spatial interaction models, we measured respectively, the effects of inland distance and frequency of sailings on port choices. Other factors, which were not included in the model, were discussed through the visualization of preferential relationships and barrier effects elicited from the model residuals. The presence of high capacity alternatives to road transport, such as rail and waterway, may explain an important part of the preferential relationships. Another important source of deviations is the port specialization on certain commodity types.

Bremerhaven, Rotterdam, Hamburg and Antwerp handle most of the US-bound shipments of Central European countries. Mediterranean ports and Le Havre are **mostly** left out of the picture. We showed that there are barrier effects between Mediterranean ports and most countries of Central Europe, as suggested by previous works (Acciaro et al., 2016). However, our model based on truck drive time and sailing frequency showed that Mediterranean ports and Le Havre are not underperforming in their relationships with Switzerland. This result is important and suggests that the hinterland potential of French ports may have been overestimated by former studies. Another important finding of this study is the prevalence of the specialization of ports in certain commodities, in spite of the standardization of handling equipment and procedures brought by containerization. It is worth noting the specialization of Antwerp, Rotterdam and Mediterranean ports in chemicals, and of the German ports in Transportation Equipment. The value of cargo, which has not been analyzed in the current work, may play a role as well, as suggested by the cases of Rotterdam and Hamburg, whose specializations in Prepared Foodstuffs contrast with the under-specializations of Antwerp and Bremerhaven. Future works shall take into account these differences to assess how commodities of different value are more or less sensitive to sailing frequency.

This study has also some limitations. We focused on the shipments to the US. We are aware that Bremerhaven is highly specialized in the **bilateral** trade with the US. A study including the trade with East Asia may lead to similar results, with Hamburg playing an equivalent role for countries in Central Europe (Kolar and Rodrigue, 2016). Also, our data are from 2006. Recent accounts on Central European countries highlight the emerging role of Gdansk, Koper and Piraeus, which **studies have found to** handle respectively 15% and 2% of the container trade of the Czech Republic (Rodrigue and Kolar, 2016, Bierman and Wedemeier, 2016). The share of Bremerhaven and Hamburg may also have declined since the early 2010's to the benefit of Rotterdam (Notteboom, 2016).

Future research shall take into account the presence of the land-side alternatives to the road which are particularly important for countries in Central Europe, especially the rail (more than a half of the TEUs shipped through Bremerhaven) and the waterways (Rhine and Danube). Another avenue for further research is to assess if friction of the geographic space is affecting

trade relationships differently. For instance, our study showed that the proximity of Mediterranean ports to most of Central European countries does not result in a higher market share. However, in the competition between the German ports on the one hand, and Rotterdam and Antwerp, on the other hand, distance seems to play a key role. To clearly distinguish these situations, future studies would provide separate estimations of friction for each port.

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