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Inland port performance: a statistical analysis of Dutch inland ports

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Abstract

Most scientific attention in freight transportation port studies centers on the characteristics of deep-sea ports, in particular container ports. In our paper, in contrast, we focus our attention on the performance of inland ports in a European context, which is up to now an overlooked part in the scientific literature on port development. Based on a large-scale quantitative dataset of Dutch inland ports we perform various statistical analyses to arrive at a more detailed understanding of the performance of inland ports. We try to explain the performance of inland ports in terms of transshipment level and growth in transshipment by several transport and economic factors. We test for differences in size and in volume growth and control for differences in diversity of transshipped goods and in availability of a container terminal in the inland port. Our findings contribute to the understanding of the performance of inland ports, as explained by general port characteristics. A better understanding of the characteristics and growth patterns of inland ports might also be beneficial to European practitioners and policy-makers in dealing with inland ports' development strategies in their daily practice.

Keywords: inland port, port system development, transshipment, performance indicator, port governance

1. Introduction

Most scientific attention in freight transportation port studies centers on deep-sea ports and more in particular container ports. Especially the efficiency of maritime ports and terminals has received much attention, but also the

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analysis of the role of deep-sea ports in transport and supply chains and the analysis of the management and organization of ports and terminals forms part of the body of scientific literature (e.g. Van Klink & Van den Berg, 1998; Hesse & Rodrigue, 2004; Notteboom & Rodrigue, 2005; Notteboom, 2010). In the hinterland of deep-sea ports (i.e. in inland ports) most scientific attention also goes to container terminals in combination with the logistics role of inland ports versus the hinterland of the larger maritime ports (see for instance the recent Inside-Out, Outside-In discussion in Wilmsmeier et al., 2011 and Monios & Wilmsmeier, 2012). However, inland ports are becoming more important in global supply chains and up to now the scientific attention to these processes is lagging behind for the inland ports, especially in the European context. Furthermore, governmental bodies such as inland port authorities, municipalities and regions try to optimize their production factors in terms of people, planet and profits in and around inland ports and might therefore also be benefitted by a more detailed insight in the performance of inland ports in Europe. This leads us to the following research question: "How can the performance conditions of inland ports explain their change in size and growth?"

In our paper, we focus our attention on the inland ports in general (i.e. as compared to focusing solely on container terminals in inland ports). By doing so, we aim to address the undervalued position of European inland ports in the academic literature. In Section 2, we present a literature review of port studies. Due to the limited availability of scientific literature purely focusing on inland ports, the review mainly focuses its attention on issues identified in the context of maritime ports and the implications of these respective issues for the context of European inland ports. In Section 3, we explain the development of a large-scale dataset of 135 municipalities in the Netherlands with information about the transport characteristics of their inland navigation activities, combined with economic characteristics of the inland port, the municipality and the region. In Section 4, based on this large-scale quantitative dataset, we perform various statistical analyses (single-measure performance measurement and multivariate regression analyses) in order to arrive at a detailed understanding of the performance of inland ports. We try to explain the performance of inland ports by several transport and economic factors. We test for differences in size and in volume growth and control for differences in diversity of transshipped goods and in availability of a container terminal in the inland port. Section 5 contains the conclusions of our paper and the implications of our findings for port governance strategies in the daily practice of European inland ports.

2. Inland waterway transport and inland ports

2.1. Characteristics of inland waterway transport and inland ports

Inland waterway transport including the use of inland ports has been important for several centuries for both the transport of freight and passengers. In the past, horses were used to pull the barges towards their destinations. Later on, industrialization led to the introduction of steam engines in inland waterway transport but it also led to the introduction of rail transportation for both passengers and freight. This resulted in a shift from passengers away from barges to trains and, nowadays, inland waterways are usually only used for tourism purposes and no longer for regular passenger transportation services. Inland waterway transport stayed important though for freight transportation. Rail freight transport developed into a serious competitor for inland waterway freight transport, especially for large bulk freight flows to and from industrial production facilities. But also inland waterway freight transport was able to keep their market share and develop new markets for freight transport. Recently, dry bulk and liquid bulk together account for approximately 80% of all transported volume (in Europe). A new market developed by inland waterway freight transport is the hinterland transportation of containers to and from large deep-sea ports but also between inland ports.

Over the centuries, due to these developments, the institutional role of inland waterway transport has changed. It started off as being one of the most important transport modes, accompanied by a large institutional interest in inland waterway transport. New canals and locks were built and the inland waterway network grew in importance and size. After the introduction of rail freight transport and lorry transport, the institutional role of inland waterway transport changed. In land-bounded transportation, inland waterway transport has developed into the third transport mode after road and rail transport. The main institutional focus is now on the maintenance of the network (links and locks) and on solving capacity constraints.

Due to these historical and institutional developments, the position of inland ports in logistic functions and chains has also changed. Logistics functions have developed between traffic, transshipment and production towards added value services, integrated logistics, and extended gate port functions. The inland port area is an area of a certain size governed by a municipality encompassing road infrastructure, inland waterway(s) and rail infrastructure(s). In the inland port one or more public container terminals can be located. Tri-modal terminals connect rail and inland waterway, but also terminals with only inland waterway or rail access might exist. Next to these public container terminals, also many private properties with industrial production functions do possess direct water access enabling transshipment at their private quays. These properties with industrial functions usually have an important function in the logistics chain (break-of-bulk). In the inland port area, many companies are found providing production, logistics and transport services. Close to or 'interfering with' the port area, in many cases a city area can be found leading to a number of issues where port and city interact under the governance of the municipality. For our paper, the interaction between city and port is outside the scope of the research. For further reading we refer to Witte et al. (2014) and Wiegmans and Louw (2011). In the end, different combinations of infrastructures, terminals, companies, functions and regulatory settings lead to different outlines for the governance of inland ports.

Inland ports are increasingly receiving scientific attention in recent years. However, there is no consensus about the term 'inland port' itself. Both Rodrigue et al. (2010) and Monios and Wang (2013) provide an in-depth analysis of the different definitions of inland ports. The main conclusion from both papers concerning the definition of inland ports is that there exist different levels of inland port geographies, actors, regulatory settings and functions. Inland port geographies can range from the container terminal, to the inland port, to the hinterland of the inland port, up to the connections with the deep-sea ports. Inland port actors include public authorities, the port authority, transport operators of the respective transport modes, logistics service providers, and the terminal operators. Regulatory settings refer to the type of ownership of the inland port and the type of port governance strategy used by the public authorities. Inland port functions refer to the transport and logistics functions performed inside the inland port, but also to the network function of the inland port versus other inland ports and its relations towards deep-sea ports. What is largely absent in the definitions of inland ports is the performance of the inland port. The performance of inland ports is therefore the focus in our paper and is particularly reflected in the data analysis on the inland port performance in relation to the transshipment level and growth in transshipment.

Classification of inland ports is necessary in order to be able to differentiate in analyzing inland ports. A first classification is according to infrastructure availability. Inland ports (and/or inland terminals) can be accessible by rail, inland waterways or a combination of both (next to road). Secondly, inland ports can be classified according to type of ownership; public ownership (e.g. a municipality province, and/or regional body), private ownership (e.g. a privatized port authority), or a public private partnership where public and private entities cooperate. A third classification is according to the importance of transportation and logistics activities (such as customs clearance, intermodal transport, production, logistics, and supply chain management) in inland ports. In our analysis, the focus in classifying inland ports is on inland port size and growth. We combine this with the diversity of goods which are transshipped in inland ports and the availability of a container terminal in the inland port because this connects well with the data that we have available and is also quite a 'neutral' classification.

2.2. Issues for inland port studies: towards hypotheses

In a thorough literature analysis, Pallis *et al.* (2010) define seven topics as the most researched issues in port economics, policy, and management: 1. terminal studies, 2. ports in transport and supply chains, 3. port governance, 4. port planning and development, 5. port policy and regulation, 6. port competition; 7. spatial analysis of seaports. Given the breadth and depth of their study and the lack of a sufficient number of scientific studies that focus solely on inland ports, we have taken their defined topics as a starting point for structuring our analysis of the scientific literature for inland ports. Furthermore, we connect our data to the topics of Pallis *et al.* (2010) in order to develop hypotheses regarding the performance of inland ports.

Terminal studies and port performance: Deep-sea terminal studies especially focus on the measurement of terminal performance, terminal operations and strategies of maritime terminal companies. These issues are not extensively studied for inland ports. Data on terminal operations in inland ports is missing in our database. Inland port strategies are not present in our database as well. Furthermore, Witte *et al.* (2014) have found that these inland port strategies are oftentimes missing or 'under construction'. Therefore we broaden the scope for measuring performance from the terminal level to the port level. Consequently, in our database, some data can be used to develop hypotheses relating to port performance on the inland port level:

- *The transshipment level is negatively related to the growth in transshipment* (if the basic level of transshipment already is high, inland ports are less likely to sustain further growth, because of convergence processes on the port system level)
- *The transshipment level and the growth in transshipment are positively related to the presence of a container terminal in the inland port* (because container terminals are expected to be located in strategic locations, creating an additional pull-factor, which can attract higher levels of the overall transshipment capacity and trigger further growth in transshipment)

Ports in transport and supply chains: This category consists of shipping networks, supply chain trends, logistics activities, information flows and hinterland chains (e.g. Notteboom & Rodrigue, 2005; Veenstra *et al.*, 2012). For inland ports, Rodrigue *et al.* (2010) have found that the functional outcome of inland ports remains relatively similar irrespective of their geographical, regulatory and operational settings. Not the distance from a deep-sea port is important for an inland port, but more important is the possibility for the 'massification' of flows (regular rail and/or barge service) between a port and an inland port. In Europe, port authorities and terminal operators tend to be the major actors in inland port development, while in the American context, rail operators and real estate companies tend to take the initiative. In our database, several data can be used to develop hypotheses relating to 'ports in transport and supply chains':

- *The transshipment level and the growth in transshipment are positively related to the number of jobs in the region to which the inland ports belongs* (because a larger number of jobs is expected to result into greater flows of people, goods and services, which can attract higher levels of transport capacity and trigger further growth in transshipment)
- *The transshipment level and the growth in transshipment are positively related to the functional range of the inland port's distribution activities* (the greater the catchment area of an inland port, the larger the volumes and growth are expected to be; thus we expect the long distance range to have a greater effect on volumes and growth compared to the medium and short distance ranges)

Port governance: This category consists of port models and port reform, the role of the port authority, industrial relations in ports and the port community cooperation in seaports. In the inland port scientific literature attention to inland port governance is almost non-existing. In our database, some data can be used to develop a hypothesis relating to 'port governance', especially focusing on industrial relations in inland ports:

- *The transshipment level and the growth in transshipment are positively related to the diversity in types of transshipped goods* (because the diversity in types of goods is expected to be beneficial in creating a portfolio strategy in port governance, which can attract higher levels of transshipment capacity and trigger further growth in transshipment)

Port planning and development: This category consists of trends and developments in port planning, descriptive case studies of ports and port development, forecasting, economic impact studies of ports and cost estimates, port expansion projects and tendering and concessions in ports. In the field of inland port planning and development, an interesting paper has been written by Monios and Wang (2013). In their paper they analyses the spatial and institutional characteristics of inland port development in China. One of their main findings is that the focus of Chinese policy for inland ports is on expansion and on subsidizing these inland port developments. They also find strategy misalignment between local and regional scales for inland ports. In Europe, expansion of inland ports (at current locations) is often difficult. Inland ports need to make choices and be efficient within the limited space which is available. Many inland ports choose to develop or expand container terminals. However, certain inland ports, such as Rheinhafen Bendorf in Germany choose to not develop a container terminal and instead focus on redevelopment for other industrial sectors (Dormann & Herbort, 2012). In our database data is lacking to develop hypotheses relating to inland port policy and regulation.

Port policy and regulation: This category consists of port pricing, state aid and national policy, environmental, safety and security regulations in ports, anti-trust regulations, issues in ports, and supranational port policies. In general, port activities – and thus also inland port activities – do have a considerable environmental impact at the local and regional level (Van Duin & Van der Heijden, 2012). Deep-sea ports have negative external effects such as congestion, noise nuisance, CO2 exhaust and PM10 exhaust. In the last decades, seaports have been under increasing regulatory pressure in order to limit emissions, noise nuisance, congestion, water pollution and other negative external effects resulting from port activities. Given this pressure, seaports have sought ways to relocate parts of their activities to inland ports. If the possibilities for port activities are again enlarged in seaports (e.g. through land reclamation) then the port activities might relocate again from inland port to seaport. Next to additional economic advantages for inland ports, this has also enabled seaports to 'export' parts of their negative external effects to inland ports. If for example, end-haulage road transport from the seaport to the final destination is replaced by inland waterway transport to an inland port combined with end-haulage road transport from the inland port to the final destination, the seaport might become 'greener' but the inland port becomes less environmentally friendly. This is underlined by Haezendonck (2001) who argued that the environmental impact of a port is largely determined by the externalities generated by the transport modes used to and from the hinterland. In our database, however, data is lacking to develop hypotheses relating to inland port policy and regulation.

Port competition: This category consists of port competition, strategy analysis, port performance and port choice. To our knowledge, literature on competition between different inland ports is – so far – not very well developed; inland port competition has not been discussed as focal point in scientific research papers. Moreover, our database is lacking information to develop hypotheses relating to inland port competition.

Spatial analysis and features of seaports: This category consists of spatial change in seaports, spatial studies of port networks, studies of spatial change of port cities and the port city interface and analysis of port hinterlands. In the inland port, the traffic structure which represents the relative shares of the different transport modes used for incoming and outgoing flows to and from the hinterland is important (Dooms *et al.*, 2013). Often in the inland ports, traffic imbalances exist between imports and exports leading to empty vessel movements and also to empty load units movements (such as containers). Data problems often arise due to measurement issues connected to quay measurement or terminal measurement. Furthermore, quays and terminals can be under (or outside) the jurisdiction of the inland port authority, which complicates data issues (Dooms *et al.*, 2013). Still, some data in our database can be used to develop hypotheses relating to the spatial features of inland ports:

- *The transshipment level and growth in transshipment are negatively related to the distance from an inland port to the nearest access point to a main road or motorway* (because a short distance from the inland port to a main road or motorway is expected to result into greater accessibility of the inland port, which can attract higher levels of transport capacity and trigger further growth in transshipment)

The research focus of our paper is summarized in Table 1. In the next section, we explain the characteristics of our database and the methods we used for our analyses.

Table 1: Overview of issues for inland port studies

	Data available	No data
Theories/sources	- Terminal studies (Hyp 1, 2)	- Port planning and development
	- Ports in transport and supply chains (Hyp 3, 4)	- Port policy and regulation
	- Spatial analysis of ports (Hyp 6)	
No theories/sources	- Port governance (Hyp 5)	- Port competition

Source: Authors' own categorization based on Pallis et al. *(2010)*

3. Data analysis approaches for inland port performance

3.1. Data availability, sampling and characteristics

Data availability: The basis of our analyses is a large-scale quantitative dataset of Dutch inland ports, consisting of transshipment figures and related transport and economic factors. The transshipment figures are based on data from CBS Statistics Netherlands on the overall transshipment level in inland navigation in tons/year for all Dutch municipalities in 2006. The municipal level is the best proxy for the inland port level itself, as nearly all municipalities in the Netherlands only have one inland port within their territory. After 2006, figures on the transshipment levels in inland navigation have not been collected anymore in a systematic way on the local scale;

only at an aggregated level, which cannot be differentiated for inland ports. On the one hand one could argue that the data are a bit old, on the other hand, the advantage is that the crisis and post crisis years with large volume changes are not included in the data. The variable growth in transshipment has been created by calculating the factor increase or decrease over the 2001-2006 period.

The data on the overall transshipment level in inland ports can be disaggregated to transshipment levels per NSTR-unit (*Nomenclature uniforme des marchandises pour les Statistiques de Transport, Revisée*). This means that a subdivision can be made into transshipment in agriculture products; nutrition products; mineral oils; petroleum products; minerals; iron, steel and semi-manufactured goods; pure minerals and manufactured goods; fertilization products; chemical products; and vehicles, machines and other general cargo. These disaggregated figures are used to construct the variable diversity in types of goods (only including the number of NSTR-units exceeding transshipment of 100,000 tons/year).

Other data on transport factors which have been collected include the presence of a container terminal in the inland port and the functional range of distribution activities of the inland port. The presence of a container terminal is derived from information provided by the Dutch Centre for Expertise and Innovation in Inland Navigation and is constructed as a dummy variable (0=not present, 1=present) in our dataset. The functional range of distribution activities relates to the distance class to which (or from) the majority of the cargo of an inland port is being transshipped. Based on an earlier definition of the functional range of distribution activities by the NVB Dutch Inland Ports Association (2004) we have constructed three categories: the short distance range (with a distribution radius ranging from 0 to 100 km from the inland port), medium distance range (101-350 km radius) and long distance range (351-N km radius). Destination data of transshipment from the inland port to (and from) a certain distance class are linked to these three categories.

Data on economic factors which have been collected include the number of companies and the number of jobs in the region to which the inland port belongs. Both variables have been derived from CBS Statistics Netherlands data. Because of the – obvious – high correlation between the two, only the number of jobs in the region is used in the analysis. Finally, the variable distance to the nearest access point to a main road or motorway is also derived from CBS Statistics Netherlands data and can be used as a proxy to measure the relative accessibility of the inland port.

Data sampling and characteristics: In the first step of creating a representative sample from the raw data, the total number of municipalities in the Netherlands in 2006 (365 municipalities) was brought down to the total number of municipalities which actually showed transshipment levels exceeding 0 in 2006 (217 municipalities). The second step consisted of excluding municipalities which are hosting a deep-sea port instead of or next to an inland port and municipalities which are an island, thus are not part of the inland navigation work of the mainland. These exclusions are derived from the classification made by the NVB Dutch Inland Ports Association (2004). This leaves 203 municipalities hosting an inland port, not being a deep-sea port or an island. Next, municipalities which did not show transshipment figures for 2001 but did show figures for 2006 were excluded to avoid infinite growth figures. The remaining dataset consisted of 185 municipalities hosting an active inland port both in 2001 and 2006.

Finally, a filter was applied to select those municipalities which hosted an inland port having a critical mass of transshipment of at least 100,000 ton/year in 2006. This final limitation resulted in a dataset consisting of 135 inland ports. Some descriptive characteristics of the final sample are outlined in Table 2. It should be noted that this filter was applied only for the 2006 data, and not for the 2001 data. This means that there is a theoretical possibility that inland ports with a transshipment level of over 100,000 ton/year in 2001 who somehow showed negative growth rates in the 2001-2006 period resulting in a figure smaller than 100,000 ton/year in 2006, have been excluded. The reason for this is an institutional one and has to do with municipal restructuring in the Netherlands in between 2001 and 2006, resulting in larger municipalities in 2006, made up of multiple smaller ones from 2001. Looking at the data, it is only logically and practically possible to match disaggregated data of 2001 to aggregated data of 2006, and not vice versa. However, we expect that the theoretical possibility of excluding these few cases has no far-reaching implications for the interpretation of the results of the regression analysis (Table 5).

An interesting observation which can be made on the basis of Table 2 is that while the mean transshipment level has decreased over the 2001-2006 period, the mean growth figure over the same period is still positive. At the same time, the minimum level of transshipment has increased, while the maximum level of transshipment has decreased. Apparently, some convergence processes have taken place on the port system level, implying that the differences between small and large inland ports have relatively narrowed down. In other words, smaller ports are possibly 'catching up' in terms of transshipment volume. However, the discussion of the regression analyses in the next section is decisive in confirming or rejecting this hypothesis. Another observation relates to the functional ranges of distribution activities, where a – not unexpected – gradual decrease of volumes can be observed from the short (regional) to the long distance (European) scale. Finally, it should be stressed that most of the variables show a positive skewness which exceeds the critical threshold value of 2. This means that the data should be transformed before they can be used in the regression analyses.

Table 2: Descriptive statistics of inland ports' characteristics (n=135)

	Minimum	Mean	Maximum	Std. Dev.	Skewness
Transhipment level 2001 ton/year (x 1,000)	20	1,027.13	10,645	1,316.89	3.960
Transhipment level 2006 ton/year (x 1,000)	103	970.06	7,686	1,155.03	2.835
Growth in transhipment 2001-2006	0.12	1.38	12.35	1.50	4.344
Diversity in types of goods 2001 (0-9)	0	1.72	8	1.49	1.844
Diversity in types of goods 2006 (0-9)	0	1.84	9	1.52	1.960
Number of jobs in the region 2001 (x 1,000)	1.12	25.03	244.43	36.20	3.388
Number of jobs in the region 2006 (x 1,000)	1.19	27.64	266.58	39.51	3.359
Short distance distribution ton/year (x 1,000)	0	445.99	3,650.77	607.90	2.704
Medium distance distribution ton/year (x 1,000)	0.50	410.56	3,301.21	541.74	2.542
Long distance distribution ton/year (x 1,000)	0.48	88.96	609.74	127.25	2.078
Distance to access point main road (km)	0.60	1.55	4,10	0.58	1.143

Source: Authors' own data computations

3.2. Research methodology: regression analyses

In our paper we discuss the relation between the performance of inland ports (in terms of transshipment level and growth in transshipment) and some determining transport and economic factors. To this end, we make use of multivariate regression analyses. To meet the condition of normality for using regression analyses we transformed our database using log-transformations to correct for positive skewness of the data. Another condition for using regression analyses is that there is no perfect multi-collinearity between independent variables. We checked this by looking at Pearson's correlation coefficients and the Variance Inflation Factors. None but one of the correlation coefficients is excessively high (all are below 0.7) and none of the Variance Inflation Factors exceeds the critical threshold value of 5 (the highest being 2.7). Also, there are no problems with homoscedasticity of variances. Based on these conditions, all remaining independent variables could be included in the models. Because we had no prior expectations about the relative importance of the independent variables and because the relations between our x and y variables are likely to be linear, we built our models using ordinary least squares (OLS). The results are discussed in the next section.

4. Data analysis: results inland port performance

Modelling outcomes: We built two models to discuss our hypotheses. The first model is the OLS-model for the transshipment level in 2006 (Table 3). The model is significant (F: 45.216; p: 0.000) with an adjusted R2 value of 0.721. Most independent variables show significant relations with the dependent variable. The second model is the OLS-model for the growth in transshipment from 2001 to 2006 (Table 4). This model is also significant (F: 12.516; p: 0.000), but the explained variance is somewhat lower compared to the first model (adjusted R2: 0.402). Possibly the 'static' transshipment level in 2006 is easier to explain using our independent variables compared to the 'dynamic' growth over a 6-year time period, where other exogenous factors which are not captured by our independent variables may influence the growth patterns to some extent as well. Note that in the second model the transshipment level in 2001 is included to control for the 'basic level' in explaining growth patterns. Also note that the variable 'Medium range distribution' is omitted because it was too highly correlated with the before-mentioned transshipment level in 2001. The outcomes of the regression analyses are discussed in the same order that we used in the introduction of the hypotheses (Section 2).

Table 3: Modelling outcomes for transshipment level 2006 (** $p < 0.05$)

	Beta	t	VIF
Constant	2.215**	3.334	
Presence container terminal	0.382**	3.175	1.289
Number of jobs in region	0.054	1.118	1.488
Short distance range distribution	0.070**	2.028	1.156
Medium distance range distribution	0.198**	3.803	1.876
Long distance range distribution	0.025	0.748	1.754
Diversity in types of goods	0.316**	7.683	1.845
Distance to access point main road	-0.510**	-3.396	1.206
Adjusted R2	0.721		

Source: Authors' own data computations

Table 4: Modelling outcomes for growth in transshipment 2001-2006 (** $p < 0.05$; * $p < 0.10$)

	Beta	t	VIF
Constant	2.702**	4.851	
Transshipment level 2001	-0.570**	-7.459	2.716
Presence container terminal	0.302**	2.370	1.343
Number of jobs in region	0.052	1.023	1.512
Short distance range distribution	-0.014	-0.342	1.571
Long distance range distribution	0.065*	1.893	1.652
Diversity in types of goods	0.190**	3.867	2.250
Distance to access main road	-0.292**	-1.815	1.280
Adjusted R2	0.402		

Source: Authors' own data computations

Inland port performance: In Section 2 we stated that container terminals are expected to be located at strategic locations in the general port system. We argued that the presence of a container terminal in a port can be considered an additional pull-factor for the port, which can consequently attract higher levels of overall transshipment capacity and trigger further growth in transshipment. We hypothesized that for the port performance on the inland port level the presence of a container terminal in an inland port should be positively related to the transshipment level and growth in transshipment of the inland port. This hypothesis is confirmed by the results (Table 4 and 5). As expected, the presence of a container terminal is positively and significantly related to the transshipment level in 2006 and to the growth in transshipment from 2001 to 2006. These outcomes add to the argument that containerization is becoming more important in the general port system (Rodrigue & Notteboom, 2009).

We also hypothesized that convergence processes would take place on the port system level, leading to smaller differences between small and large inland ports. In other words, the transshipment level should be negatively related to growth in transshipment. This hypothesis is also confirmed by the results (Table 5); if the basic level of transshipment already is high, inland ports are less likely to sustain further growth. This means that the relative 'catching up' of smaller inland ports – as was indicated in the previous section – is indeed likely to be happening. Perhaps this is not so surprising, given the literature on the outsourcing of capacity to smaller ports in the hinterland (e.g. Notteboom, 1997; Notteboom & Rodrigue, 2005).

Inland ports in transport and supply chains: With regard to the positioning of inland ports in transport and supply chains we stated in Section 2 that especially the long distance range of distribution would be important in attracting and sustaining transshipment volumes. We argued that the greater the catchment area of an inland port, the greater the level of and growth in transshipment would be. In other words, the long distance range of distribution was hypothesized to show a greater influence on the dependent variables level and growth, compared to respectively the medium and short distance range of distribution. On basis of the results, this hypothesis can only partly be confirmed. For the growth in transshipment (Table 5), the long distance range indeed shows a positive sign, but this is only significant on the $p < 0.10$ level. The short distance level is – based on our results – not of great importance for growth in transshipment. For the transshipment level (Table 4), the results are contrary to what we expected; the short and medium distance levels of distribution both show positive and significant outcomes, whereas the long distance level is not significantly related to the transshipment level. With some caution we can therefore argue that our results indicate that the short and medium distance levels of distribution are important in achieving an initial basic level of transshipment, and that distribution should over time shift to the long distance range to sustain further growth in transshipment.

We also hypothesized that the number of jobs in the region would result into greater flows of people, goods and services, which would in turn attract higher levels of transport capacity and trigger further growth in transshipment. This hypothesis cannot be confirmed on basis of our results. Both models indicate that the number of jobs neither is related to the transshipment level nor to growth in transshipment. Apparently the relation between regional employment levels and transshipment figures on the inland port level is too indirect to cause any significant relations between the two. This means that the often made supportive argument in the literature of ‘investments in inland port activities leading to employment growth’ cannot be confirmed based on our analyses.

Inland port governance: Although the data we use are not explicitly highlighting inland port governance, we argued in Section 2 that the diversity in types of goods which is being transshipped in an inland port can be viewed as a good proxy to indicate a distinction in two types of port governance strategies: focusing on either monofunctional or multifunctional inland ports. We hypothesized that the diversity in types of transshipped goods would be positively related to the level of and growth in transshipment. In other words, transshipping many different types of goods can be regarded as a portfolio strategy in port governance to attract and sustain growth, compared to a port governance strategy which is more oriented on specialization in a specific type of good (e.g. a monofunctional sand/grid port). Based on the modelling outcomes in Table 4 and 5, this hypothesis can be confirmed. Perhaps the positive and significant outcome for diversity in the transshipment level model is not that surprising; ports transshipping a great variety of goods also show high overall levels of transshipment capacity. Yet, it is interesting to find that diversity in goods is not only related to high levels of transshipment capacity, but also to growth in transshipment over a prolonged period of time. Our results therefore indicate that having a portfolio strategy in port governance can be beneficial both in attracting a basic level of transshipment volume and in sustaining further growth in transshipment. Apparently an inland port is better protected against external influences such as market dynamics when the variety in types of goods is greater.

Spatial features of inland ports: Our final hypothesis which was formulated in Section 2 brought to the fore the influence of the accessibility of an inland port on the level of and growth in transshipment. We argued that the distance from the inland port to an access point of a main road or motorway would be negatively related to the level of and growth in transshipment, because the shorter the distance, the greater the accessibility would be. Our results confirm this hypothesis, both for the level of and growth in transshipment (Table 4 and 5). In both cases the distance variable is negatively and significantly related to the dependent variable. It is likely that a good accessibility by road can be beneficial for an inland port, because efficient pre- and end-haulage can be regarded a pull-factor in port selection (Yeo et al., 2008; Wiegmans et al., 2008).

5. Conclusions

This paper has focused its attention on inland port performance, which is up to now an overlooked part in the scientific literature on port system development. The overview of port issues provided by Pallis et al. (2010) combined with our dataset has led us to formulate specific hypotheses regarding the performance of inland ports in the European network. Our central problem definition was: “How can the performance conditions of inland ports explain their change in size and growth?”.

Our empirical analyses discussed the relation between the level of and growth in transshipment and a number of transport and economic factors. First, we conclude that the presence of a container terminal is an important performance condition for inland ports, both in attracting transshipment capacity and in sustaining further growth. This finding is in line with the growing attention to containerization and externalities in the academic literature (see also Macharis et al., 2010). Secondly, other important characteristics that influence inland port performance in terms of transshipment level are ‘diversity in types of goods’ and a relatively large share of distribution on the medium distance range. Thirdly, the accessibility of an inland port by road can be considered an important indicator for inland port performance both in terms of transshipment volume and growth. Finally, we have found that the transshipment level is inversely related to growth in transshipment. Apparently, convergence or ‘catching up’ of smaller ports is happening at the port system level, which is not so surprising given the scientific literature on the tendency to outsource production factors when traditional port areas become congested.

Next, for answering the problem definition, we have also tested six hypotheses. Hypothesis 1 and 2 regarding port performance on the inland port level can be confirmed. Next, our findings concerning the positioning of inland ports in transport and supply chains (hypothesis 3) and concerning the number of jobs in a region (hypothesis 4) were not particularly convincing. We suggest that further research needs to be done here, for instance regarding the influence of regional clusters of economic activity on the performance of inland ports. Our results also indicate that inland port activities are only of limited importance for the number of jobs in a region. Hypothesis 5 shows that a portfolio strategy – as compared to specializing in a monofunctional port – can be regarded beneficial in port governance; not only to attract an initial level of transshipment volume, but also to sustain further growth. Finally, the hypothesis about accessibility (shorter distance to the road network is more beneficial) is confirmed. These results pave the way for more in-depth analyses of inland port performance in future studies.

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