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Characteristics of European inland ports: A statistical analysis of inland waterway port development in Dutch municipalities

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ABSTRACT

Most scientific attention in port studies centers on deep-sea ports, in particular container ports. In our paper, in contrast, we focus our attention on the characteristics of inland *waterway* ports in a European context. This is an overlooked part in the scientific literature on inland port development, which is up to now mainly concerned with US-based understandings of inland ports. We try to broaden the application of the inland port concept by explaining the development of inland ports in terms of inland waterway bounded cargo throughput. Based on a large-scale quantitative dataset of inland port development in Dutch municipalities we perform various statistical analyses to arrive at a more detailed understanding of the question: What are the characteristics of European inland waterway ports and what transport and economic factors influence cargo throughput on the municipal level? The results in particular highlight the importance of the presence of a container terminal, the diversity in types of goods which are being handled by the inland port and the accessibility of the inland port relative to the regional motorway network as important factors in explaining the size and growth of inland ports. Interestingly, the popular claim in policy of 'investments in inland port development leading to employment growth' cannot be confirmed.

1. Introduction

Most scientific attention in port studies centers on deep-sea ports, in particular container ports. This is not surprising, given the importance of containerized traffic in shaping global freight flows in present-day transport networks. In this process, especially the efficiency of maritime ports and of terminals has received much attention. Also, the analysis of the role of deep-sea ports in transport and supply chains, including the analysis of the management and organization of ports and terminals forms part of the body of scientific literature (e.g. Van Klink and Van den Berg, 1998; Bontekoning et al., 2004; Hesse and Rodrigue, 2004; Notteboom and Rodrigue, 2005; Woxenius, 2007; Notteboom, 2010; Pallis et al., 2010). In the hinterland of deep-sea ports (i.e. in inland ports) most scientific attention also goes to intermodal container terminals in combination with the logistics role of inland ports versus the hinterland of the larger maritime ports (see for instance the Inside-Out, Outside-In discussion in Wilmsmeier et al., 2011 and Monios and Wilmsmeier, 2012). However, in the European context, where the focus is mainly on terminals – in line with the US-based understanding of inland ports – there is surprisingly little

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scientific attention to the characteristics and development of inland *waterway* ports. The characteristics of inland waterway ports and the relation with cargo throughput on the municipal level have not been studied extensively nor systematically, although many municipalities are facing spatial challenges with regard to accommodating conflicting port and urban functions, which are to a certain extent influencing their governance strategies (see e.g. Wiegmans and Louw, 2011; Witte et al., 2014). Therefore, they can be expected to benefit from more detailed insights into the determining characteristics of inland ports in Europe. This leads us to the following research question:

''What are the characteristics of European inland waterway ports and what transport and economic factors influence cargo throughput on the municipal level?''

In our paper, we focus our attention on the characteristics of inland *waterway* ports (i.e. as compared to focusing solely on container terminals in inland ports or on inland ports as large-scale freight sites and focusing only on inland waterway cargo; rail and road are excluded). In Section 2, we present a literature review of port studies in which we position inland waterway ports relative to 'traditional' 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 waterway port development, combined with economic characteristics on the municipal and regional level. Furthermore, we derive the hypotheses and we discuss our methodology. In Section 4 we perform multivariate regression analyses in order to arrive at a detailed understanding of the characteristics of inland waterway ports. We try to explain the development of inland waterway ports in terms of cargo throughput by several transport and economic factors. We test for differences in size and in volume growth and we control among others for differences in type of port and in the presence of a container terminal in the municipality. Section 5 contains the conclusions of our paper.

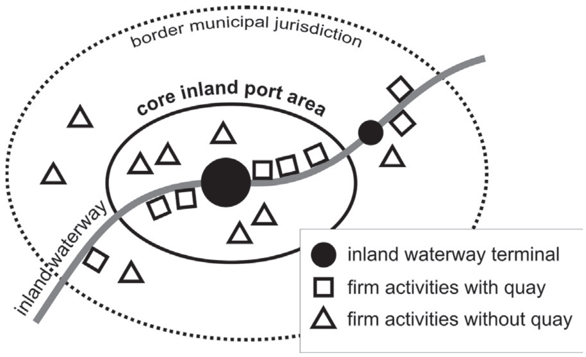
2. From inland port, to inland waterway port: a literature review

2.1. Defining inland ports

Although scientific attention to inland ports is growing in recent years, 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 are different levels of inland port geographies (spatial scales), actors, regulatory settings and functions. Inland port geographies can range from an individual company with a quay, to a container terminal, to a number of companies with quays concentrated in a municipality, to the inland port municipality, to the hinterland of the inland port, up to the connections with the deep-sea ports. Inland port actors can include public authorities, the port authority, transport operators of the respective transport modes, logistics service providers and the terminal operators. Regulatory settings can refer either to the type of ownership of the inland port or the type of port governance strategy used by the public authorities. In a broader sense, regulatory settings also cover e.g. land use policy, planning regulations, traffic management and so on, which potentially influence the institutional context in which inland ports are embedded. Inland port functions for their part can 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 toward deep-sea ports. In Fig. 1, we combine inland port geographies, actors and functions in order to define the 'borders' of our analysis.

In Fig. 1, we define a municipality as an area of a certain size (the large oval) encompassing road infrastructure and inland waterway(s). In the center of the large oval, two smaller ovals are depicted that are inland waterway terminals. In different municipalities, different constellations of one or more terminals, one or more concentrations of companies with quay access (along the river extension in the upper part of the figure), and one or more companies with quay access 'outside' of the core inland port area of the municipality can be found. Inside the municipality in the core inland port area, many companies without a quay are found providing production, logistics and transport services and services like hotels, shops, restaurants, post office, and operational services like container cleaning and repair. In municipalities also urbanized areas can be found, often leading to a number of issues where inland port and city compete or are complementary. For our paper, the interaction between city and inland 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.

In the scientific literature, there exist important differences in inland port definitions between the US and Europe. Much of the academic literature which pays specific attention to inland ports is focused on empirical evidence stemming from the American context (e.g. Leitner and Harrison, 2001; Walter and Poist, 2004; Rahimi et al., 2008; Monios and Wang, 2013). Especially in the US-based literature, inland ports usually refer to larger freight sites with mostly rail terminals (and sometimes water) including surrounding business properties and an own governance structure. This also relates to the historical development of rail freight transport which is much more important in the US than in Europe. In Europe, such a rail oriented node is generally known as freight village, Güterverkehrszentrum, interporto or dry port (and not as inland port). In the European perspective – and following the dictionary definition of a 'port', an inland port is a place (or a town or city) along a waterway with facilities for loading and unloading ships. This latter understanding is also how we define the inland port in our paper which means that in our case an inland location without water access cannot be called an inland port from the



Source: Authors' own drawing

Fig. 1. The relation between inland waterway terminal, inland port and municipality.

European perspective. This implies that our definition is restricted to a barge-only setting, which is not dedicated to terminals-only and which can also relate to smaller-scaled port activities in a municipality which are not bound to the core inland port area. We use this definition to explain the development of European inland ports in terms of inland waterway bounded cargo throughput.

Throughout any municipality any location with a quay owned by a shipper, transport company, logistics service provider, terminal operator, etc. can be called an inland port. In general, a town or city along a waterway might be expected to have more than one location with a quay and facilities for loading and unloading ships. In the European context, in addition to inland navigation traffic which is scattered across a municipality in the form of small quays and terminals where shippers, transport companies and logistics providers move their own freight, without any governance structure whatsoever, dedicated container handling services are provided at inland waterway container terminals which are sometimes also called inland ports. Finally, also the clustering of cargo handling and throughput in a larger freight area where multiple companies with quays are located can be called an inland port, which relates well to the traditional US-based definition, but in this case specifically limited to a barge-only setting. Our data thus refers to inland waterway bounded cargo throughput in municipalities. All companies located in the municipality with water access (e.g. through a private quay or terminal) are included in the data (see Section 3.1).

2.2. Characteristics of inland ports

Despite the growing body of literature regarding inland ports, we up to now found no study which systematically and coherently discusses the various spatial, transport, economic and institutional characteristics which are of relevance for the context of inland ports. However, in the context of deep-sea ports, such studies do exist. In particular the research undertaken by Pallis et al. (2010) systematically outlines a number of key issues which are important in maritime port studies. Given the breadth and depth of their study (i.e. covering a great diversity of issues and incorporating the majority of relevant studies in these fields of research), we have taken their defined topics as a starting point for structuring our analysis of inland ports. We selected three main topics from the Pallis' study which together are intended to represent the key issues for inland port studies. Below, we discuss the main features of: (1) Terminal studies and port performance; (2) Ports in transport and supply chains and (3) Spatial analysis of ports. In the next section, these topics are related to the inland port context and to our data. Consequently, five hypotheses are derived from that.

1. *Terminal studies and port performance:* Deep-sea terminal studies focus especially 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 mostly missing in scientific research, as in our research. Furthermore, Witte et al. (2014) have found that inland port strategies are often either missing or 'under construction'. Therefore, we broadened the scope for measuring performance from the terminal level to the (municipal) port level. Moreover, performance can be measured in various ways. In our paper, we try to measure 'performance' of inland waterway ports in particular by exploring the development of the port in terms of growth in cargo throughput on the municipal level. However, we have also created some single-performance measurement benchmarks, which can give an impression of the performance of the inland ports in our dataset (see Section 3).
2. *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 and Rodrigue, 2005; Veenstra et al., 2012). For inland ports, Rodrigue et al. (2010) have found that the functional outcome remains relatively similar irrespective of their geographical, regulatory and operational settings. 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 paper, we try to explore and analyze the networks, flows and chains by zooming in on the relation between inland port development and the regional employment level, the functional range of distribution activities of inland waterway ports and the diversity of goods which are handled by an inland waterway port.

3. *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 unit 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, in our paper we are interested in relating accessibility of inland waterway ports to their development in terms of cargo throughput.

In the next section we explain the characteristics of our dataset and relate the data to the topics as discussed above. This allows us to formulate hypotheses which can be used in our analyses. The next section ends with data sampling issues and a discussion of the methodology which is used.

3. Data, hypotheses and methodology

3.1. Data characteristics

The basis of our analyses is a large-scale quantitative dataset of Dutch inland waterway ports based on data provided by CBS Statistics Netherlands, consisting of cargo throughput figures on the municipal level (in tons) and related transport and economic factors. We have defined two dependent variables which are intended to explore the development of inland waterway ports: cargo throughput level and growth in cargo throughput.[1] The *cargo throughput level* is based on data from CBS Statistics Netherlands on the overall cargo throughput in inland navigation in tons/year for all Dutch municipalities in 2006.[2] The municipal level offers the best available data for our analyses. Moreover, following our definition of inland waterway ports, the municipal level is a good proxy for the inland waterwa port level itself, as over three-quarters of all municipalities in the Netherlands with cargo throughput figures only have one main area of port development within their territory (see Appendix A). Since 2006, figures on the cargo throughput levels in inland navigation have not been collected in a systematic way on the local scale, but only at an aggregated level, which cannot be differentiated for specific inland waterway ports within a municipality. The variable *growth in cargo throughput* has been created by calculating the factor increase or decrease over the 2001–2006 period.[3]

In our dataset, we have included several independent variables which reflect the most important transport and economic factors taken into account. Data on transport factors that have been collected include the *presence of a container terminal* in the municipality and the *functional range of distribution activities* of the inland waterway 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 waterway 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 waterway port), *medium distance range* (101–350 km radius) and *long distance range* (351-N km radius). Actual destination data of cargo throughput from the inland waterway port to (and from) a certain distance class are linked to these three categories.

With regard to economic factors, the data on the overall cargo throughput level in inland waterway ports can be disaggregated to cargo throughput levels per NSTR-unit (*Nomenclature uniforme des marchandises pour les Statistiques de Transport, Revisée*). This means that a subdivision can be made into cargo throughput in agriculture products; foods; mineral oils; petroleum products; minerals; iron, steel and semi-manufactured goods; pure minerals and manufactured goods; fertilizers; 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 cargo throughput of 100,000 tons/year).

[1] These dependent variables are used in the regression analyses. We have checked other performance indicators as well by exploring single-measure performance benchmarks (see Section 3.4).

[2] Unfortunately, disaggregated data on container throughput in TEU/year are not available. Moreover, following our definition of inland waterway ports (see Section 2.1) we are interested in *all* throughput on the municipal level; not merely the containerized throughput.

[3] We are aware that the market conditions for freight distribution in Europe have changed considerably following the economic collapse of 2008. However, whereas this might have important implications for the downfall of certain inland ports since the financial crisis, we still think our analyses can provide interesting explorative insights on the characteristics and development of inland ports in Europe. On the other hand, it can be argued that by focusing on the 2001–2006 period, the findings are at least not blurred by these cyclical economic effects.

Other data on economic factors which have been collected include the *number of companies* and the *number of jobs* in the region. 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. 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 waterway port. Finally, the number of central inland port locations within a municipality is checked by means of the Blue Road Map database with regard to inland navigation activities of the Dutch information agency BVB (*Bureau Voorlichting Binnenvaart*). Two dummy variables are included to control for the number of central inland port locations within a municipality (see Appendix A); one dummy for municipalities with one main port area (0 = no discernable main port area, 1 = one main port area) and one dummy for municipalities with more than one main port area (0 = no discernable main port area, 1 = two or more main port areas).[4]

3.2. Hypotheses

In order to explore and analyze the characteristics of inland waterway ports, we formulated hypotheses regarding issues which are in our view relevant for inland port studies. We based our hypotheses upon a combination of the issues presented in Pallis et al. (2010) and relevant to inland waterway ports, and the availability of data on inland waterway ports as was discussed in this section. Consequently, our five hypotheses are:

a. The cargo throughput level is negatively related to the relative growth in cargo throughput (if the basic level of cargo throughput is already high, inland waterway ports are less likely to sustain further growth, because of convergence processes on the supra-regional level).
b. The cargo throughput level and the growth in cargo throughput are positively related to the presence of a container terminal in the municipality (because container terminals are expected to be located in strategic locations, creating an additional pull-factor, which can attract higher levels of cargo throughput and trigger further growth in cargo throughput).
c. The cargo throughput level and the growth in cargo throughput are positively related to the number of jobs in the region (because a larger number of jobs is expected to result in greater flows of people, goods and services, which can attract higher levels of transport capacity and trigger further growth in cargo throughput).
d. The cargo throughput level and the growth in cargo throughput are positively related to the diversity in types of goods (because the diversity in types of goods is expected to protect the inland waterway port from the impact of external shocks (i.e. in contrast to specializing in one product sector). This relative 'resilience' can in turn attract higher levels of cargo throughput and trigger further growth in cargo throughput).
e. The cargo throughput level and growth in cargo throughput are negatively related to the distance from an inland waterway port to the nearest access point to a main road or motorway (because a short distance from the inland waterway port to a main road or motorway is expected to result into greater accessibility of the inland waterway port, which can attract higher levels of transport capacity and trigger further growth in cargo throughput).

The remainder of this section explains our data sampling, introduces the descriptive statistics of the variables as discussed above and discusses the methodology which is used.

3.3. Data sampling and descriptive statistics

In the first step of creating a representative sample from the raw data, the total number of municipalities in the Netherlands in 2006 (458 municipalities) was brought down to the total number of municipalities which actually showed cargo throughput 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 waterway port and municipalities which are an island, thus are not part of the inland navigation network 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 waterway port and not hosting a deep-sea port or being an island. Next, municipalities which did not show cargo throughput 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 waterway port in both 2001 and 2006. Finally, a filter was applied to select those municipalities which hosted an inland waterway port having a critical mass of cargo throughput of at least 100,000 ton/year. This final limitation resulted in a dataset consisting of 135 inland ports (see also Appendix B).[5] Some descriptive characteristics of the final sample are outlined in Table 1.

[4] Municipalities which score '0' in both dummies have no discernable main port area, but still can have throughput via private quays or terminals, scattered across the municipality.

[5] Initially, the sample consisted of 136 inland ports, but the case of Rozenburg turned out to be an extreme outlier. The throughput of the municipality of Rozenburg in fact belongs to the port activities of the Port of Rotterdam. The reason that this throughput is not included in the figures of Rotterdam is that the data are measured at the municipal level, and the municipal boundaries do not match the port area of Rotterdam. Rozenburg was therefore excluded from the sample, leaving 135 inland waterway ports suitable for using in the regression analyses.

Table 1
Descriptive statistics of inland waterway ports ($n = 135$).

	Min.	Mean	Max.	Std. dev.	Skew.
Cargo throughput level 2001 ton/year (×1000)	20	1027.13	10,645	1316.89	3.960
Cargo throughput level 2006 ton/year (×1000)	103	970.06	7686	1155.03	2.835
Growth in cargo throughput 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 (×1000)	1.12	25.03	244.43	36.20	3.388
Number of jobs in the region 2006 (×1000)	1.19	27.64	266.58	39.51	3.359
Short distance distribution ton/year (×1000)	0	445.99	3650.77	607.90	2.704
Medium distance distribution ton/year (×1000)	0.50	410.56	3301.21	541.74	2.542
Long distance distribution ton/year (×1000)	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.

Table 2
Outcomes single-measure performance benchmark.

	Low	Median	Mean	High
1. Cargo throughput in tons/resident	0.30	10.10	23.10	255.60
2. Cargo throughput in tons/surface (ha)	0.80	60.00	143.21	1384.10
3. Cargo throughput in tons/company	6.30	194.50	459.36	5841.50
4. Cargo throughput in tons/job	0.40	24.20	66.75	676.30
5. Residents/company	12.50	20.30	20.22	36.70
6. Jobs/resident	0.13	0.39	0.42	1.39
7. Jobs/company	2.40	8.1	8.53	28.60

Source: Authors' own data computations.

An interesting observation which can be made on the basis of Table 1 is that while the mean cargo throughput 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 cargo throughput has increased, while the maximum level of cargo throughput has decreased. Apparently, some convergence processes have taken place on the supra-regional level, implying that the differences between small and large inland waterway ports have narrowed down relatively. In other words, smaller ports are possibly 'catching up' in terms of cargo throughput volume. A possible explanation might be that most of the inland waterway ports are subsidized (one way or the other) preventing certain levels of concentration among inland ports leading to a situation of subsidized competition. In the period after 2006, a more active involvement of port authorities and terminal operators might again have started divergence processes among inland ports. However, the discussion of the regression analyses in the next section is decisive in confirming or rejecting this hypothesis. Also, it should be stressed that most of the variables show a positive skewness which exceeds the critical threshold value of 2. This implies that the data should be transformed before they are used in the regression analyses.

3.4. Methodology

In order to analyze and compare the performance of inland waterway ports, a benchmark can be helpful. A benchmark can be defined as something whose quality, quantity or capability is known and which can therefore be used as a standard with which other things can be compared. For our analysis, some benchmarks have been checked to get a better grip on the data (Table 2). In our regression analyses, however, we only make use of the dependent variables 'cargo throughput level' and 'growth in cargo throughput' (Section 3.1), which in itself can be considered a useful benchmark for measuring the development of inland waterway ports. Therefore, the single-measure performance benchmarks will not be used in the regression analyses and will only serve the purpose of analyzing the performance of inland waterway ports in an explorative way.

Table 3
Modeling outcomes for cargo throughput level 2006.

	B	*t*	VIF
Constant	2.154**	3.212	
Presence container terminal	0.377**	3.055	1.344
Number of jobs in region	0.041	0.813	1.614
Short distance range distribution	0.070**	2.027	1.158
Medium distance range distribution	0.195**	3.711	1.894
Long distance range distribution	0.023	0.665	1.766
Diversity in types of goods	0.320**	7.700	1.865
Distance to access point main road	−0.504**	−3.317	1.219
Dummy one main port area	0.163	0.931	2.242
Dummy two or more main port areas	0.139	0.614	2.290
Adjusted R^2	0.718		

Source: Authors' own data computations.
** $p < 0.05$.

Table 4
Modeling outcomes for growth in cargo throughput 2001–2006.

	B	*t*	VIF
Constant	2.699**	4.708	
Cargo throughput level 2001	−0.572**	−7.423	2.727
Presence container terminal	0.313**	2.388	1.400
Number of jobs in region	0.048	0.905	1.628
Short distance range distribution	−0.014	−0.342	1.577
Long distance range distribution	0.063*	1.816	1.667
Diversity in types of goods	0.194**	3.881	2.313
Distance to access main road	−0.298*	−1.828	1.296
Dummy one main port area	0.055	0.306	2.210
Dummy two or more main port areas	−0.031	−0.130	2.272
Adjusted R^2	0.393		

Source: Authors' own data computations.
** $p < 0.05$.
* $p < 0.10$.

In our paper we discuss the relation between the development of inland waterway ports (in terms of cargo throughput level and growth in cargo throughput) and several transport and economic factors. To this end, we make use of multivariate regression analyses. In order 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 multicollinearity between independent variables. We checked this by looking at Pearson's correlation coefficients and the Variance Inflation Factors. Only one[6] of the correlation coefficients is too high (all others are below 0.7) and none of the Variance Inflation Factors exceeds the critical threshold value of 5 (the highest being 2.875). 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) and including all variables at once. The results are discussed in the next section.

4. Analyzing inland waterway port development in Dutch municipalities

We built two models to discuss our hypotheses. The first model is the OLS model for the cargo throughput level in 2006 (Table 3). The model is significant (*F*: 34.916; *p*: 0.000) with an adjusted R^2 value of 0.718. Most independent variables show

[6] The medium distance range of distribution correlated too highly with the cargo throughput level in 2001. We have therefore excluded the medium distance range from the growth model.

significant relations with the dependent variable. The second model is the OLS model for the growth in cargo throughput from 2001 to 2006 (Table 4). This model is also significant (F: 9.631; p: 0.000), but the explained variance is somewhat lower compared to the first model (adjusted R^2: 0.393). Possibly the 'static' cargo throughput level in 2006 is relatively easier to explain using our independent variables compared to the 'dynamic' growth over a six-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 cargo throughput 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 cargo throughput 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 3.2).

4.1. Level versus growth

We hypothesized that convergence processes would take place on the supra-regional level, leading to smaller differences between small and large inland waterway ports. In other words, the cargo throughput level should be negatively related to growth in cargo throughput. This hypothesis is confirmed by the results; if the basic level of cargo throughput is already high, inland waterway ports are likely to grow relatively slower than smaller inland waterway ports (with a lower basic level of cargo throughput). This means that the relative 'catching up' of smaller inland waterway ports – as was indicated in Section 3.3 – 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 and Rodrigue, 2005). An alternative explanation to the 'catching-up' assertion would be that the levelling of differences between smaller and larger inland ports is part of the wider context of port development in Europe. As existing sites are already used and thus no longer available to new entrants, they will correspondingly select another available site (cf. greenfield development in urban planning). Also, it could be a capacity issue; as some facilities are built for single customers and single uses, new entrants are forced to find alternative locations.

4.2. Presence of a container terminal

In Section 3.2 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 municipality can be considered an additional pull-factor for activities in inland waterway ports, which can consequently attract higher levels of overall cargo throughput capacity and trigger further growth in cargo throughput. We hypothesized that the presence of a container terminal in an inland waterway port should be positively related to the cargo throughput level and growth in cargo throughput of the inland waterway port. This hypothesis is confirmed by the results (Tables 3 and 4). As expected, the presence of a container terminal is positively and significantly related to the cargo throughput level in 2006 and to the growth in cargo throughput from 2001 to 2006. These outcomes add to the argument that containerization is becoming more important in the general port system (Rodrigue and Notteboom, 2009).

4.3. Number of jobs

With regard to economic factors, we hypothesized that the number of jobs in the region would result in greater flows of people, goods and services, which would in turn attract higher levels of transport capacity and trigger further growth in cargo throughput. This hypothesis cannot be confirmed on the basis of our analysis. Both models indicate that the number of jobs is related neither to the cargo throughput level, nor to growth in cargo throughput. Apparently the relation between regional employment levels and cargo throughput figures on the inland waterway port level is too indirect to cause any significant relations between the two. This implies that the often-made argument in the professional literature and policy-documentation of 'investments in inland port development leading to significant employment growth' cannot be confirmed based on our analyses. For the expansion of inland waterway ports, effects on regional employment growth should thus be expected to be modest. In other words, in terms of job creation there might be better alternatives for achieving growth.

4.4. Diversity in types of goods

We argued in Section 3.2 that the diversity in types of goods can be viewed as a good proxy to indicate a distinction in two types of strategies: focusing on either monofunctional inland waterway ports (i.e. specializing in one product sector) or multifunctional inland waterway ports (i.e. a variety of product sectors). We hypothesized that the diversity in types of goods would be positively related to the level of and growth in cargo throughput. Based on the modeling outcomes in Tables 3 and 4, this hypothesis seems to be confirmed. Perhaps the positive and significant outcome for diversity in the cargo throughput level model is not that surprising, for ports handling a great variety of goods also show high overall levels of cargo throughput capacity. Of course, it should be stressed that the variety in types of goods is a hard to influence condition, for this is highly dependent upon the individual location preferences of shippers and logistics companies. Also, our tentative conclusion regarding growth patterns should be sustained with further empirical evidence in the future, including measurement over a greater span of years.

4.5. Accessibility

Our final hypothesis which was formulated in Section 3.2 dealt with the influence of the accessibility of an inland waterway port on the level of and growth in cargo throughput. We argued that the distance from the inland waterway port to an access point of a main road or motorway would be negatively related to the level of and growth in cargo throughput. We reasoned that the shorter the distance, the greater the accessibility would be. Our results confirm this hypothesis, for both the level of and the growth in cargo throughput (Tables 3 and 4). In both cases the distance variable is negatively and significantly related to the dependent variable. It is likely that good accessibility by road can be beneficial for an inland waterway port, because efficient pre- and end-haulage can be regarded a pull-factor in port selection (Wiegmans et al., 2008). In other words, the accessibility to a regional highway system is associated to greater throughput levels and can thus be considered as a precondition for the development of inland waterway ports.

5. Conclusion and discussion

This paper has focused its attention on characteristics of inland waterway ports in a European context, which is up to now an overlooked part in the scientific literature on inland port system development. The overview of port issues provided by Pallis et al. (2010) combined with our dataset has led us to formulate five specific hypotheses regarding the development of inland waterway ports in terms of cargo throughput in the European network. Our central question to be answered was: *"What are the characteristics of European inland waterway ports and what transport and economic factors influence cargo throughput on the municipal level?"*. In interpreting our results, it is important to be aware of the differences in inland port definitions between the US and Europe. We have defined an (European) inland port as a place (or a town or city) along a waterway with facilities for loading and unloading ships. This is in contrast to the US-based definition, in which inland ports are larger freight sites with mostly rail terminals (and sometimes water) including surrounding business properties and an own governance structure. This might explain part of the ambiguity on the term 'inland port'. To stress the difference with the American definition, we have spoken of inland *waterway* ports in a European context, using a dataset of inland waterway bounded cargo throughput in Dutch municipalities.

Our empirical analyses discussed the relation between the level of and growth in cargo throughput on the municipal level and a number of transport and economic factors. We have found that the cargo throughput level is inversely related to growth in cargo throughput. 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 (e.g. Notteboom, 1997; Notteboom and Rodrigue, 2005). Also, the wider context of port development in Europe or capacity issues might explain these outcomes. Moreover, we concluded that the presence of a container terminal is an important condition for inland waterway ports, both in attracting cargo throughput capacity and in sustaining further growth. This finding is in line with the growing attention to containerization in the academic literature (Rodrigue and Notteboom, 2009). This might imply that the spatial features of an inland waterway port to an increasing extent have to be aligned with the preconditions for accommodating containers, as has been happening in the context of seaports for decades. Still, for the context of inland ports, this might have important implications in terms of governance of port and urban functions (Wiegmans and Louw, 2011; Witte et al., 2014).

Another important characteristic that influences cargo throughput level of inland waterway ports is the diversity in types of goods. Our results indicate that having a 'resilient' strategy of handling a variety in types of goods can be beneficial both in attracting a basic level of cargo throughput volume and possibly in sustaining further growth in cargo throughput. Apparently an inland waterway port is better protected against external influences such as market dynamics when the variety in types of goods is greater. This finding can be mirrored with insights from evolutionary economic geography regarding the specialization versus diversity tandem and the importance of accommodating variety as a growth strategy (see e.g. Frenken et al., 2007; Boschma, 2015). Using evolutionary economic geography concepts and theorizing might be valuable in discovering more patterns in future studies of inland waterway ports as well. For instance, it could be interesting to explore the relation between inland waterway ports, regional clustering and agglomeration externalities. Also, the accessibility of an inland waterway port to a regional highway system is associated to greater throughput levels and can thus be considered an important indicator for the volume of and growth in cargo throughput. This was already confirmed on the seaport level (Wiegmans et al., 2008), but it is important to note that this can be an important pull-factor for inland waterway ports as well.

Interestingly, the often-made argument in the professional literature and policy-documentation of 'investments in inland port development leading to employment growth' cannot be confirmed based on our analyses. These findings might therefore shed a critical light on the governance strategies of municipal policy-makers in dealing with inland port development. We suggest that further research needs to be done here, for instance regarding the influence of regional clusters of economic activity on the development of inland waterway ports. Finally, while we have been able to draw some conclusions regarding the characteristics of European inland ports based on our dataset of inland waterway ports development in Dutch municipalities, more work remains to be done in this relatively new field of scientific research. Of specific interest would be further inquiry into the economic, spatial and institutional dimensions of inland waterway ports. Some work has been done here already, but based on our findings it is clear that plenty of conceptual and empirical questions still lay ahead.

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Appendix A. Overview of municipalities with cargo throughput in the dataset (*n* = 135).

Number of port areas	Number of cases (%)	List of municipalities (in some cases, the name of the specific public quay, port or city of interest is in brackets)
No discernable main port area	18 (13.3%)	Borsele, Dongeradeel, Etten-Leur, Giessenlanden, Hardenberg, Heiloo, Leerdam, Lingewaal, Loenen, Nieuwegein, Overbetuwe, Roggel en Neer, Rozenburg, Ubbergen, Wieringen, Wijk bij Duurstede, Zaltbommel, Zuidhorn
One main port area	102 (75.6%)	Alkmaar, Almelo, Almere, Amersfoort, Arnhem, Baarn, Bergen op Zoom, Bernisse (Zuidland), Beverwijk, Boarnsterhim (Grou), Breda, Capelle a/d Ijssel ('s-Gravenland), Cuijk, De Marne (Zoutkamp), Delft, Deventer, Doetinchem, Dongen, Dordrecht, Druten, Eindhoven, Elburg, Enkhuizen, Enschede, Geertruidenberg (Raamsdonkveer), Gennep, Goes, Gorinchem, Gouda, Grave, 's-Gravendeel, 's-Gravenhage, Haarlem, Haarlemmermeer (Aalsmeer/Uithoorn), Haelen (Buggenum), Halderberge (Standdaarbuiten), Harderwijk, Hardinxveld-Giessendam, Heel (Wessem), Heerenveen, Helmond, Hengelo, 's-Hertogenbosch, Hillegom, Hof van Twente (Goor), Hoorn, Houten, Huizen, Kampen, Katwijk, Krimpen a/d Ijssel, Leeuwarden, Lemsterland (Lemmer), Liesveld (Groot Ammers), Lith (Lithoijen), Lochem, Maasbracht, Maasdriel, Maassluis, Maastricht, Meppel, Moerdijk, Muiden, Neerijnen (Haaften), Nieuwerkerk a/d IJssel, Nieuw-Lekkerland, Nijkerk, Oirschot, Oosterhout, Oss, Papendrecht, Reimerswaal (Yerseke), Rheden, Rijnwaarden (Tolkamer), Rijnwoude, Roermond, Roosendaal, Schouwen-Duiveland (Zierikzee), Sliedrecht, Smallingerland (Drachten), Sneek, Son en Breugel (Son), Spijkenisse, Stein, Tholen (St. Philipsland), Tiel, Tytsjerksteradiel (Burgum), Urk, Utrecht, Veendam, Venlo, Waalwijk, Wageningen, Werkendam, Windschoten, Wormerland (Wormer), Woudrichem, Wymbritseradiel (Heeg), Zutphen, Zwartewaterland (Hasselt), Zwijndrecht, Zwolle
Two or more main port areas	15 (11.1%)	Alphen aan den Rijn, Kapelle (Wemeldinge/Schore), Lelystad, Meerlo-Wanssum, Middelburg, Nijmegen, Schagen ('t Zand), Schiedam, Sittard-Geleen (Born), Tilburg, Veghel, Vlaardingen, Wieringermeer, Zaanstad, Zeewolde

Source: Authors' own data computations.

Appendix B. Dataset consisting of 135 inland ports in the Netherlands

Note: the top-10 largest inland ports in the Netherlands (throughput > 3 million tons/year) and the functional classes of the most important inland waterways (III/IV/Va/VIb/VIc) have been included for reference.

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