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Competition or complementarity in Dutch inland port development: A case of overproximity?

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ABSTRACT

The port economics literature is extensive, but does not address well the economic effects of inland ports development. This paper explores the extent to which spatial proximity of inland ports vis-a-vis each other influences agglomeration externalities. Spatially lagged regression models are employed to analyse whether spatial dependence between proximate inland ports can be observed or, alternatively, whether the density of the inland port network in the Netherlands is leading to diseconomies of scale because of overproximity. The conclusions indicate that especially in the context of the dense fluvial network of the Netherlands inland ports development involves much competition among inland ports; being proximite to strong neighbouring inland ports is not necessarily beneficial to the growth prospects of an inland port. This indication of overproximity highlights a need for reflection on the possibility of an integrated and coordinated regional governance approach towards inland port development in the Netherlands and North-West Europe. The relationship between inland ports and regional development is obviously present, but ambiguous since it involves a multiplicity of interactions among a diversity of actors.

1. Introduction

The development of inland port facilities has been a particular dimension of deep-sea port development in recent decades (Ng et al., 2014). The port economics literature is extensive (see Pallis et al., 2010 for an overview), but does not address well the economic effects of inland ports development. The same observation applies to the literature that specifically deals with inland ports (Wiegmans et al., 2015). This shortcoming is particularly due to the fact that inland ports were mostly considered from an operational and planning perspective (see Monios and Wilmsmeier, 2012), since their core role is to support the hinterland access of deep-sea ports. The economic effects of inland ports are often uncertain, leading to difficulties for the administrative units where inland ports are located to develop accurate governance strategies for their future development (Witte et al., 2016). Also, data availability regarding inland ports is and often remains a problematic aspect of studying inland port development. As a result, the possible economic relationships among inland ports themselves, and between inland ports and maritime deep-sea ports,[1] often remain vague.

Another underlined effect relates to the principle of co-location, where the setting and operation of inland port terminal facilities are jointly planned with the setting of adjacent logistical activities. There has been some research delving into the issue of co-location in logistics, but this research is especially focused on the firm/establishment level (see e.g. Sakai et al., 2015; Van den Heuvel et al., 2013, 2014). Little is however known on the extent to which spatial proximity in and among inland ports (as a more aggregated level of analysis compared to the firm level) influences agglomeration externalities, and on how this relates to different inland ports types at different scale levels. For expanding our understanding of the relation between logistics and related theories of agglomeration and clustering, this is an important research gap to address.

This paper aims to fill part of this research gap, by analysing the relation between spatial proximity of inland ports, agglomeration externalities and the characteristics and development of inland ports in the case of the Netherlands. Because of its dense fluvial network with many inland ports located relatively close to each other in a confined

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[1] Although the relation between inland ports and maritime deep-sea ports is highly interesting, due to data limitations the empirical analyses in this paper are limited to spatial proximity in and among inland ports.

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space, agglomeration externalities are expected to be especially important in the context of the Netherlands. Based on national register data and additional own desk research, a dataset has been developed covering 135 municipalities in the Netherlands with inland navigation transhipment of over 100.000 tons/year. Spatially lagged regression models are conducted that are sensitive to different inland port types. The following research questions are developed: *how does spatial proximity of inland ports vis-a-vis each other influence agglomeration externalities, and how does this differ between inland port types?*

To answer these questions, first, the existing body of literature on inland ports is analyzed, particularly as it relates to their spatial and economic impacts. In the analytical framework, inland ports are related to agglomeration externalities by linking up inland ports with existing theories and concepts stemming specifically from economic geography. This results into an analytical framework for studying inland ports. Section four contains a description of the data and methodology. Section five presents the results of the analyses. Section six contains the conclusions of the paper, a discussion of limitations and suggestions for future research.

2. Inland ports as an emerging field of research

2.1. The multi-level nature of inland ports

There has been considerable debate on defining inland ports in various geographical contexts. This paper focuses especially on the European understanding of an inland port as an inland waterway facility (see Wiegmans et al., 2015), which is distinctively different from the American understanding of inland ports as inland terminals that are linked to ports by rail (Rodrigue et al., 2010), or the European and Asian understanding of dry ports (Roso et al., 2009; Beresford et al., 2012; Qiu et al., 2015). A thorough discussion of the different definitions of inland ports is however beyond the scope of this paper; here, we are mainly interested in the multi-level nature and different scales of inland ports (Fig. 1).

The lowest level is the intra-inland port level, where the operations of firms and relations between firms can be observed (cf. Van den Heuvel et al., 2013, 2014). This is the level at which co-location between inland port terminal facilities and adjacent logistical activities can occur. Many inland port facilities are developed as co-location projects between a terminal operator and a commercial real estate developer. The next level is the inter-port level, both within and between different hosting municipalities (Wiegmans et al., 2015). A city or municipality can host multiple inland port locations that are either competitive or complementary to one another. However, different municipalities can host an inland port that competes or complements other inland ports. Complementarity takes place when two or more inland terminals service a different customer base (supply chains) and are able to benefit from their respective proximity. This can involve the setting of some joint services such as drayage. The third scale level concerns the positioning of inland ports relative to deep-sea ports, forming an inland load centres network (Notteboom and Rodrigue, 2005). It could be argued that either the proximity of a deep-sea port impedes inland port development, or that inland ports can benefit from deep-sea ports' facilities and network positions, in this way providing an enhanced accessibility relative to the congested deep-sea port areas, notably through the setting of satellite facilities. The inland ports offer the opportunity to more efficiently service the hinterland through modal shift (through rail or barge services) while satellite facilities support of a level of freight diversion away from congested areas.

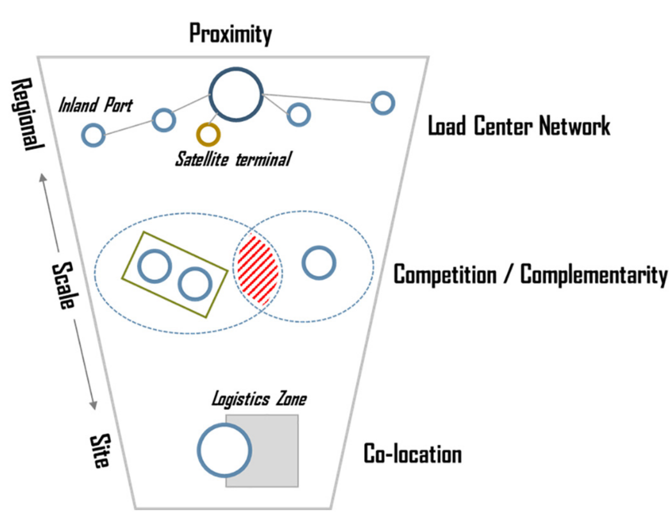

Fig. 1. The scale effects of inland ports.

2.2. Inland ports: towards an analytical framework

A systematic discussion of the various transport, spatial, economic and governance dimensions which are relevant for the analysis of inland ports is lacking, in particular, the economic dimension. An analytical framework that can capture the variety of dimensions of inland ports and their economic dimension could provide valuable insights. Witte et al. (2014) developed an integrated framework for the analysis of inland port governance strategies, consisting of four dimensions: infrastructure, spatial structure, governance structure and economic structure. This framework can also be used for structuring the current body of literature regarding inland ports development (Table 1), because it captures well the variety of and the gaps in the debate regarding inland port development.

Most authors relate the emergence of inland ports as a field of study to the process of port regionalisation (Notteboom and Rodrigue, 2005) in the evolution of port systems. The main focus is either to the implications for the *organisation and functioning of the wider transportation network*, or to the implications for the *spatial and institutional structures of inland ports themselves*. With regard to the network implications, Rodrigue and Notteboom (2009) reviewed the role of inland terminals in supply chains and Wilmsmeier et al. (2011) investigated the position of inland ports within hinterlands and corridors. With regard to the spatial and institutional implications, Monios and Wilmsmeier (2012) have

Table 1
Four analytical dimensions of inland ports.

Infrastructure	Spatial structure
-Port system evolution (position of inland ports in supply chains, hinterlands and corridors) -Variety of functions (service, warehousing, distribution, handling, customs, etc.) Sources: e.g. Rodrigue and Notteboom (2009), Wilmsmeier et al. (2011), Rodrigue et al. (2010)	-Different geographical settings (North-America vs. Europe; variety of scales and modes involved) -Multi-level port-city challenges (different land-use claims, fragmented ownership structures, externalities, etc.) Sources: e.g. Rodrigue et al. (2010), Wiegmans et al. (2015), Witte et al. (2014)
Governance structure	**Economic structure**
-Variety of actors (port authorities, terminal operators, real-estate managers, municipalities, etc.) -Variety of institutions (formal governance structure, laws and regulations, development orientations) Sources: e.g. Monios and Wilmsmeier (2012), Raimbault et al. (2015), Witte et al. (2016)	-Spatial proximity (how does spatial proximity of inland ports vis-à-vis each other influence agglomeration externalities?) -Agglomeration externalities (how do agglomeration externalities differ between different inland port types?)

drawn attention to the spatio-temporal development directions of inland ports in the hinterland and Witte et al. (2014) have introduced the emergence of inland port-city challenges by linking inland ports development to the maritime port-based literature on port-city relations.

Recent research has further substantiated the transport/network dimension of inland ports and their spatial/institutional dimension of inland ports. In particular, the positioning of inland ports within the wider transportation networks with the actors and institutions operating in inland ports has underlined the issue of *inland port governance* (e.g. Raimbault et al., 2015; Witte et al., 2016; Debrie and Raimbault, 2016). Raimbault et al. (2015) investigated inland ports development from a relational perspective, using the inland port of Venlo as a case study. They found that actor-specific practices and processes across territorial scales can shape the outcomes as to how a certain inland port develops in the future. This has been followed up in a cross-national comparison by Debrie and Raimbault (2016). Witte et al. (2016) found different governance strategies for inland ports in terms of intra- and inter-regional cooperation and different informal and formal institutions which are at play simultaneously. The infrastructure, spatial structure and governance structure have been largely covered in the literature, but the economic dimension of inland ports development has received relatively modest attention.

3. Linking inland ports to theories of clustering and agglomeration

As economic benefit arguments are often used for the promotion of inland ports development, it is relevant to look into the potential economic impacts of inland ports as a specific form of infrastructure development. Conventionally infrastructure investments are often about creating links, but the relation between nodal entities, such as inland ports, and regional clustering and agglomeration externalities can be explored as to whether inland ports enjoy economic benefits from spatial proximity of other inland ports and as to what factors are important in determining the growth patterns of inland ports.

3.1. Convergence and divergence through agglomeration economies

Most of the literature on clustering and agglomeration either focuses on processes and developments occurring at the firm level, or on the effects of accumulated activities on the urban or regional level (e.g. De Bok and Van Oort, 2011 and Farole et al., 2011). Inland ports include both levels. On the one hand, an inland port is usually involving several individual firms which are located within the inland port area. On the other hand, although an inland port can have spill-over effects that goes beyond the inland port, it remains unclear to what extent inland port development can influence economic development at the regional level. Therefore, linking inland ports to theories of clustering and agglomeration requires caution because the relations that have been empirically validated either on the firm level or the regional level not necessarily hold true at the inland port level.

Economic geography can provide insights as to what factors can explain the differences in growth patterns of inland ports. Agglomeration economies can be considered the greatest drivers of convergence and divergence. They can be viewed as benefits which firms enjoy from being located in close proximity of other (related or unrelated) firms (Frenken et al., 2007). Consequently, divergence *between* regions can contribute to increased clustering *within* regions as an outcome of forces of agglomeration. Several attempts have been made to integrate the convergence and divergence argument into a consistent analytical framework. One of these attempts is formalised in the New Economic Geography (NEG) literature (see Farole et al., 2011 for an overview). It underlines the concentration of economic activity in core urban regions. By bringing together forces of convergence and divergence in a coherent analytical framework, why similar types of regions can develop different patterns of economic development can further be articulated. These differences may not be driven per se by traditional comparative advantage, but instead by self-reinforcing agglomeration.

When related to transport infrastructure, it can be suggested that indirect effects of infrastructure investments on regional economic development occur to a great extent because of agglomeration externalities. Infrastructure investment trickles down to affect interregional trade and labour markets. As a result, firms will – because of improved infrastructure – see their products become more competitive on other regional markets and/or see products from other regional markets becoming more competitive on their market. Which effect will prevail depends on the relative dependency of a region to trade, and the size of the regional market. Ultimately, agglomeration economies influence spatial economic developments such as location decisions of firms (De Bok and Van Oort, 2011). Translated to the context of inland ports development, differences in growth patterns between inland ports with respect to their position relative to other proximite ports may be expected.

3.2. Competition or complementarity in the European inland waterway port network

Although inland ports often develop independently and in isolation, it can be argued that inland ports could experience economic benefits from being located in proximity to other ports. This argumentation is in line with existing literature on port competition and cooperation found in the context of container ports, port clusters and port hinterlands (see e.g. Song, 2002; Wang et al., 2012). Following the divergence argument, the process of inland ports development is assumed to be influenced by cumulative causation as well: efficiency of inland ports increases when being in proximity to other ports, and such spatial dependence tends to arise in places where many inland ports and maritime ports are located. Agglomeration economies are also expected to occur in places of high accessibility and positive spill-over effects, such as centred around main network nodes and/or along main corridors. The position of inland ports at different scale level requires to be investigated. This is performed here in the context of the European inland waterway port network, specifically focussing on the north-western part of the fluvial network because of its density in terms of waterway connections and because of its large number of spatially proximate ports (see Wiegmans et al., 2015). The empirical contribution of this paper is to explore whether spatial dependence between proximate inland ports can be observed or, alternatively, whether the density of the network is leading to diseconomies of scale because of an oversupply of ports, terminals and related facilities (cf. Rodrigue et al., 2010).

4. Data and methodology

To assess the spatial dependence between proximate inland ports in the north-western European inland waterway network a quantitative dataset of inland waterway ports is used. Data is collected from the context of the dense fluvial network in the Netherlands. Up to and including 2006 this data has been collected as national register data by CBS Statistics Netherlands on a disaggregated level (i.e. per municipality). In the Netherlands, the municipal level is even more specific than the European NUTS-3 classification, which in the Netherlands is a more aggregated administrative unit called COROP. After 2006, however, CBS collected this data no longer on the municipal level or on the NUTS-3 level, but only on the aggregated NUTS-1 level which in the Netherlands is just an artificial unit consisting of the four large parts of the country (north, east, south, west). This is making it impossible to relate the more recent data to a specific location of an inland port. Still, the aggregated data that is available from 1999 to 2015 can be used to present a general overview of the development of inland waterway-bound cargo throughput in the Netherlands (Fig. 2). What can be observed is that after 2006 the cargo throughput has remained relatively steady – with the exception of 2009 as the first post-crisis year. This means in terms

Fig. 2. Total throughput of inland waterways, Netherlands.
(Source: CBS Statistics Netherlands, 2016.)

of methodology that although the disaggregated data up to 2006 are somewhat outdated, the context of inland waterway transportation has not changed much since.

The data up to 2006 that can be used consist of cargo throughput figures at the municipal level (in tons/year) and related transport, spatial and economic factors. The dependent variables to capture economic development of inland ports are cargo throughput level (in 2006) and growth in cargo throughput (from 2001 to 2006). The independent variables – the factors that might explain differences in economic development – include: presence of a container terminal, number of jobs in the region, number of logistics and wholesale firms, functional range of distribution activities (short distance, medium distance, long distance), diversity in types of goods handled, distance to the nearest motorway entrance/exit and travel times in minutes by road to the nearest inland and/or maritime port for each inland port. Spatial dependence relative to maritime ports could not be included in the modelling, because the influence of the maritime ports on the model parameters was too large. As all the data is measured on the municipal level, two dummy variables are included to control for the presence of more than one central inland port location within a municipality.

The presence of a container terminal is derived from information provided by the Dutch Centre for Expertise and Innovation in Inland Navigation. The number of jobs in the region is taken from the CBS register data and is chosen as an indicator of economic performance over other factors such as value of income or number of companies, because it is often presumed in policy that investing in infrastructure will foster job creation in the region. The number of logistics and wholesale firms is taken from the LISA database on firms' activities in the Netherlands to look at the effects of inland ports development on proximate logistics activities. The functional range of distribution activities is taken from earlier research on the economic importance of inland ports in the Netherlands (NVB, 2004). The categories are based on the same NVB research and consist of short distance i.e. local/regional distribution (0 to 100 km radius), medium distance i.e. national distribution (101 to 350 km radius) and long distance i.e. continental distribution (351 + km radius). Diversity in types of goods handled is also taken from the NVB research and is determined through counting the number of NSTR-units over 100.000 tons/year. The NSTR-units are 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. Distance to the nearest motorway entrance/exit is used as a proxy for relative accessibility of an inland port and is taken from the CBS register data. Travel time in minutes by road is used as a proxy for spatial proximity and is calculated using FLOWMAP software. This can help to understand whether or not spatial dependence is observable for proximate inland ports. Finally, the presence of multiple inland port centres within one municipality was checked based on the Blue Road Map database of the Dutch Information Agency for Inland Navigation (BVB).

All the independent variables are based on 2006 data to ensure consistency with the dependent variable. On the one hand, although more recent data are available, for example with regard to number of jobs, and the possibility exists that since 2006 additional container terminals or motorway access points have been constructed, this can of course not influence the cargo throughput in 2006. On the other hand, more historical data on a disaggregated level are often not available (e.g. changes in distance to a motorway access point have not been collected prior to 2006), or – especially in the case of the growth model – are not relevant to include (e.g. when examining the growth in cargo throughput from 2001 to 2006 it makes more sense to look at the influence of the number of jobs in 2006 than the number of jobs in 2001). The descriptive statistics of the interval/ratio variables used can be found in Table 2. The

Table 2
Descriptive statistics of inland ports dataset (N = 135).

	Min.	Max.	Mean	Std. dev.	Skew.
Dependent variables					
Cargo throughput (2006) (×1000 tons)	103	7686	975	1158	2.825
Growth in cargo throughput	0.12	7.51	1.30	1.16	3.197
Independent variables					
Cargo throughput (2001) (×1000 tons)	58	10,645	1035	1319	3.958
Number of jobs in the region (×1000)	1.19	266.58	27.81	39.61	3.348
Number of logistics and wholesale companies	12	567	113.27	102.30	2.056
Short range distribution (×1000 tons) [0–100 km]	1.66	3651	452	610	2.688
Medium range distribution (×1000 tons) [101–350 km]	0.50	3301	413	542	2.535
Long range distribution (×1000 tons) [351 + km]	0.48	610	90	128	2.067
Distance to nearest motorway (×100 m.)	0.6	3.0	1.54	0.54	0.733
Travel time to nearest inland port (in minutes)	3	28	11	4.67	0.747
Travel time to nearest maritime port (in minutes)	7	91	41	22.94	0.605

travel time variables are omitted from the regression analyses, because they only capture travel time by road and do not cover other modalities. Instead, we used coordinates as a more 'neutral' way to capture spatial autocorrelation between inland ports. Of course, this limitations means that we can only measure spatial proximity, and not network proximity.

The original sample consisted of 217 municipalities with cargo throughput in 2006. A filter has been applied for sufficient critical mass (cf. Rodrigue et al., 2010). Also, the cases of inland ports which were located too close to the river catchments of deep-sea ports (e.g. Rozenburg in the case of Rotterdam) were exluced, because of counting problems with regard to municipal borders.[2] As a result, a sample of 135 inland ports with a total cargo throughput of over 100,000 tons/year remains. All interval/ratio variables are log-transformed to correct for positive skewness (Table 2). Multicollinearity between the independent variables was verified by looking at correlations and Variance Inflation Factors, which were all acceptable, except for the number of logistics and wholesale companies, which had a too high bivariate correlation with the number of jobs in the region. Because of possible multicollinearity between the two, the number of logistics and wholesale companies was removed from the regression analyses. The models were estimated in several sequential steps. First, OLS-models were created to check the robustness of the dataset. Next, Maximum Likelihood (ML) models including spatial lags (SL) using inverse distance weighting matrices were estimated to see whether there is spatial dependence between proximate inland ports.

Finally, spatial regimes were introduced and Spatial Chow-Wald tests were performed to find significant differences between the identified groups. A spatial regime captures spatial heterogeneity by varying the estimated effects between independent variables and dependent variables over different types of space (Anselin, 1990). First, a corridor variable is included which relates every inland port location to whether or not this location is part of a major inland waterway route (the main south and east axes going from the port of Rotterdam to the hinterland, classified as V or VI level waterways). Next, a similar contrast can be developed for inland ports with or without a container terminal facility. Finally, the sample was split into two halves to differentiate between the 50% inland ports with the largest cargo throughput volumes, and the 50% inland ports with the lowest cargo throughput volumes. By including these variables, a spatial regime analysis can be performed, in which the size of the inland port in terms of throughput volume (small [SM] vs. large [LA]), the presence of a container terminal (CT+ versus CT−), corridor membership (CO+ versus CO−) can be used as differentiating regimes. These regimes can be used to simultaneously estimate spatial econometric models in and outside certain categories of inland ports, to explain their level of and growth in cargo throughput (cf. Frenken et al., 2007). The 135 cases can so be distributed over the regimes of spatial heterogeneous groups. Table 3 gives a first impression of the differences between the groups which are identified, based on a comparison of the means.

Some differences can be observed between the groups on basis of the descriptive statistics. In terms of cargo throughput in 2006, inland ports within a corridor, as well as inland ports with a container terminal score considerably better compared to inland ports outside a corridor and without a container terminal (needless to say, the same goes for large vs. small inland ports). Larger inland ports might tend to invest earlier in a container terminal than smaller inland ports. The growth rate of inland ports without a container terminal is higher than their counterparts with a terminal, which could be explained by a relative convergence or 'catching-up' of ports without a terminal, due to operating close to maximum capacity of ports with a terminal making further growth difficult, or a combination of both factors. The growth rate also refers to tons while a container terminal also handles many empty containers (e.g. repositioning related to European negative containerized trade imbalances) which reduces the growth in tons. Finally, the difference could be explained through a reversed relation with cargo throughput (the higher the level, the lower the growth). Many of the independent variables show relatively higher numbers for inland ports within corridors, with container terminal and with higher throughput volumes compared to those outside corridors, without terminals or with lower throughput volumes. The advanced regression models have to reveal though whether these between-group differences are significant.

5. Spatial proximity and agglomeration externalities of inland ports

A total of ten different regression models have been estimated to explore the dataset (see Appendix A and Appendix B). For each of the two dependent variables – cargo throughput level and growth in cargo throughput – the sequential steps in the modelling as described above have been conducted. This resulted in four models for each independent variable: OLS, ML-SL and three ML-SL's with differentiating spatial regimes (one for the corridor variable, one for the container terminal variable and one for the size variable).

5.1. No economic benefits of spatial proximity

As a first step in the modelling, two OLS models for cargo throughput level and growth in cargo throughput (i.e. the first column in both appendices) were performed. For explaining the cargo throughput level in 2006, the constant, presence of a container terminal, short - and medium range distribution, diversity in types of goods and distance to the nearest motorway turned out to contribute positively and significantly. For the growth model, the outcomes look alike, although the importance of the distribution ranges is no longer significant. Finally, the negative relation between the cargo throughput level in 2001 and the growth over the 2001–2006 period was to be expected because of the inverse relation between level and growth (a higher level leads to lower growth).

Interestingly, when looking at the error term of Moran's i, in both models this value turns out not to be significant (p: 0.907 for the 2006 model, respectively p: 0.566 for the growth model). This gives a first indication that the importance of spatial proximity for the cargo throughput of inland ports is negligible. Thus, at first sight, the level of or growth in cargo throughput of an inland port seems unrelated to the location of an inland port relative to other nearby inland ports.

This is also confirmed by running the Moran's i test for spatial autocorrelation over all independent variables to test for spatial dependence between observations based on their x and y coordinates (latitude; longitude). One would expect to find significant differences in running this test when spatial dependence is assumed. In contrast, the *p*-values of all independent variables are not significant, regardless of the power used in creating inverse distance matrices. One – technical – explanation of these results could be that the distances between inland ports within the Netherlands are too small to trigger significant results. This has to be cross-checked in further research by including inland ports in other countries (thus creating larger distances between the inland ports). Perhaps the specific situation in the Netherlands with many inland ports and a dense inland waterway network is influencing the results.

As a final exploration of the importance of spatial proximity for cargo throughput of inland ports, two spatially lagged Maximum Likelihood

[2] Content-wise, we would like to capture the important relation between inland ports and maritime ports in the modelling. However, because of these counting problems, and also because of the extreme differences in throughput between the deep-sea ports and the inland ports, these outlier cases have to be omitted to not obscure the entire analysis too much.

Table 3
Descriptive statistics (mean values) of the spatial regimes.

	CO +	CO −	CT +	CT −	LA	SM
Cargo throughput (2006) (×1000 tons)	1176	765	1838	685	1657	304
Growth in cargo throughput	1.32	1.28	1.13	1.36	1.49	1.12
Cargo throughput (2001) (×1000 tons)	1253	805	1892	746	1594	483
Number of jobs in the region (×1000)	21.98	33.91	48.40	20.88	38.55	17.24
Number of logistics and wholesale companies	109	118	146	102	144	83
Short range distribution (×1000 tons)	516	385	629	392	603	301
Medium range distribution (×1000 tons)	488	336	733	306	672	159
Long range distribution (×1000 tons)	91	88	162	61	144	32
Distance to nearest motorway (×100 m.)	1.52	1.55	1.69	1.48	1.54	1.53
Travel time to nearest inland port (in min.)	10	13	12	11	11	11
Travel time to nearest maritime port (in min.)	43	40	45	40	45	38
Number of cases	69	66	34	101	67	68

regression models were estimated (i.e. the second column of both appendices). In both models, the spatially lagged dependent variable that is then added to the equations (w_cargo throughput, respectively w_growth in cargo throughput) turned out to be not significant. When compared to the OLS models, the adjusted R-squared value slightly increases and the significant relations remain intact, with the exception of the constant in the 2006 model, which is no longer significant.

The context and the dataset which led to the assumption that inland ports would enjoy economic benefits of spatial proximity has to be rejected. It appears from the data that spatial autocorrelation is completely absent, and when delving into the differences between inland ports inside or outside a corridor, or with or without a container terminal, the influence of spatial proximity even turns into negative values. This implies that inland ports appear to face much competition among each other. These outcomes could hint at the suggestion that cargo throughput in an area of highly concentrated number of inland ports is not dependent upon the physical location of an inland port. Rather, other (internal) factors such as diversity in types of goods handled seem to be more decisive in determining the cargo throughput level and growth in cargo throughput.

5.2. Proximity to inland waterway corridors is important

The first differentiating regime is the location of an inland port within or outside the main inland waterway corridors in the Netherlands (i.e. the third and fourth column in both appendices). Statistically, for both the 2006 model and the growth model the adjusted R-squared values increase, highlighting that including the corridor variable increases the variety that can be captured by the models. Surprisingly, when comparing the outcomes of the Spatial Chow-Wald tests between the two models, an important difference is observed. Whereas the 2006 model is significant, albeit slightly (p: 0.068), this is not the case for the growth model (p: 0.450). This implies that for explaining the cargo throughput *level* of an inland port, the location of an inland port relative to an inland waterway corridor can be important, but that for explaining the *growth* in cargo throughput, the location relative to a corridor is no longer relevant. This could imply that large volumes tend to be connected to the specific location of an inland port whereas growth of an inland port might be more linked to present sectors in an inland port and less so to the exact geographical location.

Looking at the 2006 model, some differences are observed between the corridor group and non-corridor group regarding the importance of the independent variables. Outside of an inland waterway corridor, few significant results are found. Diversity in types of goods remains crucial, and short range distribution seems to be important and positively related to the cargo throughput level of these inland ports. For inland ports within the inland waterway corridor, almost all independent variables are significantly related to the cargo throughput level, even the number of jobs on the regional level (which was not significant in the previous OLS model). The most important differences between the two groups relate to the presence of a container terminal, the medium and long distance distribution ranges and the distance to the nearest motorway. Surprisingly, long range distribution negatively affects the cargo throughput level of inland ports within an inland waterway corridor. This can perhaps be explained by the divergence argument and the introduction of new competitors on the domestic market negatively affecting the performance of existing ports.

The relations and differences found in the growth model are more or less the same, but it has to be stressed that the Spatial Chow-Wald test turned out to be non-significant. This means that although some significant differences between the groups can be observed concerning one particular independent variable, but that these differences are not large enough to trigger a significant difference for the entire model.

In sum, the corridor variable as a differentiating regime has returned mixed findings. Although the proximity of an inland waterway corridor can be considered important to explain the cargo throughput *level* of those proximate inland ports, the same cannot be said for explaining the *growth* in cargo throughput. In addition, being located close to a corridor almost all independent variables are significantly and positively related to either the level of or growth in cargo throughput, whereas outside of the corridor this is not the case. Finally, the long distance range variable indicated that some of the benefits of a proximate corridor can also potentially be a threat when the domestic market becomes more easily accessible to new competitors.

5.3. Container terminals are crucial assets to inland ports development

A comparison of inland ports with a container terminal to inland ports without a container terminal was also undertaken. Some observations come to the fore when introducing this as a differentiating regime (i.e. the fifth and sixth column in both appendices). As with the case of inland waterway corridors, the quality of the model increases when introducing the presence of a container terminal as a differentiating regime. An important difference is that for the container terminal regimes, the 2006 model as well as the growth model show significant differences between groups (i.e. significant Spatial Chow-Wald test values) for the entire models (p: 0.008, respectively p: 0.029). This means that the presence of a container terminal can explain important differences in the level of and growth in cargo throughput for different inland port types.

When looking at the 2006 model, inland ports without a container terminal are more heavily reliant upon short range distribution and the proximity of a motorway entrance/exit as compared to inland ports with a container terminal (where these factors are not significantly related to cargo throughput). Alternatively, when a container terminal is present, solely the diversity in types of goods handled and the medium range distribution are important in explaining cargo throughput. When comparing the groups, these are also the variables that return significant differences between the groups. For inland ports without a container terminal, handling a large diversity in types of goods is especially important.

In the growth model, some of the outcomes are comparable to the 2006 model. For instance, the distance to the nearest motorway is again more important to inland ports without a container terminal, compared to inland ports with a container terminal. In this case, the difference between the groups is also significant. The same goes for the diversity in types of goods handled. A final significant difference between the groups concerns the cargo throughput level in 2001, which is influencing the growth in cargo throughput far more strongly for inland ports without a container terminal. This could imply that once a container terminal is in place, past performance is less decisive in determining prospects for growth. It can be confirmed that the differences between the groups and the overall influence of the container terminal regime are significant. At the same time, for inland ports with a container terminal many of the independent variables related more strongly to the outcome variable.

5.4. Port size is related to presence container terminal

Finally, a comparison of large inland ports to small inland ports in terms of throughput volume was performed. When introducing this as a differentiating regime (i.e. the final two columns in both appendices), the results are in many respects comparable to the differences between inland ports with and without a container terminal. Out of the three differentiating regimes, the explanatory power of these models are the highest (adjusted R^2 0.841 for the throughput model, respectively 0.752 for the growth model). Observations with regard to the 2006 throughput model relate to the distribution ranges: for smaller inland ports regional distribution is more important, whereas for larger inland ports the national scale is of greater importance. Although the European range was not found to be significant for either the small or the large ports in the 2006 model, the difference between the two groups is nevertheless significant, indicating great between-group differences despite being of minor importance in explaining the overall throughput in 2006. The same holds true for the growth model.

An important difference in the 2006 throughput model was found with regard to the presence of a container terminal. Whereas a container facility proved to be significant in explaining the throughput volume of large ports, this turned out not to be the case for the small ports. Here, the causality issue which is central in many studies of agglomeration externalities related to infrastructure investments is of relevance. There is no certain way of knowing whether having a container facility increases the growth prospects of inland ports, resulting in larger ports, or alternatively, whether larger ports are more likely to attract container facilities. The evidence presented in this analyses seems to favor the latter option; larger ports are more interesting locations for investing in container facilities. This is supported by the lack of significant effects with regard to container terminals in the growth model. In other words, having a container facility does not significantly increase the growth aspects of both large and small ports. This seems a reasonable conclusion, as supply of infrastructure facilities mostly follows customer markets in the densely populated North-Western European context.

6. Conclusion and discussion

6.1. Findings and conclusion

This paper has drawn attention to the economic dimension of inland ports development, which has received only limited attention in inland ports research. An analytical framework was developed, which underlined that the economic effects of inland ports development are more pronounced than is up to now recognized in the academic literature. Theories and concepts stemming from economic geography literature – notably on regional clustering and agglomeration externalities – were used to explore the relation between investing in infrastructure (i.e. inland ports development) and the associated economic development effects. Drawing on the convergence versus divergence debate, and the nature of agglomeration externalities, inland ports should benefit from the economic benefits of being located proximate to other inland ports and that especially being located in close proximity of network nodes and/or main corridors would be beneficial.

Based on running eight different regression models on a dataset of 135 Dutch inland waterway ports, the findings are rather mixed. Proximity does not seem to be important for explaining the level of or growth in cargo throughput of inland ports. There is no observable effect of spatial dependence. Rather, it seems that inland ports face much competition among each other and that other factors explain the economic effects of inland ports development to a far greater extent. Either the actual distances between the inland ports within the Dutch inland waterway network are too small to render significant results regarding spatial autocorrelation, or inland ports development involves much competition among inland ports; being proximite to an important port is not necessarily beneficial to the growth prospects of an inland port. This indication of overproximity could have implications for policy-making and inland port governance, highlighting the need for an integrated and coordinated regional governance approach towards the future planning of inland ports, terminals and related logistics activities. Although the current supply of ports and related firms' activities is not necessarilty problematic, future expansion of ports and facilities should be handled with caution, particularly when it involves public funds. Further work on the positioning of stakeholders in and around inland facilities is needed.

Delving into different inland port types (within a corridor versus outside a corridor; with a container terminal versus without a container terminal, large-sized versus small-sized inland ports), led to nuances in the interpretations of the effects of proximity. Regarding the proximity of an inland waterway corridor, being located close to a corridor contributes positively and significantly to cargo throughput. Also, differences between inland ports outside a corridor are pronounced and significant, highlighting the importance of such large-scale bundles of infrastructure. At the same time, the European dimension of corridor development can be a threat to domestic inland ports development, as the introduction of new competitors by means of increased accessibility may make it harder for existing inland ports to draw sufficient volume to finance their operations. This can reinforce the case of overproximity as discussed above. Regarding the presence of a container terminal, the findings underlined that they are crucial assets in inland ports development. Inland ports without a container terminal are more heavily reliant on specific factors such as the proximity of a motorway entrance/exit, short range distribution and a large variety in types of goods handled, whereas these factors seem less important once a container terminal is already in place. This is confirmed when looking at the differences between inland ports with larger throughput volumes compared to their smaller counterparts; container terminals are important in explaining the size of large inland ports, where this is not the case for small inland ports.

6.2. Limitations and future research

Based on the findings, some limitations and suggestions for further research can be identified. There are two important limitations. First, the different levels of inland ports development and the different types of economic benefits associated with it need to be expanded. This paper has mainly focussed at the inter-port level. Either by looking at the economic effects of firm activities at the intra-port level, or looking at the economic effects of ports in the wider regional to (trans-)national context would be revealing. The relation between inland ports and maritime ports could also be considered in this respect. Second, the data could be expanded both in time and in geographical scope. Now the research is limited in the sense that only inland port development in the Netherlands up to and including 2006. It would be very useful to analyse developments since 2006 at the disaggregated level – in particular how the global economic crisis of 2008 has impacted the development of inland ports – and to see to what extent the results of this research also apply to different geographical and hydrological/fluvial contexts.

For future research, cross-referencing different spatial regimes, for instance looking at inland ports with a container terminal within a corridor, would also be relevant. Also, the diversity in types of goods has proven significant in each and every model. However, this is a rather crude variable which could be expanded by calculating a specialisation/diversity index. It can be expected that by doing so, a sector-based analysis of inland port development can be performed more effectively, which could indicate in more detail cases of complementarity between inland ports. Taking diversity of goods to distinguish between single user facilities and multiple commodities could also enrich the analysis. Finally, the issue of how differences between inland port types play out in terms of inland port governance could be explored in greater detail. Like their deep-sea port counterparts, the relationships between inland ports and regional development is obviously present, but ambiguous since it involves a multiplicity of interactions among a diversity of actors.

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Appendix A. Modelling outcomes for cargo throughput in tons/year (2006) (n = 135)

	OLS	ML–SL	ML–SL		ML–SL		ML–SL	
			Regimes		Regimes		Regimes	
			CO+	CO–	CT+	CT–	LA	SM
Constant	3.213**	3.123	3.571	4.896*	2.648	3.534	2.920*	1.661
	(5.901)	(1.315)	(1.459)	(1.916)	(0.982)	(1.493)	(1.692)	(0.911)
Presence container terminal (0/1)	0.410**	0.410**	0.581**	0.169	N/A	N/A	0.248**	0.071
	(3.100)	(3.221)	(3.361)	(0.944)			(2.333)	(0.378)
Number of jobs in the region (ln)	0.052	0.052	0.122*	0.045	−0.121	0.083	−0.017	0.070
	(1.010)	(1.048)	(1.712)	(0.665)	(−0.844)	(1.568)	(−0.332)	(1.376)
Short range distribution (ln)	0.079**	0.079**	0.118**	0.072*	0.090	0.083**	0.054	0.060**
	(2.478)	(2.556)	(2.547)	(1.822)	(1.191)	(2.521)	(1.519)	(2.021)
Medium range distribution (ln)	0.126**	0.126**	0.220**	0.042	0.298**	0.080*	0.137**	0.056
	(2.675)	(2.770)	(3.669)	(0.633)	(2.488)	(1.675)	(3.073)	(1.082)
Long range distribution (ln)	−0.001	−0.000	−0.089**	0.057*	−0.060	−0.003	−0.038	0.041
	(−0.020)	(−0.019)	(−2.248)	(1.655)	(−0.875)	(−0.103)	(−1.262)	(1.618)
Diversity in types of goods (0–9)	0.362**	0.362**	0.323**	0.401**	0.274**	0.428**	0.220**	0.597**
	(8.779)	(9.113)	(6.529)	(6.086)	(3.972)	(8.683)	(6.248)	(4.703)
Distance to motorway (ln)	−0.501**	−0.501**	−0.849**	−0.152	−0.256	−0.512**	−0.279*	−0.350**
	(−3.247)	(−3.373)	(−4.164)	(−0.728)	(−0.583)	(−3.311)	(−1.661)	(−2.438)
Multiple inland port centres (0/1)	−0.087	−0.021	0.164	−0.024	−0.054	0.049	−0.001	−0.097
	(−0.127)	(−0.133)	(1.065)	(−0.153)	(−0.249)	(0.373)	(−0.007)	(−0.867)
W_cargo throughput	N/A	0.014	−0.201		−0.006		0.265	
		(0.039)	(−0.545)		(−0.017)		(1.023)	
Adjusted R–square	0.668	0.690	0.722		0.711		0.841	
Spatial Chow–Wald test			15.955	(p: 0.068)	20.584	(p: 0.008)	128.504	(p: 0.000)

* p<0.1; ** p<0.05; t–values in parentheses. Coefficients that significantly differ over regimes are shaded.

Appendix B. Modelling outcomes for growth in cargo throughput in tons/year (2001–2006) (n = 135)

	OLS	ML–SL	ML–SL Regimes		ML–SL Regimes		ML–SL Regimes	
			CO+	CO−	CT+	CT−	LA	SM
Constant	3.213**	3.123	3.571	4.896*	2.648	3.534	2.920*	1.661
	(5.901)	(1.315)	(1.459)	(1.916)	(0.982)	(1.493)	(1.692)	(0.911)
Presence container terminal (0/1)	0.410**	0.410**	0.581**	0.169	N/A	N/A	0.248**	0.071
	(3.100)	(3.221)	(3.361)	(0.944)			(2.333)	(0.378)
Number of jobs in the region (ln)	0.052	0.052	0.122*	0.045	−0.121	0.083	−0.017	0.070
	(1.010)	(1.048)	(1.712)	(0.665)	(−0.844)	(1.568)	(−0.332)	(1.376)
Short range distribution (ln)	0.079**	0.079**	0.118**	0.072*	0.090	0.083**	0.054	0.060**
	(2.478)	(2.556)	(2.547)	(1.822)	(1.191)	(2.521)	(1.519)	(2.021)
Medium range distribution (ln)	0.126**	0.126**	0.220**	0.042	0.298**	0.080*	0.137**	0.056
	(2.675)	(2.770)	(3.669)	(0.633)	(2.488)	(1.675)	(3.073)	(1.082)
Long range distribution (ln)	−0.001	−0.000	−0.089**	0.057*	−0.060	−0.003	−0.038	0.041
	(−0.020)	(−0.019)	(−2.248)	(1.655)	(−0.875)	(−0.103)	(−1.262)	(1.618)
Diversity in types of goods (0–9)	0.362**	0.362**	0.323**	0.401**	0.274**	0.428**	0.220**	0.597**
	(8.779)	(9.113)	(6.529)	(6.086)	(3.972)	(8.683)	(6.248)	(4.703)
Distance to motorway (ln)	−0.501**	−0.501**	−0.849**	−0.152	−0.256	−0.512**	−0.279*	−0.350**
	(−3.247)	(−3.373)	(−4.164)	(−0.728)	(−0.583)	(−3.311)	(−1.661)	(−2.438)
Multiple inland port centres (0/1)	−0.087	−0.021	0.164	−0.024	−0.054	0.049	−0.001	−0.097
	(−0.127)	(−0.133)	(1.065)	(−0.153)	(−0.249)	(0.373)	(−0.007)	(−0.867)
W_cargo throughput	N/A	0.014	−0.201		−0.006		0.265	
		(0.039)	(−0.545)		(−0.017)		(1.023)	
Adjusted R–square	0.668	0.690	0.722		0.711		0.841	
Spatial Chow–Wald test			15.955	(p: 0.068)	20.584	(p: 0.008)	128.504	(p: 0.000)

* p<0.1; ** p<0.05; t–values in parentheses. Coefficients that significantly differ over regimes are shaded.

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