AUTOMATICALLY GENERATED PORT HINTERLANDS

PRELIMINARY WORK

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abstract

Competition between ports depends on inland freight distribution and the spatial structure of the hinterland. With this, ports and port regions increasingly compete to serve distant hinterlands. In a European context, many researchers refer to the agglomeration of economic activity in the Rhine-Ruhr area and the 'blue banana' to explain the concentration of port activity in the Hamburg-Le Havre port range. Besides this, the incorporation of new member states in the European market has changed the structure of port hinterlands. In this paper we attempt to reveal the spatial structure of the hinterland of the Hamburg-Le Havre ports using automated zoning techniques. These techniques aggregate geographical areas in homogeneous clusters using spatial as well as content-related constraints. The aim is to use both economic characteristics of hinterland regions and variables which express the link between these regions and ports to create a new map of the port hinterland. Besides an improved insight in the spatial structure of the hinterland, this analysis can deliver a set of areas which can be used in economic models. Indeed, creating an 'optimal' zoning is one of the strategies researchers employ to handle observational units with often arbitrary boundaries.

Keywords: Ports; Europe; Hamburg-Le Havre range; automated zoning algorithms

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1. Introduction

The relation between ports and their hinterlands is well-studied and is conceptualised in models that focus on supply chains which connect ports with locations of consumption and production. Especially since the late 1990s ports are no longer seen as a kind of special places but as elements in supply chains/value chains (Suykens and Van De Voorde, 1998; Robinson, 2002). This new paradigm of 'ports as elements in value-driven chain systems' stresses that you can only understand a port if you take into account its place and function in the supply chain, i.e. a port is a node in a network that connects different production and/or consumer locations in different regions. To what extent a port can add value to this (global value) chain determines its position and functioning. With this, the main focus is on the hinterland, although some studies discuss the foreland too (Rodrigue and Notteboom, 2010).

One of the most quoted (Pallis et al., 2010) models in port studies is the 'port regionalisation phase' of Notteboom and Rodrigue (2005). This model illustrates that the size and position of ports (load centres) are strongly related to the links with the hinterland and the way how the distribution of goods in and from the hinterland is organised (with freight corridors and inland ports). A growing body of literature focuses on the role of inland ports which are connected with seaports via inland waterways and/or rail (Roso et al., 2009; Rodrigue et al., 2010). Three elements are crucial for the development of inland ports, (1) standardisation of transport through containerisation, (2) the existence of dedicated links with high capacity, and (3) massification of flows to create economies of scale (Rodrigue et al., 2010). Besides the emergence of inland ports, relations between ports in the same region have grown and e.g. Notteboom (2009, p.756) notes that in 2005, 850 000 TEUs were shipped via barge between Rotterdam and Antwerp and 285 000 TEU by rail (in 2004).

Given the strong linkages between ports and their hinterlands, port throughput is often modelled as a function of the economic situation in the hinterland using GDP or trade figures (Janssens et al., 2003; Meersman and Van De Voorde, 2008; Meersman, 2010). In most cases, these approaches focus on the dynamics using time series. As an alternative, Chapelon (2007) explains the size of European ports on the basis of the accessibility to the European population and welfare. Indeed, many authors and policy makers are fascinated by the dominant position of

the Hamburg-Le Havre ports in the European port landscape. Even when leaving freight corridors aside and only taking into account road transport, the Rhine-Scheldt Delta ports (notably Antwerp and Rotterdam) can access in the same time span more people and wealth than other European ports (Chapelon, 2007). However, this study does not take into consideration the effect of density (agglomeration) which is crucial in the logistic chain approaches which stress the importance of massification (which is only possible in large markets). On the other hand, time-series analyses are too often restricted to economic indicators of just one country (Vanoutrive, 2010). Therefore, we here aim to get a more comprehensive view on the hinterland. In concrete, we discuss the potential of automated zoning techniques to aggregate European regions in meaningful spatial units in order to get a better insight in the structure of the European port hinterland.

2. Methodology: Automated Zoning Algorithms

In essence, automated zoning procedures aggregate areal units (zones) into larger units which are less or more homogenous. The maximisation of homogeneity can be based on some selected variables. Furthermore, size and spatial constraints can be taken into account to obtain a set of 'meaningful' zones. The development of automated zoning algorithms is linked to discussions on the Modifiable Areal Unit Problem (MAUP, Openshaw and Taylor, 1981) and a renewed interest appeared in research for the UK censuses of 2001 and 2011 (Martin et al., 2001; Flowerdew et al., 2008). In this paper, we employ the AZTool. As a consequence, 'The authors gratefully acknowledge the use of the AZTool software, which is copyright David Martin, Samantha Cockings and University of Southampton.' (http://www.geodata.soton.ac.uk/software/AZTool/).

In this preliminary analysis, we use population and GDP data at the European NUTS 2 level to explore the structure of the port hinterland. Population data as well as other statistical information is made available by Eurostat using NUTS regions. Although there is some rationale behind the delimitation of these regions and European policy allocate some funds using this spatial zoning, there is a lot of critique on the use of these rather heterogeneous and arbitrary regions in empirical analyses (see e.g. Dall'erba and Le Gallo, 2008). One of the reasons to use spatial econometric techniques is to overcome problems caused by arbitrary zonations. Indeed,

if parts of a real region are separated by an arbitrary boundary, taking into account the value of the neighbouring region is helpful. In the spatial econometric literature we also find another reason to apply automated zoning algorithms, i.e. the existence of different spatial regimes (Dall'erba and Le Gallo, 2008). This means that processes can be different in one group of regions, compared to other groups of regions. Zoning algorithms have the potential to detect the different kind of regions. In the case of port hinterlands, more dense regions can have a larger impact on port throughput due to the massification of flows (scale economies).

3. Level of aggregation

In the previous section we mentioned that the arbitrary nature of boundaries is one of the main reasons to use automated zoning algorithms. With this, we referred to the Modifiable Areal Unit Problem (MAUP). Besides this zoning problem, MAUP has a second aspect, the scale issue. Indeed, relations between variables change when measured at different levels of aggregation, which is also known as ecological correlations (Robinson, 1950).

To check the influence of level of aggregation on port-hinterland relations, we made a simple analysis of the percentage of regions within a country which has port X as nearest port. Distance between ports and regions is measured as the crow flies. We compare the port of Antwerp with those of Rotterdam and Hamburg, and a region is considered nearer if the difference in distance is at least 10%. We did this for a selection of European countries where the difference in distance is significant in some regions. We did this for the NUTS levels 0 to 3. Figure 1 gives the results and it can be seen that the level of aggregation has an impact on analyses of port-hinterland relations. Figure 2 shows the nearest port of some European regions in a cartographic way. The map illustrates that the port of Antwerp is for large parts of France and even for southwest Germany at least 10% nearer than the ports of Hamburg or Rotterdam when distance is measured as the crow flies.

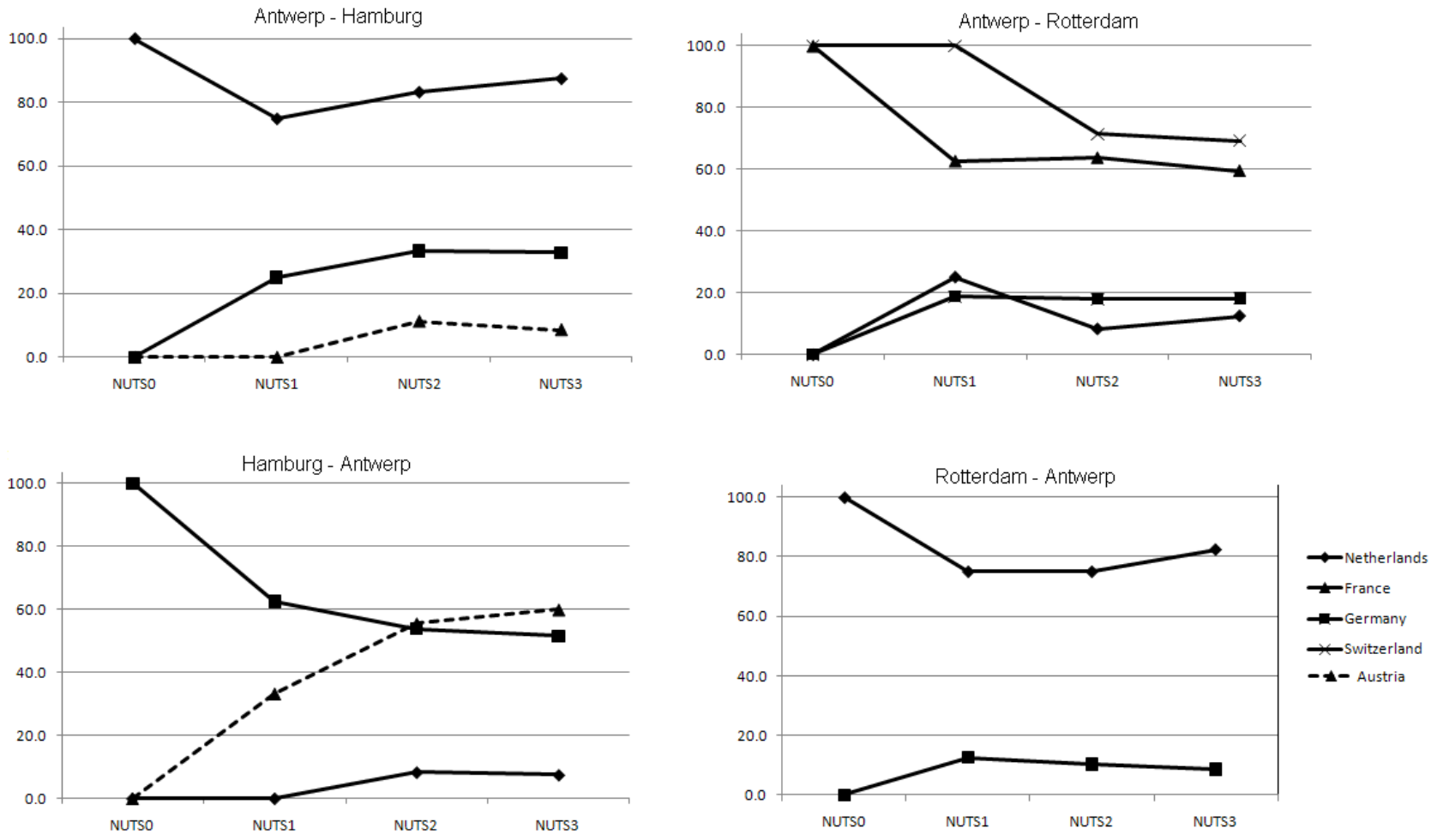


Figure 1: Impact of level of aggregation on the nearest port to a region
Percentage of regions in a country for which the first port is located at least 10% nearer than the second port

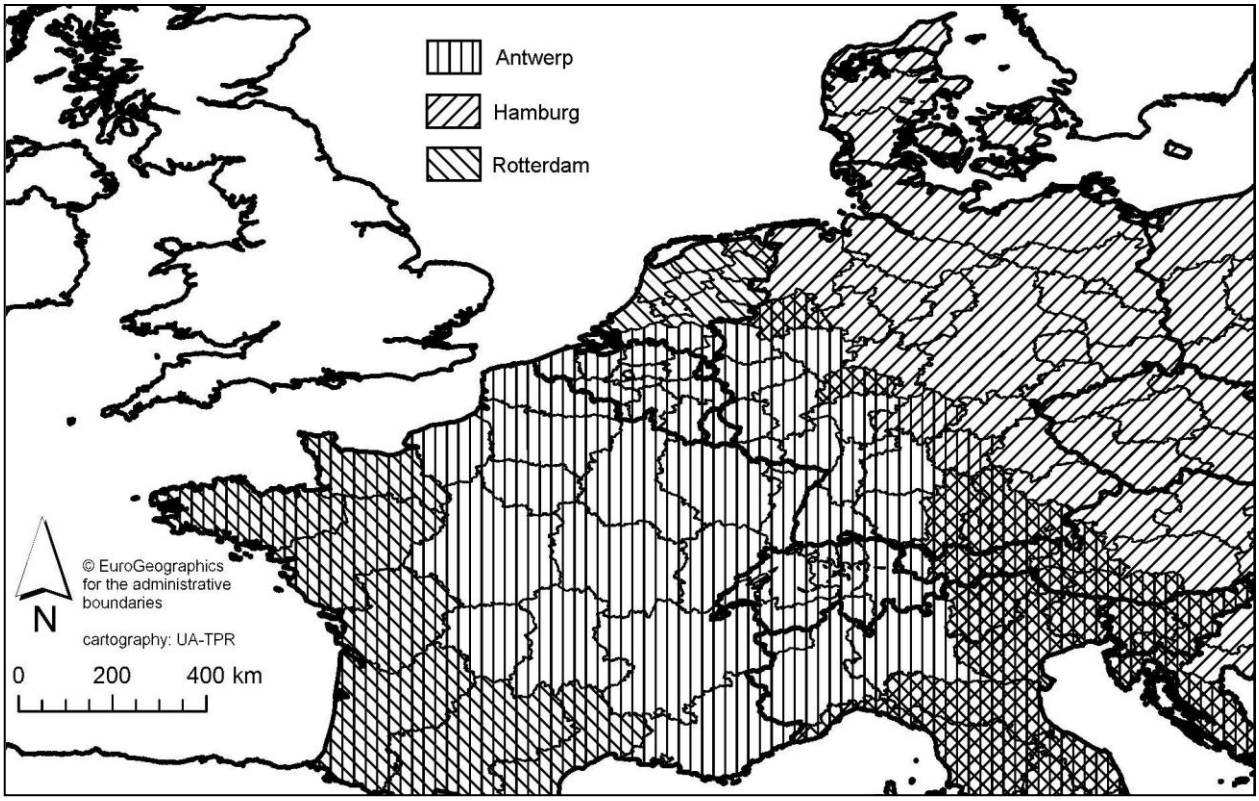


Figure 2: Nearest port(s) for NUTS 2 regions in selected European countries

4. Spatial distribution of population and GDP in Europe

Since the demand for transport is strongly related to consumption and production, we show the spatial distribution of population and GDP in Europe (Figures 3-5). For GDP, we show next to GDP per capita figures (Figure 4) also the GDP/km² since this better reflects the density, and thus the demand for transport. These figures at the NUTS 2 level are the basis for the creation of an improved zoning of European regions.

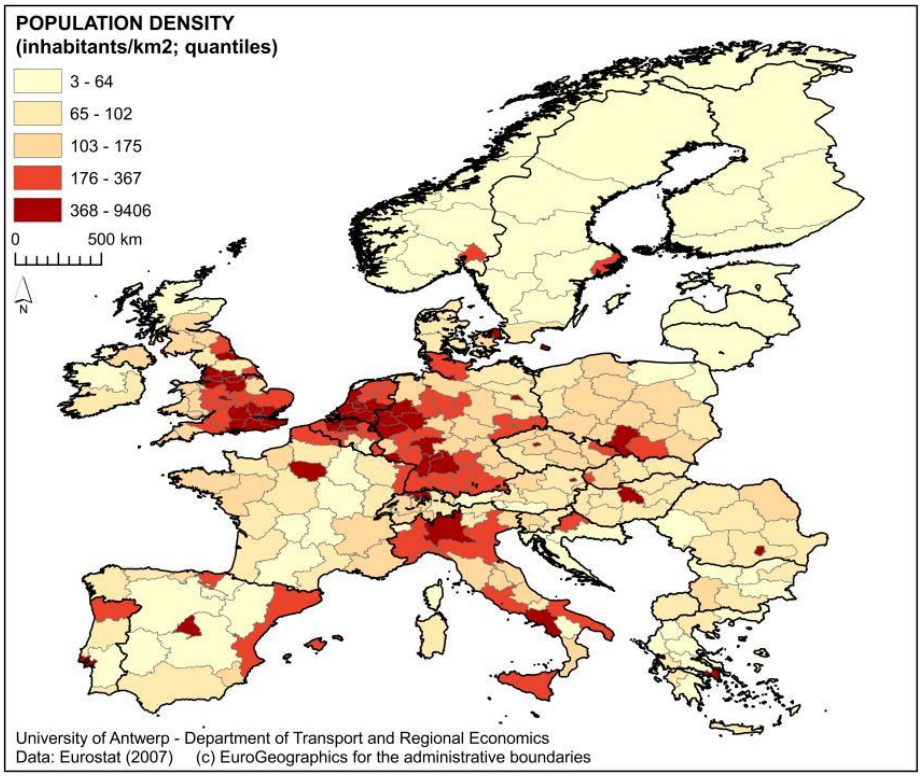


Figure 3: Spatial distribution of population density in Europe

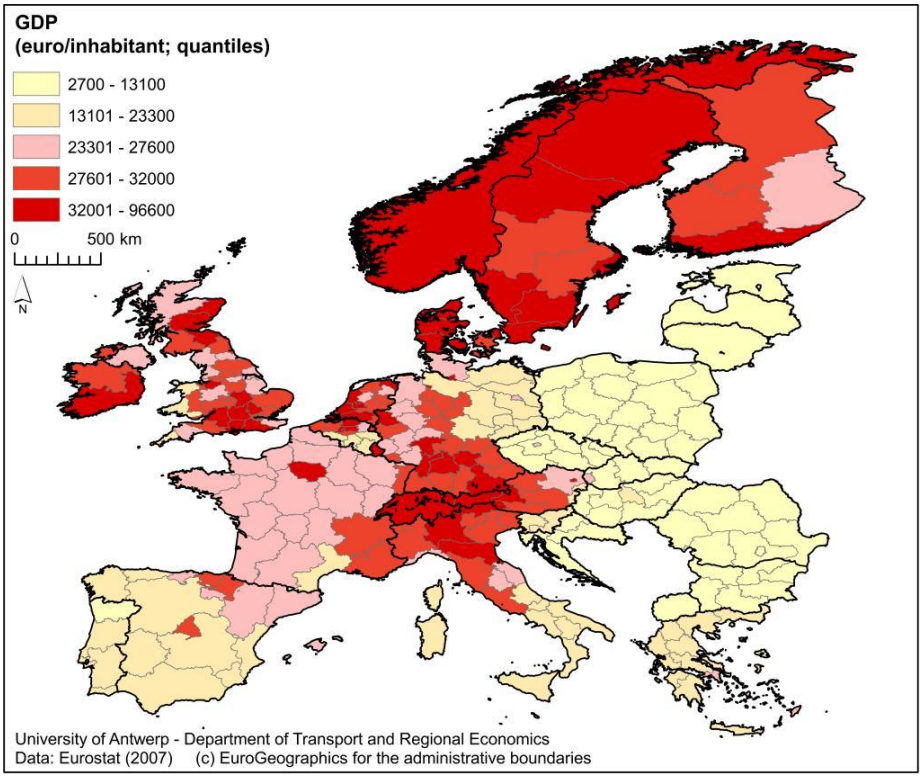


Figure 4: Spatial distribution of GDP/capita in Europe

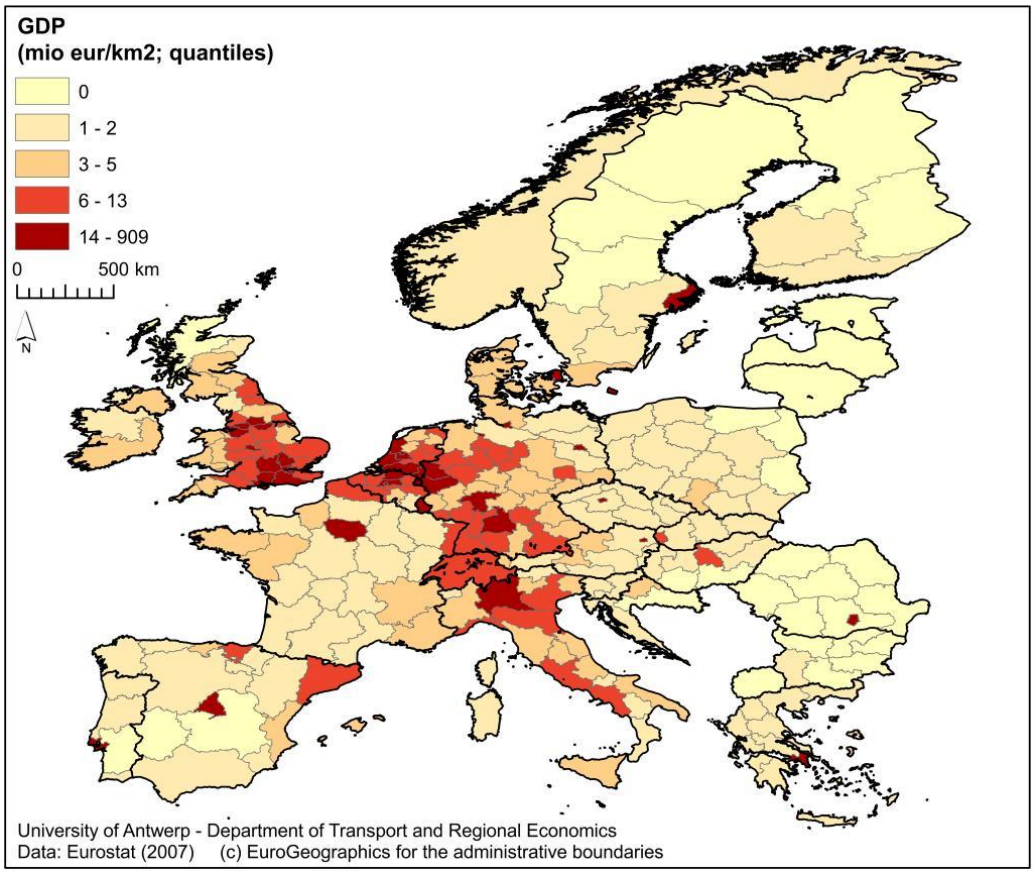
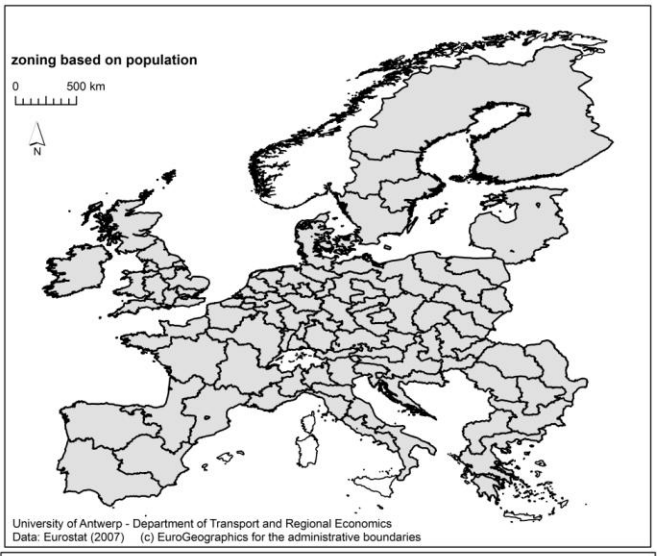
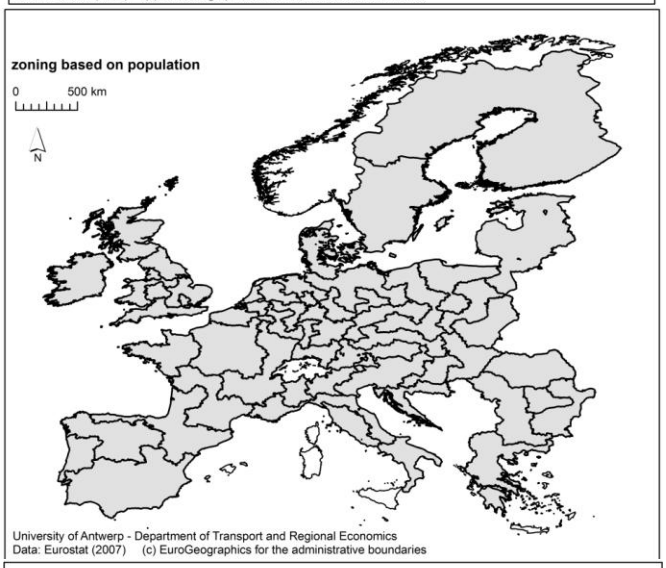


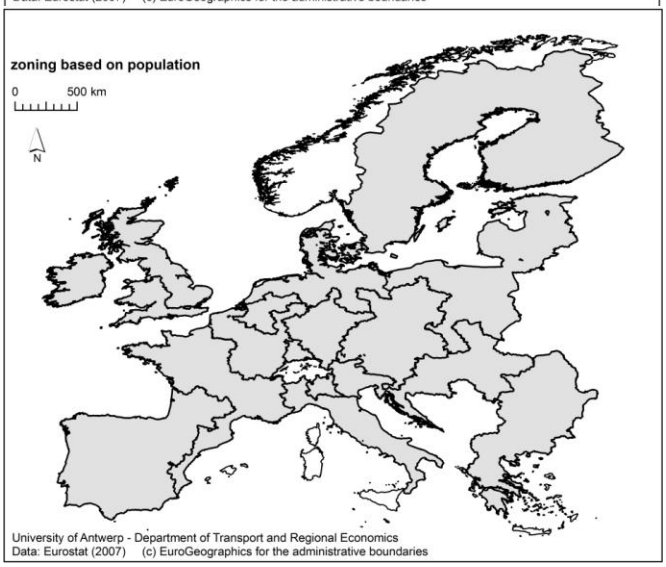
Figure 5: GDP per km² in Europe

5. **Results**

We here present the outcome of the automated zoning algorithm which took into account two parameters. First, the algorithm tries to create zones with almost the same amount of inhabitants. Second, the zones are made as homogenous as possible in terms of population density. By playing with thresholds and the like, we obtained three different zonings which are given in Figures 6-8. Doing this, Europe was subdivided in approximately 80, 55 and 17 zones respectively. Unsurprisingly, relatively densely populated regions like the low countries, parts of northern Italy and the French-Spanish Mediterranean coast can be detected on the map.







Figures 6-8: results of the automated zoning algorithm

6. Discussion and Conclusion

This paper presents some preliminary results of the method we plan to apply to reveal the spatial structure of the European port hinterland. These first results look promising and we hope that further improvements will lead to a quantitative method which enables us to further explore the hinterland landscape as sketched in e.g. Figure 9.

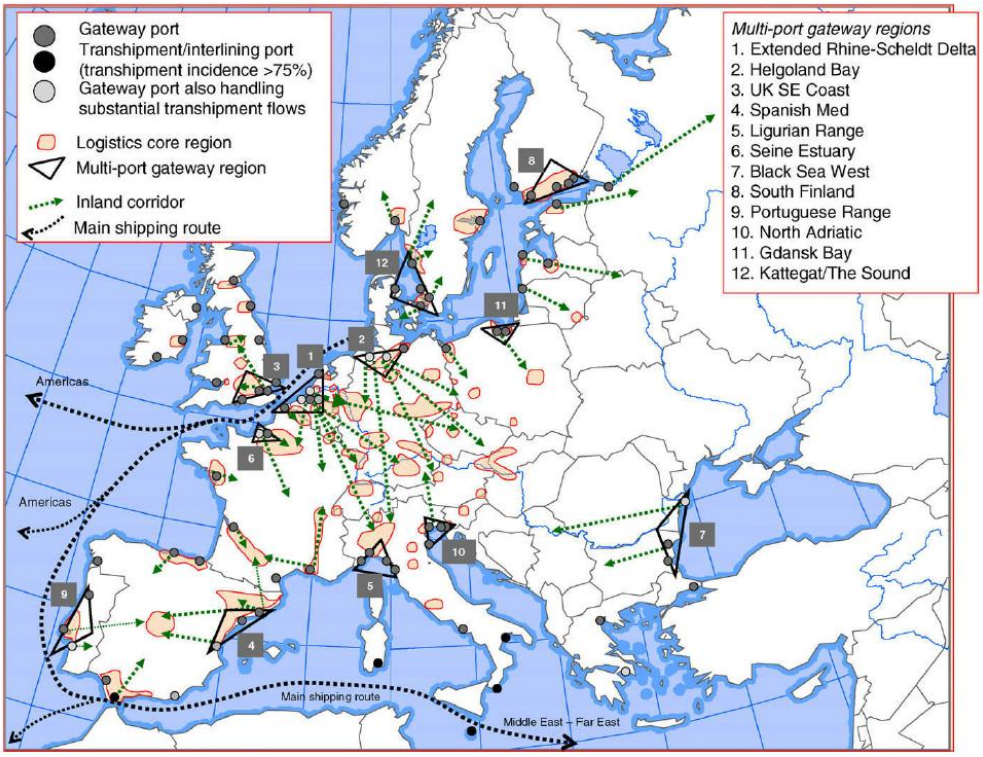


Figure 9: The European container port system and logistics core regions in the hinterland. (Notteboom, 2010, p. 572)

Further research will focus on the addition of more variables in the algorithm, like GDP, industrial production and the share of the workforce that is active in manufacturing. Furthermore, more reference shall be made to theoretical literature that focuses on the role of density since a disproportionate part of maritime traffic has its origin or destination in the most dense regions of Europe. Presumably, the analysis will also benefit from the incorporation of transport networks and linking islands to the mainland. Finally, more attention should go to the spatial constraints that can be imposed on the shape and size of regions. One particular element is the use of the distance to some major ports as parameter which will result in smaller zones closer to these ports and larger zones in remote areas. This will probably better reflect the relations between ports and hinterlands.

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