

The economic impacts of port activity in Antwerp: a disaggregated analysis

ABSTRACT

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The economic relevance of the port sector is usually measured on an aggregated level by indicators such as added value, employment and investment. This paper tries to define the economic relevance for the regional as well as for the national economy on a disaggregated level. It attempts to identify, quantify and locate the mutual relationships between the various players in the port and between these players and other industries. Finally, it proposes a method to measure the effects of changes in port activity at a detailed level.

A sectoral analysis is made by compiling a regional input-output table, using a bottom-up approach. The most important customers and suppliers of the port's key players or stakeholders are identified. A geographical analysis can be made by using data on a disaggregated level. Each customer or supplier can be located by means of his postcode. In this way, the economic impact of the port is quantified.

In the case of the port of Antwerp, the results show important links between forwarders and agents. The geographical analysis shows agglomerating effects in Antwerp as a transshipment location point.

Key words: port economics, regional input-output table, sector analysis, geographical analysis

INTRODUCTION

Every year, the National Bank of Belgium publishes a report on the economic importance of the Flemish maritime ports (Lagneaux, 2005), in which the socio-economic importance of the Flemish ports is discussed, measured by indicators such as added value, employment and investment.

On the basis of these aggregated results, a number of questions cannot be answered, unless in a rough manner. In the spring of 2002, for instance, MSC took the decision to transfer approximately 200,000 TEU from Felixstowe to Antwerp (Port of Antwerp, 18/4/2003). The consequences for the Antwerp and Flemish economy exceeded the direct turnovers and costs as a result of the handling of those additional containers. This type of decisions created a chain reaction within the port structure, having consequences for approximately all players who are active in the port, but undoubtedly also outside that port. At present, that impact cannot yet be entirely estimated. By defining the relation pattern between the different players in the port and other sectors, the impact of those changes can be described.

Furthermore, it is important to know in which geographical surroundings the relations take place. The concentration of port companies is especially attributed to the present port infrastructure. Accessibility by means of water, the quays and their infrastructure, and the connections with the hinterland are presented as a main agglomerating factor. The question to be answered is to what extent the presence of the other port companies has an agglomerating effect. What are their mutual relations? To what extent can a port company survive outside the port area and to what extent reference can be made to subharbourisation? These elements are important for answering questions concerning the extension of port areas.

Switching from an aggregated to a disaggregated port analysis opens up a relatively new research area. The contribution of this research consists in building a method and an instrument, which makes it possible to calculate the direct and indirect impact of modifications in the port activity more precisely and in great detail. The economic relationships among port actors are derived from a regional input-output table (IOT). The regional IOT is constructed using a bottom-up approach. Earlier regional input-output analysis started from a top-down or non-survey approach. Canning (2005) uses a flexible mathematical approach. Oosterhaven (2003) showed the existence of estimation errors in non-survey approaches, which are assessed in relation to the full-survey method.

But port activity goes well beyond the port perimeter. Therefore Notteboom (2005) has included a port regionalization phase, which raises the perspective of the port to a higher geographical scale, i.e. beyond the port perimeter. This research aims to measure these links with the hinterland, by a disaggregated geographical analysis. Customers and suppliers of the port actors are located in places benefiting from agglomeration effects (Weber, 1909).

Furthermore, the port actors and other sectors are brought into connection. Therefore the scope of this research goes beyond port economics.

In a first chapter the various research questions are formulated. A next chapter defines the methodology used for the sectoral as well as the geographical analysis. A regional input-output table defines and quantifies the relations between the port actors and with respect to other sectors in the economy. Next, the results for these sectoral and geographical analyses are presented for the case of Antwerp. A final chapter indicates the most important conclusions which can be drawn from the sectoral and geographical analysis.

It was decided first to submit the research on the situation of the port of Antwerp, which is the main seaport in Belgium, encompassing most of the maritime and industrial activities. This exercise can be carried out for other ports as well. It also focuses on the year 2000, as the latest version of the national input-output table, which will be used for validating our regional IOT, pertains to 2000. Furthermore only the relations in Belgium are analysed, due to data restrictions.

The port of Antwerp is one of the biggest ports in the world and plays a leading role in international trade, more than half of the cargo it handles being either destined for or coming from other European countries. With an overall cargo turnover of more than 160 millions of metric tonnes a year it is classified second in Europe, after Rotterdam, and tenth in the world, according to international maritime traffic listings in 2005. Its container traffic is soaring (about 10 p.c. increase per year) and therefore new infrastructures are planned for the coming years, such as the new terminals at the Deurganck dock. The main cluster within the Antwerp port is formed by the petrochemical industry, making it one of the world's largest centres of chemical and petrochemical production, second only to Houston, Texas. Other major industries chose to settle in the Antwerp port area, like General Motors for instance, which built one of its largest assembly plants there. The port of Antwerp is directly employing more than 62,000 full-time equivalents, roughly 24,000 of which being active in the maritime cluster (port facilities, cargo-handling, agents, forwarders, shipping companies, dredging, etc.) and 27,000 in the manufacturing industries. Taking account of the upstream activity generated by the suppliers and subcontractors, the total economic impact amounts to 148,000 full-time equivalents. In terms of value added 16 billion euro are yielded directly and indirectly, which means a global impact of 5.6 p.c. of the Belgian GDP¹.

2. RESEARCH QUESTIONS

In order to examine the direct and indirect impact of modifications in the port activity, first of all, the relations between the different port actors are quantified. Next, the relations between the port actors and the other sectors are formally determined. They provide an answer to the question: Which sector delivers to which port actor (and vice versa) and in what quantity? Furthermore, it is important to examine the spatial impact of port activity. In the case of Antwerp a distinction is made in the Antwerp port perimeter, in the districts

¹ 2004 Data. Source: NBB.

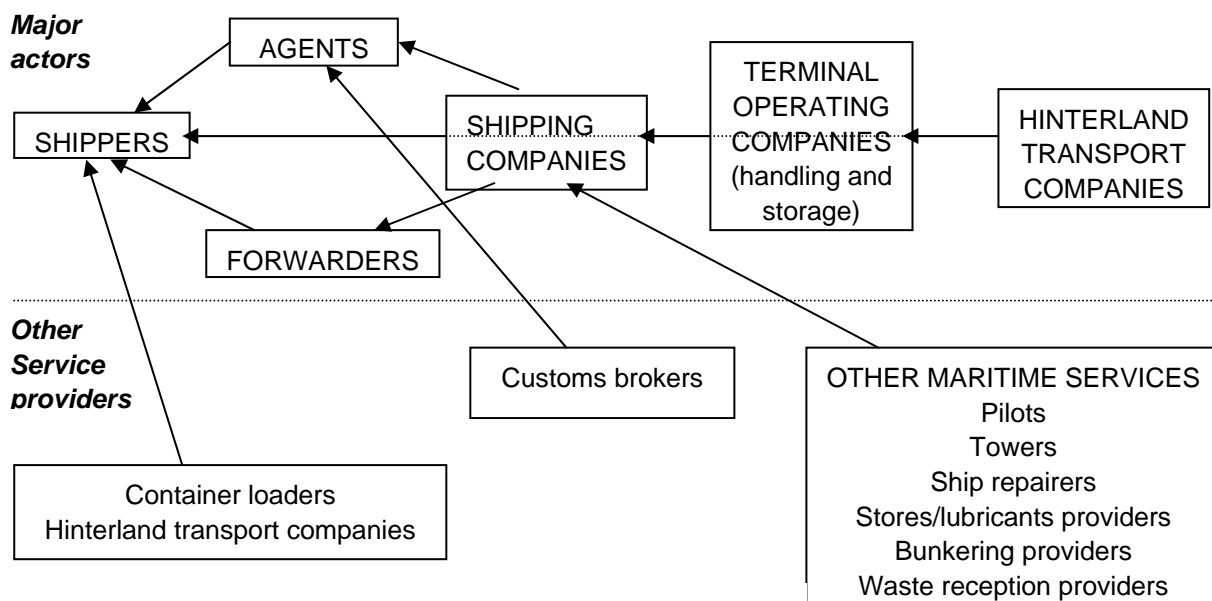
('arrondissementen') of Antwerp and in the provinces of Belgium. This results in either agglomeration or dispersal effects of port activity.

2.1. Sectoral analysis: relations between port actors and the rest of the economy

The aim of this sectoral analysis is to give a detailed overview of the underlying relations between all parties involved in port activities, inside and outside the port area. The paper distinguishes two relationships: the relations between the port actors in the port perimeter and the relationships of the port actors in the port perimeter with the rest of the economy.

The subdivision of the entire process in a port creates several main port actors. Jansson and Shneerson (1989) define seven partial processes. First, the ship approaches via river or canal and moors at the quay. During this process, the shipping company is assisted by pilots and towing services which steer the ship safely along shallow and dangerous places. Then, the cargo is discharged from the ship's holds and stored onto the quay, by terminal operating companies, which also transport the cargo to the transit storage and afterwards to loading platforms; the cargo is then loaded onto inland transportation modes. Finally, the inland transportation vehicle leaves the port and the cargo is transported to its destination in the hinterland, by rail, inland waterways or road. Figure 2.1 indicates the relations between the different actors within the port from a commodity flow point of view. The purpose of this research is, among other things, to verify and quantify the relations presented in figure 2.1.

Figure 2.1: Relations between port actors, commodity flow point of view



Source: Meersman, Van de Voorde and Vanelslander (2003), p. 4

The port groups several important actors. Shippers ensure the cargo which must be transported by ship. These are industrial companies which want their products to be transported by ship or wholesalers or third parties operating the freight transport. A shipper contacts either an agent or a forwarder. The agent works for the shipper and in partnership with a shipping company. The forwarder works for his own account and bundles goods. Then, the shipping company addresses terminal operating companies for the transfer of goods. Finally, hinterland transport companies ensure the supply of the goods in the hinterland. The shipping companies are assisted by pilots, towing services, ship repairers, etc. (all coming under the heading "other maritime services", see below).

2.2. Geographical analysis: relations between port actors and the hinterland

By means of the sectoral analysis, the relations between the actors in the port and their customers and suppliers can be described. Moreover, the impact of changes in this relation pattern can be set out, for example as a result of a government decision. So far, this tool leaves aside the spatial dimension of the industrial-economic structure. It is important to know in which geographical surroundings the relations take

place: local, regional, national or international dimensions. Thus, one gets an insight into the effects of the decisions of governments or market parties have an impact. The impact of the port activity can agglomerate locally or spread out.

3. METHODOLOGY

In order to measure the importance of the transport or distribution sector for the regional and the national economy, the literature often resorts to (regional) input-output analysis (Oosterhaven and Stelder, 2000) and so the input-output analysis has been made applicable to our research by constructing a regional input-output table by means of our disaggregated data sources. Therefore, each firm is classified as being situated within the port perimeter or not and as port actor or non-port actor. The geographical analysis of the relations of the port actors with their hinterland also requires disaggregated data to assign the customers and suppliers of the port actors to the different spatial entities.

3.1. Sectoral analysis

For the sectoral analysis, the interactions among port actors and between port actors and the rest of the economy are measured. A well-known tool to analyse intersectoral relations is the input-output table. Yet a Belgian input-output table (IOT) for 2000 is only available at the national level. Therefore, a disaggregated IOT has to be compiled.

Already in 1964 the Study Centre for Expansion of the port of Antwerp published an input-output table for the city of Antwerp. It concluded that although the district ('arrondissement') of Antwerp accounted for no more than 9 p.c. of the Belgian population, it contributed almost 12 p.c. to the gross national product. Furthermore, the non-commodity-producing sectors represent a substantial share in the generation of Antwerp's income. This means that the port plays an important role as a generator of activity for other transport modes and, moreover, the dominant industries in Antwerp's local economy were all linked to some extent to the port. But this analysis was unfortunately never made up again because statistical data at the local level were difficult to obtain (Suykens, 1989, p. 443). As disaggregated data for the port of Antwerp in 2000 are available, we will use input-output analysis to describe the complexity of the port's structure and the impact and influence on the different actors inside and outside the port perimeter.

Next, this regional input-output table has to be analysed as to the relations of the Antwerp port actors. Backward and forward linkages tell us how closely the port actors are linked with their suppliers and customers. Key sectors define the influence of the port actor on the rest of the economy. The relations of the Antwerp port actors with the rest of the economy are further analysed by means of external demand and external inputs.

3.1.1. The construction of a disaggregated input-output table

The goal is to build an input-output table for the Antwerp port actors. Such a table models the supplies from all industries to these port actors and vice versa. The table takes into account four broad categories:

1. The port actors in the Antwerp's port area (AN-PA)
2. The port actors outside Antwerp's port area (NOAN-PA)
3. The non-port actors in the Antwerp's port area (AN-NOPA)
4. The non-port actors outside Antwerp's port area (NOAN-NOPA)

The Antwerp's port area is defined by the port perimeter. Groups 1 and 3 are located within the port perimeter. Groups 2 and 4 are located outside the port perimeter, though still in Belgium. Groups 2, 3 and 4 are generally referred to as "the rest of the Belgian economy". The relations between those last three groups are not developed any further in this paper.

The Antwerp port perimeter is demarcated by the Royal Decree of 2 February 1993. This law has been made applicable to our data by defining the postcodes in the port perimeter. The set of postcodes seem to coincide more or less with the port perimeter (see figure 3.2). On the basis of their postcodes, the Antwerp port actors' customers and suppliers are assigned to the Antwerp port perimeter.

The classification of the companies among the port actors and other activity branches has been made on the basis of the NACEBEL codes from the National Accounts Institute. There are seven large port actors active in the port of Antwerp, with a further distinction in five subsections within the other maritime services. The other activities are subdivided in fourteen groups according to the sector they belong to.

The appendix shows the subdivision of the port actors. The non-port actors are subdivided into fourteen groups: food industry (NOPA-VO), land transport (NOPA-TP), public services (NOPA-PU), oil industry (NOPA-PE), electronics (NOPA-MP), metallurgy (NOPA-ME), energy (NOPA-EN), construction (NOPA-CS), trade (NOPA-CO), chemical industry (NOPA-CH), car manufacturing (NOPA-AU), other industries (NOPA-AI), other services (NOPA-AD) and Others. In a schematic way the IO table looks like table 3.1.

Table 3.1: Schematic input-output table

deliveries from to	AN-PA	NOAN-PA	AN-NOPA	NOAN-NOPA
AN-PA	(1)	(2)	(3)	(4)
NOAN-PA	(5)			
AN-NOPA	(6)			
NOAN-NOPA	(7)			

Supplies to Antwerp port actors [(1), (5), (6), (7)] are derived from the NAI's company data base. Broadly speaking, the same logic as in the construction of the supply-use tables is applied. This means that, at a first stage, total purchases (excluding imports) of the port actors at all the other sectors are computed. This yields the marginal column totals of the regional IO table. Then, these marginal totals, at a second stage, are distributed over the individual cells of the table using distribution codes computed from the VAT suppliers' listing. Similarly, the sales from port actors to port actors and to the other sectors are computed [(1), (2), (3), (4)]. Marginal row totals are computed and these totals are redistributed over the individual cells of the IOT.

3.1.2. Input-output analysis

Having constructed an input-output table, the relations among port actors and their relations with the rest of the economy can be analysed. The relations between the port actors are calculated by means of technical coefficients and backward and forward linkage measures. Key sector indicators measure the relative impact of one port actor on the others. The relations of the port actors with other sectors or with port actors outside the port perimeter are measured by external demand and external inputs.

Table 3.2 provides the basic model for an input-output table. The following methodology will be based on this table.

Table 3.2: Input-output table

	1	2	...	n	f	x
1	x_{11}	x_{12}	...	x_{1n}	f_1	x_1
2	x_{12}	x_{12}	...	x_{12}	f_2	x_2
...
n	x_{n1}	x_{n2}	...	x_{nn}	f_n	x_n
m	m_1	m_2	...	m_n	m_f	
va	va_1	va_2	...	va_n		
x	x_1	x_2	...	x_n		

n : number of industries in economy; x_{ij} : output of industry i delivered to industry j ; va : value added; m : import; f : final demand

a) Relations between the port actors

The relations between the port actors are measured by technical input and output coefficients - which measure the direct effects of changes in demand and prices - and also by backward and forward linkages, which measure the direct and indirect linkage with suppliers and customers.

Input-output analysis (Miller and Blair, 1985) subdivides an economy into a certain number n industries and final demand sectors. The final demand sectors are households' and government's expenditures, investments and exports. The output of an industry i (represented by x_i) equals the sum of its supplies to

other industries and its supplies to final demand or $x_i = \sum_{j=1}^n x_{ij} + f_i$. Defining technical coefficients as

$a_{ij} = x_{ij} / x_j$, with x_{ij} the supply of sector i to sector j and x_j the total output of sector j , this can be rewritten

as $x_i = \sum_{j=1}^n a_{ij} x_j + f_i$ or in matrix notation $x = Ax + f$, in which A is a square matrix of technical

coefficients, x a column vector of industry outputs and f a column vector of final demands. This matrix equation is the base equation of the Leontief model. It enables us to compute the total effect of an industry on the economy. The matrix $L = (I - A)^{-1}$ is called the Leontief inverse. Its column sums are the Leontief multipliers and, under the above reasoning, they provide the total effect of a unit of change in final demand for a sector. If the demand of sector j rises, the suppliers of sector j will have to produce more.

These Leontief multipliers show the impact of one industry on the rest of the economy via its supply chain. As such, they are a measure of the 'linkage' of an industry to its suppliers. This is called 'backward linkage' and the Leontief multipliers are a measure of backward linkage. As explained in Cai J., Leung P. (2004), this backward linkage measure is not pure, because of intrasectoral and cyclical deliveries. If the Leontief multiplier is considered as a measure for backward linkage, also the effects of purchases by sector i at sector i and by sector i at sector k , sector k at sector l ,... and finally sector m at sector i . Therefore this measure also contains some forward linkage. It can be 'purified' by dividing each Leontief multiplier by the diagonal element in the same column of the Leontief inverse. The total (direct and indirect) linkage of an industry with all its suppliers can thus be measured by:

$$BL_j = \frac{\sum_{i=1}^n l_{ij}}{l_{jj}} \quad (101)$$

where l_{ij} is the (i,j) element of the Leontief inverse.

Ghosh (1958) developed an alternative input-output model. The output of a sector i is equal to its purchases plus its imports plus value added. The two last terms are called the 'primary inputs' and will be noted as pi .

The base equation of the Ghosh-model is thus derived from $x_j = \sum_{i=1}^n x_{ij} + pi_j$ by defining technical output

coefficients $b_{ij} = x_{ij} / x_i$. The base equation is provided by $x = B^T x + pi$ in which the 'T' superscript means matrix transposition.

This Ghosh model can be used to analyse how costs are propagated through the economy (Dietzenbacher, 1997 and Coppens, 2006). When an industry i increases its prices, this has an impact on the costs of all its clients, i.e. the costs of their purchases increases. In order to maintain their value added at the same level they will also increase their prices, entailing cost increases for their clients.

These effects are provided by the column sums of the transposed Ghosh inverse $G = (I - B)^{-1}$. This means that the column sums of the transposed Ghosh inverse - thus the row sums of the Ghosh inverse - are a measure of linkage to the clients, i.e. forward linkage. Again this is not a pure measure. Dividing the row sums of the Ghosh inverse by the diagonal element in the same row yields a pure measure. Thus forward linkage is measured by:

$$FL_i = \frac{\sum_{j=1}^n g_{ij}}{g_{ii}} \quad (102)$$

in which g_{ij} is the (i,j) element of the Ghosh-inverse.

It should be pointed out that the measures (IO1) and (IO2) measure linkage of an industry in relation to its own size. It does not provide any information about the absolute impact of an industry. In order to analyse the absolute impact these measures must be decomposed (Coppens, 2006). As such the absolute (purified) total backward impact of an industry j on another industry i is provided by $(l_{ij}/l_{jj})x_j$, in relation to the size of industry i , yields a measure of dependence of i with respect to j (Coppens, 2005):

$$BDec_{ij} = \frac{g_{ij}}{g_{jj}} \quad (IO3)$$

and measures the share of output from industry i that is (directly or indirectly) related to industry j .

Similarly, the decomposed forward linkage measure can be found:

$$FDec_{ij} = \frac{l_{ij}}{l_{ii}} \quad (IO4)$$

is a measure of the payments of i that are attributable to j . It is a measure of cost dependence of i with respect to j .

Table 3.3: Overview of input-output indicators

Technical coefficients (direct effects)	input	$a_{ij} = x_{ij}/x_j$	supply structure	'Leontief'
	output	$b_{ij} = x_{ij}/x_i$	demand structure	'Ghosh'
Cai and Leung linkages (direct and indirect effects)	backward	$BL_j = \frac{\sum_{i=1}^n l_{ij}}{l_{jj}}$	linkage of industry j to its suppliers	in relation to the output of industry j
	forward	$FL_i = \frac{\sum_{j=1}^n g_{ij}}{g_{ii}}$	linkage of industry i to its customers	in relation to the output of industry i
Decomposed linkages (direct and indirect effects)	backward	$BDec_{ij} = \frac{g_{ij}}{g_{jj}}$	linkage of industry j to its supplier i	in relation to the output of industry i
	forward	$FDec_{ij} = \frac{l_{ij}}{l_{ii}}$	linkage of industry i to its customer j	in relation to the output of industry j

Finally we will analyse each Antwerp port actor as being a key sector within the Antwerp port actors or not. Therefore a combined measure is provided by the multiplier of Oosterhaven and Stelder (2002) that calculates the ratio of effects generated by sector j in the rest of the economy and the effect generated by the rest of the economy in sector j . If this multiplier exceeds 1, sector j is a key sector and industry j can be said to be more important for the others than the others for industry j (Dietzenbacher, 2005).

$$\frac{\text{Leontief multiplier of } j \times \text{final demand of } j}{\text{output of } j} \quad (IO5)$$

b) Relations with the rest of the economy

In order to find the most important customers and suppliers of the port actors within the rest of the economy different measures can be used.

Considering external customers, we use final demand. In our schematic example in table 3.2, final demand is found in (2), (3) and (4). Transitions t_{ie} to final demand are defined as

$$t_{ie} = \frac{\text{deliveries from port actor } i \text{ to external sector } e}{\text{total output of } i} \quad (IO6)$$

This represents the external demand for output from the port actors.

Similarly, we find the most important suppliers by r_{ie} , which represents the external inputs for the port actors.

$$r_{ie} = \frac{\text{payments from port actor } i \text{ to external sector } e}{\text{total output of } i} \quad (107)$$

In fact, the technical output coefficients indicate the fraction of output from a port actor i that is (directly) destined to another port actor j . It can be shown (see Coppens F. (2006)) that the total number of times that an output from i passes through j is provided by the element (i, j) of the Ghosh inverse. Furthermore, outputs from i that arrived in j transit to the final demand components by fractions provided by t_{ie} from formula (102).

The proportion of outputs from i arriving in final demand component f in fractions is provided by $G^{-1}.T$. This matrix yields the distribution of direct and indirect outputs of all port actors i.e. it shows the most important clients.

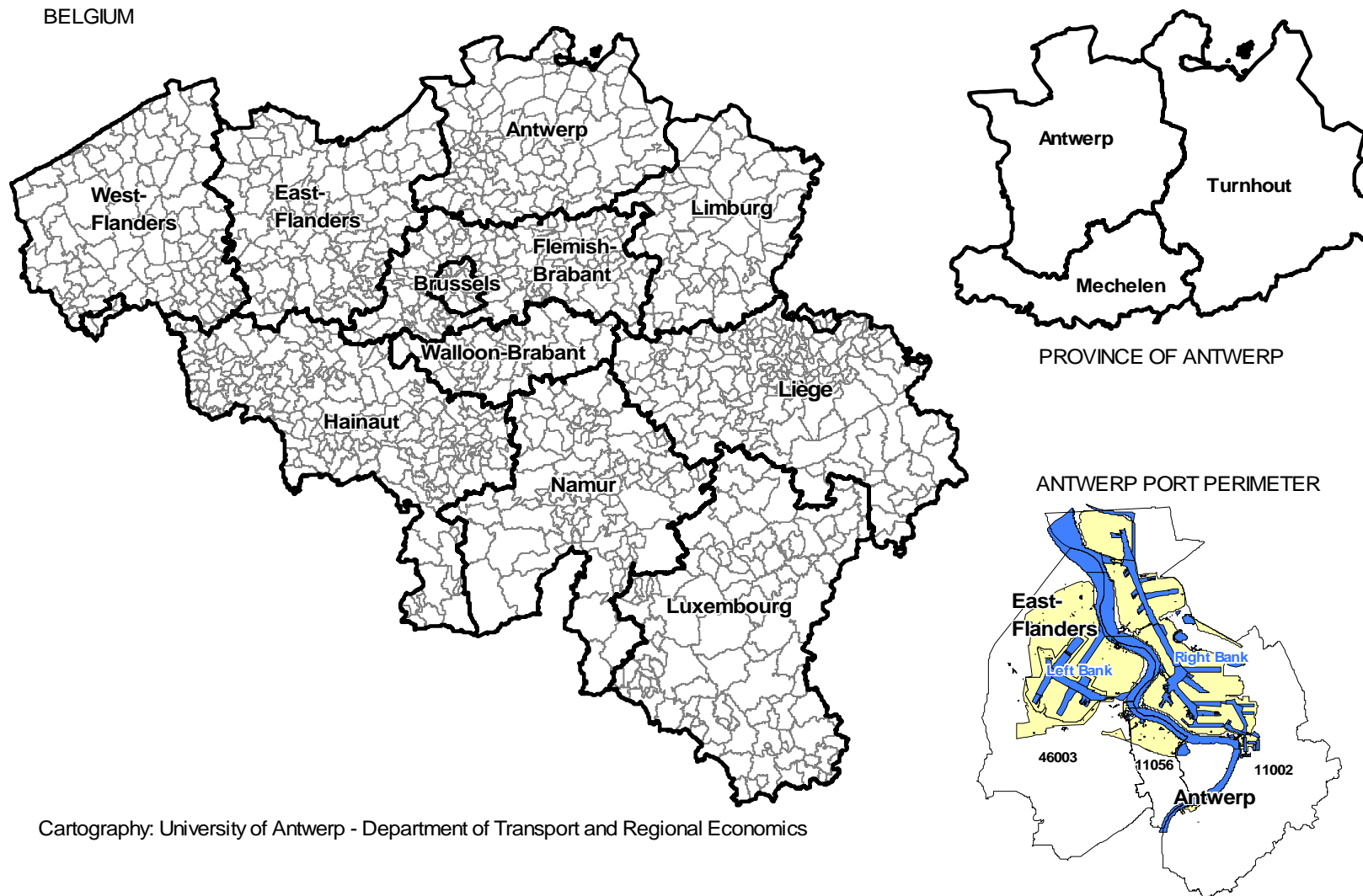
In a dual way the payments from port actors to external sectors can be found. The most important suppliers (in terms of payments by port actors) are found in $L'^{-1}.R$.

3.2. Geographical analysis

Besides the analysis of the relations between the port actors and the rest of the economy, it is also important to analyse the geographical relations to know where the most important customers and suppliers of the port actors are located.

The importance of customers and suppliers of the Antwerp port actors is measured by the net value of their purchases or of sales by the port actors. This net value is located on a map where various spatial entities are defined. Figure 3.2 shows Belgium with its ten provinces and the Brussels-Capital Region, the province of Antwerp with its three districts and the Antwerp port perimeter with the left and right bank of the river Scheldt. In the analysis a distinction is made between the different provinces through postcodes. This method is also used for the distinction between the various districts (Antwerp, Turnhout, Mechelen) within the province of Antwerp. The location of customers and suppliers in or outside the Antwerp port perimeter is done by postcodes and NSI (National Statistics Institute) codes. The set of postcodes 2000, 2020, 2030, 2040, 2060, 2070, 9120, 9130 more or less coincides with the port perimeter. As a consequence, the companies can be classified according to their address information. Furthermore, it is possible to make a distinction between the left and right bank of the river Scheldt through NSI codes. These are shown in figure 3.2 within the Antwerp port perimeter map. Companies with NSI code 46003 and 11056 are located on the left bank of the river Scheldt and companies with NSI code 11002 on the right bank. As can be seen in figure 4.3 one part of the left bank is situated in the province of East-Flanders (with NSI code 46003) and the other part in the province of Antwerp (with NSI code 11056). The port perimeter being situated in two different provinces increases the complexity of the analysis and of spatial planning. The provinces of Antwerp and of East-Flanders each provide their own spatial planning for, respectively, the right bank and the left bank of the river Scheldt (Engelen et al., 2005).

Figure 3.2: Spatial entities for geographical analysis



4. EMPIRICAL ANALYSIS: CASE OF ANTWERP

4.1. Sectoral analysis

In this paragraph the relations between the Antwerp port actors and their relations with the rest of the Belgian economy are analysed for the year 2000 by means of an input-output analysis. An input-output table of the kind presented in paragraph 3.1.1. is drawn up for the relations between the Antwerp port actors and for the relations with the rest of the economy by distributing the total deliveries and consumption over the different sectors in proportion to microeconomic data.

4.1.1. Relations between the Antwerp port actors

The analysis starts with the calculation of the Leontief and Ghosh multipliers, which in the net version indicate respectively backward and forward linkages. This corresponds to the analysis of part (1) in table 3.2. Finally the key-sectors among the port actors are described.

The technical input coefficients are an indication of the cost structure of an economy. For instance, a one-unit increase in final demand for goods of sector j requires the latter to enhance its purchases from sector i by an amount provided by the (i,j) -th technical input coefficient.

Forwarders and shipping companies create the largest output in the Antwerp port perimeter. Moreover these two port actors are highly dependent on the Antwerp port actors as a whole, respectively 47.4 and 45.2 p.c. of their purchases being supplied by them. Agents are strongly relying on themselves (16 p.c.) and on shipping companies (15 p.c.) for directly delivering more input when their demand increases. Shipping companies should provide 23 p.c. more input from themselves, when demand increases by one unit. Forwarders need 20 p.c. more input from agents. Customs brokers need more than 10 p.c. input from terminal operating companies and supporting activities, while fuel trade and terminal operating companies should provide an input for more than 10 p.c. themselves.

The technical output coefficients provide the demand structure for the various sectors. They show how much from the output of sector i is delivered to sector j . These technical coefficients only describe the direct relations between sector i and sector j .

Almost 17 p.c. of the output of the supporting activities is destined for the Antwerp agents, whereas 11 p.c. is intended for the shipping companies. Fuel trade delivers 12 p.c. to fuel trade, whereas terminal operating companies deliver to terminal operating companies, to agents, to shipping companies and to forwarders. Shipping companies deliver mostly to shipping companies (23 p.c.), to agents and to forwarders. Shipbuilding and repair delivers output to dredging. More than 37 p.c. of the output of the customs brokers goes to the forwarders. Agents deliver 16 p.c. to agents and 33 p.c. to forwarders.

A strong direct relationship exists between the Antwerp agents and forwarders. More than 20 p.c. of the input of the forwarders is provided by the agents, whereas 33 p.c. of the output of the agents is intended for the forwarders. So, forwarders are the greatest customers of the agents. This can be explained by the fact that agents are working by the order of a shipping company, whereas forwarders work for their own account and bundle goods to tranship them and therefore contact an agent, who renders its services to the forwarder.

Linkages define the relation of a certain industry to its suppliers or customers. The backward and forward linkages defined by Cai and Leung will be used to work out the size of the boxes in figures 4.1 and 4.2. The difference between the decomposed linkages and the linkages calculated according to Cai and Leung is that Cai and Leung provide the multipliers in relation to the size of the sector, whereas the decomposed linkage is measured with respect to the supplying or consuming pattern of the sector. Decomposed backward linkage gives the linkage of industry j to its supplier i , in relation to the size of the supplier i . It measures the total (direct and indirect effect) an industry has on its suppliers. The size of the boxes in figure 4.1 clearly show that the agents, forwarders and customs brokers have the most influence on their suppliers, according to their own output. As this backward linkage is decomposed it can be seen that forwarders have a very strong influence on their suppliers with respect to their own output: agents, customs brokers, supporting activities, shipping companies and terminal operating companies. Agents have an important influence on terminal operating

companies, shipping companies, supporting activities and other trade. Dredging has an influence on shipbuilding and repair as its supplier and shipping companies on terminal operating companies, supporting activities and other trade. And terminal operating companies have an influence on supporting activities as its suppliers.

The linkage of industry i to its customer j , in relation to the output of customer j , is measured by means of the decomposed forward linkage. It measures the total (direct and indirect) effect an industry has on its customers. The port actors having the strongest influence on their customers are the supporting activities, the customs brokers and the terminal operating companies, according to the size of the boxes in figure 4.2, i.e. with respect to their own output. As this measure is set in relation to the output of the customers, customs brokers are seen to have no strong linkage to their customers. Supporting activities with a very strong forward linkage, with respect to its own output, have only a strong influence on customs brokers, according to their output. Whereas shipping companies, who have not a really strong forward linkage to their own output, do have a strong decomposed forward linkage with agents and forwarders. Terminal operating companies have a strong decomposed influence on agents, customs brokers, forwarders and shipping companies. Agents have a strong decomposed forward linkage with forwarders.

Figure 4.1: Relations between the Antwerp port actors, based on decomposed backward linkage

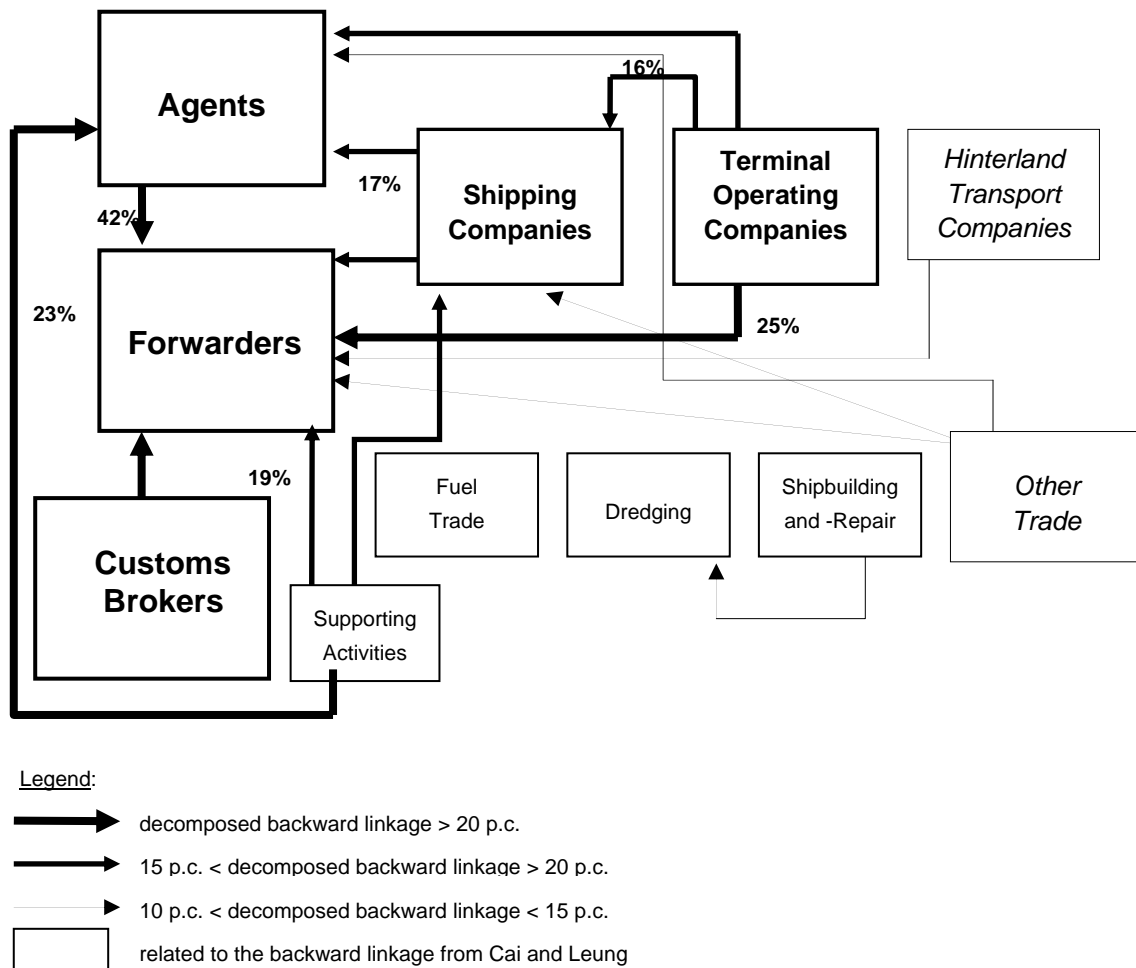
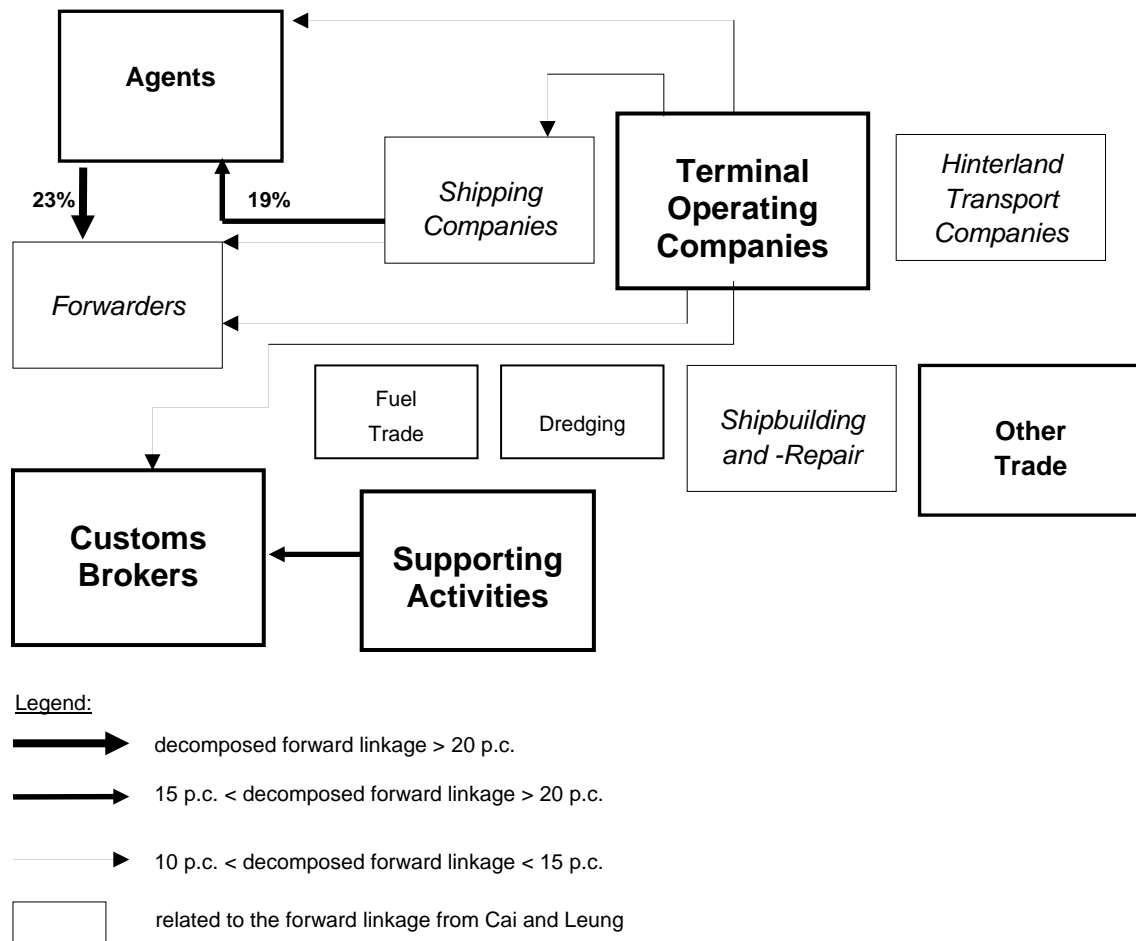


Figure 4.2: Relations between the Antwerp port actors, based on decomposed forward linkage



Antwerp forwarders constitute the first key sector among the port actors. Moreover, they have a strong backward linkage and as this linkage is decomposed, it can be seen that Antwerp agents, customs brokers, terminal operating companies and shipping companies are strongly depending on the forwarders. Therefore figure 2.1 (which shows the commodity flow) should be adapted to represent the adjusted relations based on financial flows between the Antwerp port actors.

Figure 4.3: Adjusted relations between port actors, commodity and financial flow point of view

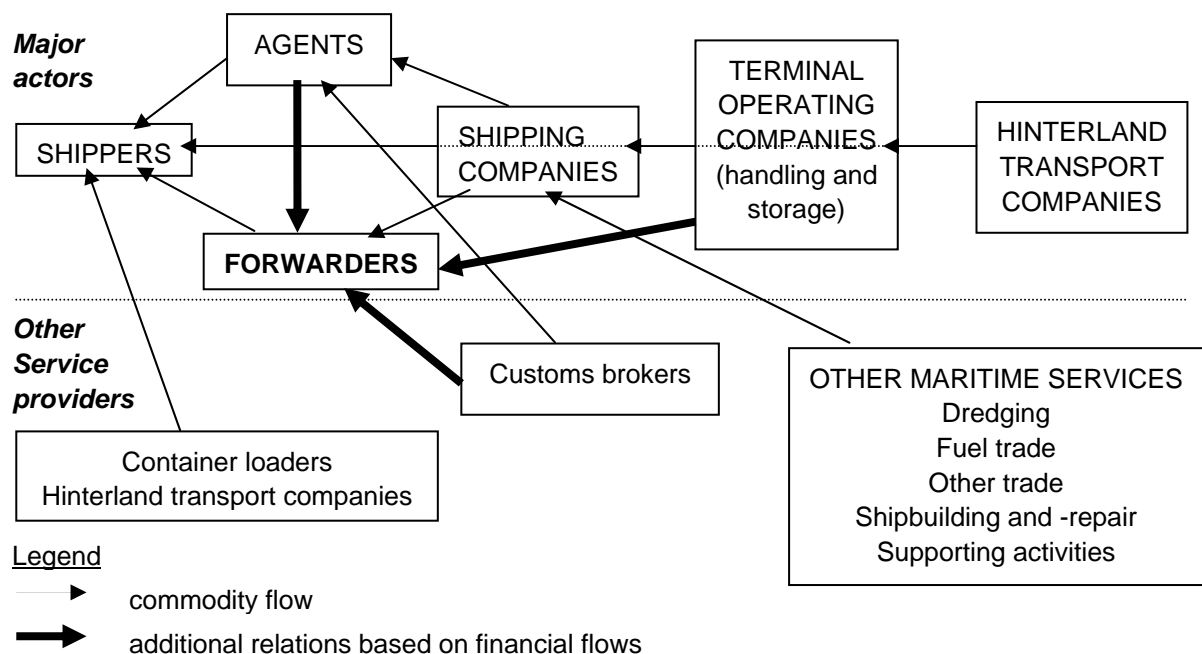


Figure 4.3 shows the relations between the Antwerp port actors from a commodity flow point of view (figure 2.1) and the adjusted additional relations on the basis of the financial data. The bold arrows denote the relation from a supplier to a customer. The figure clearly shows that forwarders are the most important customers of the port actors.

Various co-operation agreements between various port actors may explain relations between some predominant port actors. Heaver et al. (2000) sum up some possible agreements in table 4.1 below.

Table 4.1: Co-operation agreements between various market players

Market players	Shipping companies	Stevedores	Hinterland transport	Port authorities
Shipping companies	<ul style="list-style-type: none"> - vessel sharing agreements - joint ventures - conferences / cartel agreements - consortia - strategic alliances - mergers 			
Stevedores	<ul style="list-style-type: none"> - financial stake of shipping company in stevedore - joint ventures - dedicated terminals 	<ul style="list-style-type: none"> - participation in capital 		
Hinterland transport	<ul style="list-style-type: none"> - block trains and capacity sharing - alliances 	<ul style="list-style-type: none"> - joint ventures 	<ul style="list-style-type: none"> - takeover strategy of railway companies 	
Port authorities	<ul style="list-style-type: none"> - dedicated terminals 	<ul style="list-style-type: none"> - financial stakes port authorities 	<ul style="list-style-type: none"> - combined traffic terminals (Hamburg Hafenbahn, Rail Service Centra in Rotterdam) 	<ul style="list-style-type: none"> - alliances

Source: Heaver et al. (2000, p. 365), www.hafen-hamburg.de and www.portofrotterdam.com

Shipping companies, stevedores (terminal operating companies), hinterland transport companies and port authorities (subset of the supporting activities) are considered to be the predominant maritime market players. The strong co-operation between shipping companies in the Antwerp port perimeter is clear from our analysis of the technical coefficients. Almost 23 p.c. of its inputs are provided by shipping companies. Also the link between the terminal operating companies and the shipping companies can be found in Antwerp.

4.1.2. Relations of the Antwerp port actors with the rest of the economy

In this paragraph the relations of the Antwerp port actors with the rest of the Belgian economy are analysed, by external demand and external inputs, calculated by means of t_{ie} and r_{ie} .

It is important to check whether t and r are good indicators for the total external relations, because t and r only give the direct effects (direct in the sense of having effects on the first level of suppliers and customers). To check this, $G^{-1}.T$ and $L^{-1}.R$ have to be calculated. Only for a certain amount of sectors there is a difference between the total and the direct effects, i.e. there are some indirect effects.

Considering the most important customers and suppliers of the Antwerp port actors in the rest of the Belgian economy, a distinction was made between port actors outside the Antwerp port perimeter, non-port actors within the Antwerp port perimeter and non-port actors outside the Antwerp port perimeter.

Most customers (36 p.c.) of the Antwerp port actors are located outside the port perimeter and are no port actors. In this category the most important sectors are trade, other services and chemical industry. Second rank port actors inside the Antwerp port perimeter with 34 p.c. Fuel trade is the most important customer outside the port perimeter within the port actors especially for Antwerp fuel trade. The most important customers of Antwerp dredging within the port actors in the port perimeter are dredging with 99 p.c. Important customers in the port perimeter but no port actors are trade, oil industry and chemical industry.

Most suppliers of the Antwerp port actors are situated within the port perimeter and are port actors (46 p.c.). Hinterland transport companies are the most important customers outside the port perimeter within the port actors. But for Antwerp fuel trade the most important supplier is fuel trade and for

Antwerp dredging it is dredging. Considering the non-port actors in Antwerp, oil industry is the most important supplier with 55 p.c. It is more important within Antwerp than outside the port perimeter. Oil industry and other services are also important suppliers outside Antwerp.

The port of Antwerp is the second largest petrochemical complex in the world, next to Houston. These industrial companies are clustering in the port because of agglomeration advantages (Port of Antwerp, 2001), which explains the importance of the oil and chemical industry and fuel trade.

4.2. Geographical analysis

The relations between the Antwerp port actors and their customers and suppliers are shown in various figures. A principal component analysis (see appendix 6) has led to the conclusion that the geographical patterns for Belgium were similar for all Antwerp port actors, concerning their customers and suppliers. Therefore only the results for the customers and suppliers of the overall Antwerp port actors are presented.

A distinction has been made between the ten provinces of Belgium with the Brussels-Capital Region, the districts ('arrondissementen') in the province of Antwerp and the left and right bank of the Antwerp port perimeter (see figure 3.2).

The maps provide an absolute and a relative indication of the net value of purchases and sales from the Antwerp port actors. The absolute figure shows the net value of the total of customers (suppliers) of Antwerp port actors. The relative indication shows the ratio of the net value of that postcode and the net value of customers (suppliers) in Belgium as a whole.

4.2.1. Customers of Antwerp port actors

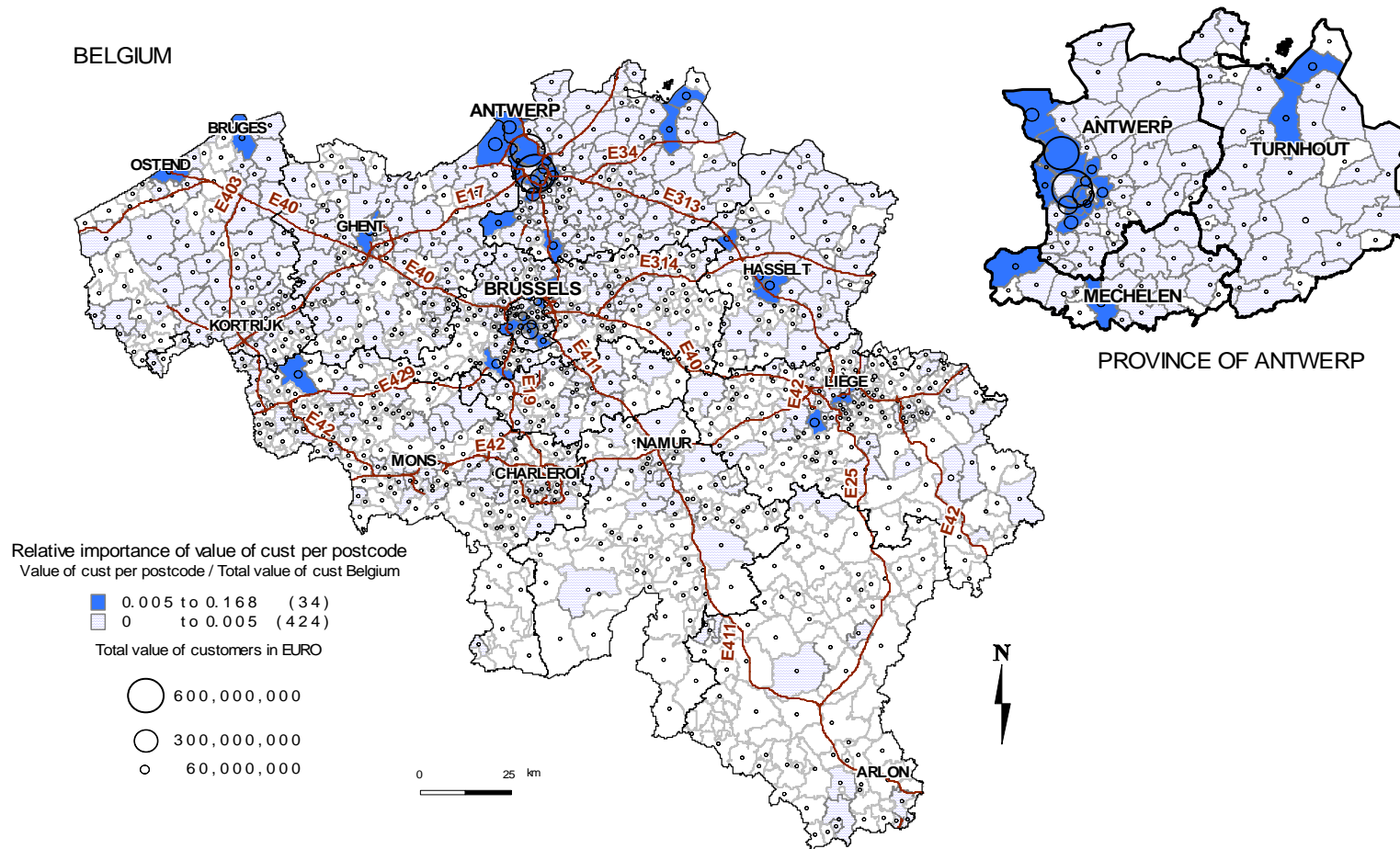
Figure 4.5 provides an indication of the location of the customers of overall Antwerp port actors.

This figure shows that, in absolute and in relative values, Antwerp and Brussels are the most important regions for the customers of the Antwerp port actors. Furthermore, relative important concentrations of customers in the other Belgian port areas are observed, such as Ghent, Zeebrugge, Liège and Ostend. Some other concentrations can be found in the rest of the province of Antwerp, especially in the district of Turnhout and in the province of Limburg. The latter two benefit from the excellent connections with the hinterland by motorways E34 and E313.

Motorway E313 and the canal between Antwerp and Liège (Albert Canal) are considered to be gateways, i.e. strategic places within an economic structure. The network 'Albert Canal' has a functional relation with the port of Antwerp and should be further developed (Provincie Antwerpen, 2001, p. 153-154).

Concerning the Antwerp port perimeter, most of the port actors' customers are located on the right bank of the river Scheldt (with NSI code 11002). But few are located on the left bank, only a small number of which in the province of Antwerp (with NSI code 11056: Zwijndrecht municipality).

Figure 4.5: Customers of overall Antwerp port actors in Belgium



Cartography: University of Antwerp - Department of Transport and Regional Economics
Source: National Bank of Belgium

4.2.2. Suppliers of Antwerp port actors

Figure 4.6 shows the location of the suppliers of overall Antwerp port actors.

The concentration of suppliers in Antwerp and particularly in the district of Antwerp is more dense than that of the customers: almost no suppliers are situated in Mechelen or Turnhout. Some suppliers are also situated in Eupen and Zeebrugge.

As we compare figure 4.5 with figure 4.6, we see that much more suppliers than customers are located in the province of Antwerp, and more customers than suppliers in the province of Limburg. Similar to the customers also the suppliers are mostly located on the right bank of the river Scheldt (with NSI code 11002). Suppliers situated on the left bank are for the main part located in the province of East-Flanders (with NSI code 46003).

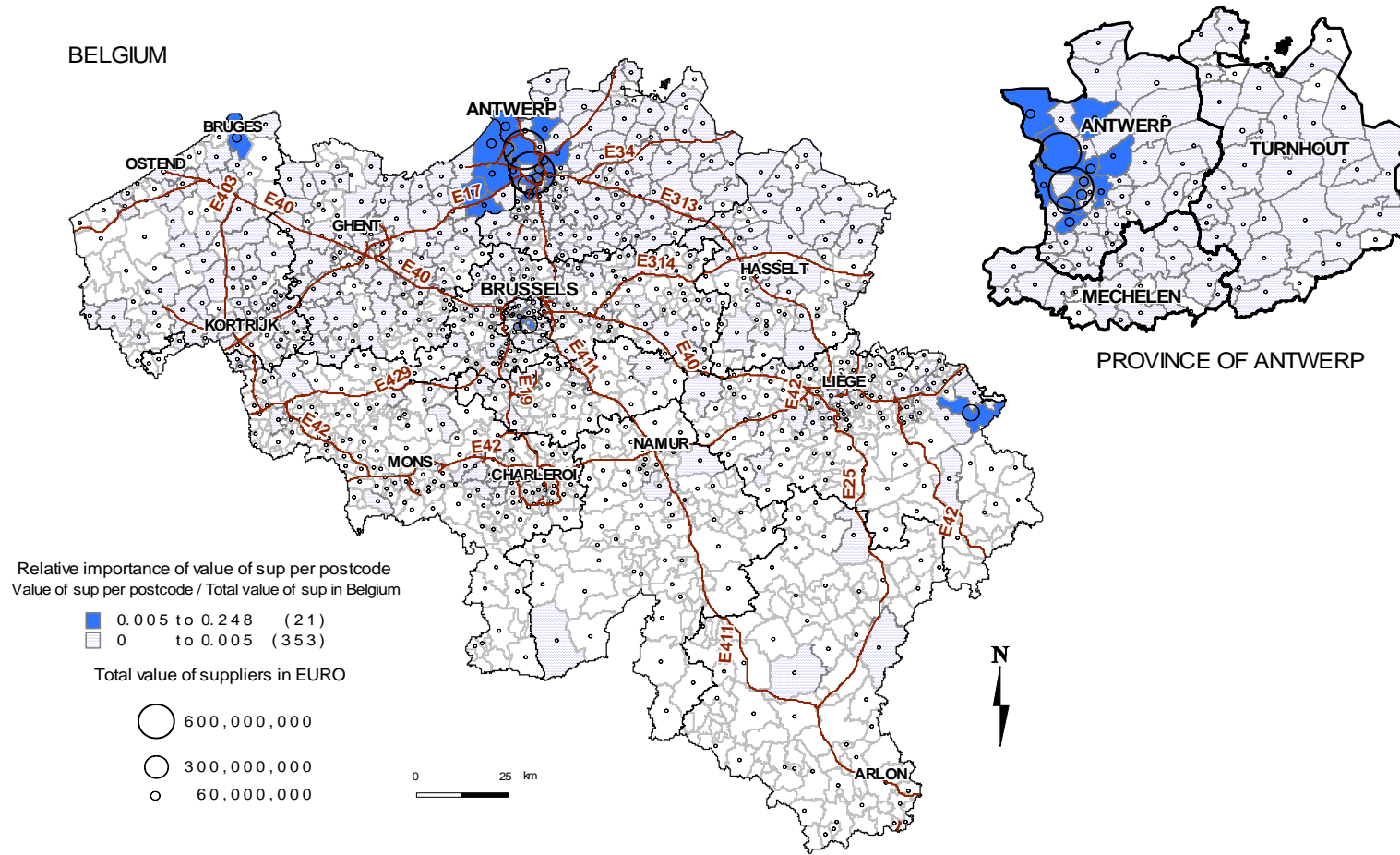
4.2.3. Geographical relations of the Antwerp port actors

Most of the Antwerp port actors' customers and suppliers are located in the province of Antwerp and the Brussels-Capital Region. Within the port perimeter, most of them are situated on the right bank of the river Scheldt. In its report for 2000, the National Bank concludes that the economic importance of the right bank of the river Scheldt is greater than that of the left bank. Two very important sectors, i.e. the oil industry and car manufacturing, for example, are located on the right bank (NBB, 2002).

This leads to the conclusion that agglomeration effects are important for the customers and suppliers of the Antwerp port actors, as they are mostly located in Antwerp. In his location theory from 1909, Weber already drew attention to agglomeration advantages. Agglomeration whereby the firm expands can generate lower costs by producing on a bigger scale. Furthermore, by agglomerating, the firm can also gain by sharing capital goods and services with other firms (Van de Voorde, Witlox, 1992, p. 259). This agglomeration of economic activity can also be seen as the concentration on a transshipment point location (2006), where economies of scale in transfer and terminal operations are observed. These locations are provided with specialised facilities for goods handling and storage.

Relating our results to the notion of accessibility, they confirm the topological and economic accessibility networks known in Belgium. As to the road infrastructure, Brussels and Antwerp are very accessible: by rail the north of Brussels and by inland waterways the triangle with the Eastern border corresponding to the Antwerp-Brussels axis is accessible. This corresponds to the locations of the majority of the customers and suppliers of the Antwerp port actors in Antwerp and Brussels. When this accessibility measure is weighted to take account of the importance of the economic activity, Thomas et al. (2003) conclude that economic activities are footloose and oriented towards international transport gates, such as the ports of Antwerp, Ghent, Zeebrugge and the airport of Brussels, which also corresponds to our findings.

Figure 4.6: Suppliers of overall Antwerp port actors in Belgium



Cartography: University of Antwerp - Department of Transport and Regional Economics
 Source: National Bank of Belgium

5. CONCLUSION

So far only a top-down aggregated approach has been used to describe the relations between the various port players and other sectors in Belgium. But by means of disaggregated data a more detailed analysis was possible. A first attempt to proceed with this new approach focused on Antwerp for the year 2000.

Before starting with the analysis, various firms had to be classified, as port actor or non-port actor (by means of the NACEBEL code) and as located within or outside the port perimeter (by means of postcodes). For the sectoral analysis a regional input-output table was created, indicating the relations among the port actors and also between the port actors and the rest of the economy. Various measures, such as technical coefficients, linkage measures and external inputs and demand were used to describe these relations. Next, the relations of the port actors with their customers and suppliers were analysed geographically. By geocoding different maps were drawn to indicate the locations of the most important customers and suppliers.

Forwarders play a key role among the Antwerp port actors. They are the most important customers of Antwerp port actors and have much influence on their suppliers, such as agents, customs brokers, shipping companies and terminal operating companies. Some of the relations between the different port actors can be explained by co-operation agreements, like dedicated terminals, strategic alliances and mergers. Outside the Antwerp port perimeter, some port actors remain important as customer or supplier to the Antwerp port actors. The fuel trade is an important customer and hinterland transport companies are the most important suppliers outside the Antwerp port area. The oil industry supplies mostly to the Antwerp port actors both inside and outside the port perimeter. Antwerp is considered to be "the Houston of Europe". Trade is a very important customer of the Antwerp port actors and acts as the shipper who delivers the goods that need to be transported.

Most customers and suppliers of the Antwerp port actors are located in the province of Antwerp, which confirms agglomeration effects on a transshipment point location. Moreover the two most important locations for customers and suppliers of the Antwerp port actors (Antwerp and the Brussels-Capital region) are best accessible by road, rail and inland waterway. Furthermore, Antwerp is considered to be an international transport gate, which attracts economic activity. But also the other port areas are quite important, mainly in view of the attraction they hold as international transport gates.

Most customers and suppliers within the Antwerp port area are located on the right bank of the river Scheldt, which is of greater economic importance than the left bank.

Policy makers ought to take these considerations into account, concerning the relative importance of the economic players within and outside the port area, in order to optimise the business and spatial planning of the port area and its hinterland. Important players such as forwarders and agents are very dependent on each other. Shipping companies and hinterland transport companies, heavy weights in the Antwerp port, are likewise bound to the agents. Moreover, the forwarders, customs brokers and agents have a considerable influence on their suppliers, while supporting activities, customs brokers and terminal operating companies have much influence on their customers. The geographical analysis has shown the agglomerating effect to have a great importance. Therefore more territory is needed close to the port area. This also counts for other international transport gates, such as the other port areas Ghent, Zeebrugge and Liège or for the international airport of Brussels. The Albert Canal network, along with the E313 motorway, forms a link between the Antwerp port area and other sectors in Hasselt and Liège and therefore needs to be further developed. Within the port perimeter it can be seen that, in 2000, the right bank of the river Scheldt attracted more customers and suppliers than the left bank. With the construction of the Deurganck and Saeftinghe docks, the distribution of the economic activity might become more balanced between the two banks.

The methodology described in this paper can be applied to other ports as well as to other important transport sectors, such as airports. Furthermore, the methodology can be extended to calculate the relations with foreign countries.

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- www.hafen-hamburg.de
- www.portofrotterdam.com

APPENDIX

Port actor	Codes	NACEBEL	Activity
Agents	AGEN	63.402 63.403	chartering ships' agencies
Customs brokers	CUST	63.404	customs agencies
Forwarders	FORW	63.401 63.405	forwarding offices transport mediation
Hinterland transport companies	HTC	60.100 60.230 60.241 60.242 60.300 61.200 63.406 64.120 71.210	transport via railways other land passenger transport furniture removal by road freight transport by road transport via pipelines inland water transport other activities of transport agencies courier-activities other than national post activities renting of other land transport equipment
Other maritime services			
Shipbuilding- and repair	OMS OMS-SHIP	35.110 35.120	building and repairing of ships building and repairing of pleasure and sporting boats
Dredging	OMS-BAG	45.241 45.242	dredging other construction of water projects
Fuel trade	OMS-COFU	51.120 51.510	agents involved in the sale of fuels, ores, metals and industrial chemicals wholesale of solid, liquid, gaseous fuels and related products
Other trade	OMS-CO	51.700	other wholesale
Supporting activities	OMS-SUP	63.220 90.002 90.003	other supporting water transport activities collection and processing of household refuse collection and processing of agricultural and industrial refuse
Shipping companies	SHIP	61.100 71.220	sea and coastal water transport renting of water transport equipment
Terminal operating companies	TOC	63.111 63.112 63.122	cargo handling in seaports other cargo handling other storage and warehousing