EXPLORING THE LINK BETWEEN PORT THROUGHPUT AND ECONOMIC ACTIVITY: SOME COMMENTS ON SPACE- AND TIME-RELATED ISSUES

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Abstract

The link between economic activity and (freight) transport is a classic issue in regional science. A subtopic is the impact of economic activity on the demand for maritime transport through ports. Understanding this relationship contributes to a better understanding of the dynamics of port throughput, which is important for infrastructure planning and other strategic decisions. This paper focuses on the port of Antwerp (Belgium) and explores the link between port throughput and GDP. An exploratory analysis reveals that not only the GDP of Belgium matters, but also that of neighbouring countries. Furthermore, different results are obtained for different commodity groups, and the most appropriate time-lag is not the same for each country. On the basis of these findings, we formulate some recommendations for port throughput models.

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1 Introduction

Given the high costs and long-term character of investments in transport infrastructure, policy makers need forecasts of (freight) transport to decide on infrastructure projects. It is common practice to use trend and time series models to predict freight transport flows. Besides pure time-related parameters, models often contain indicators for economic growth (e.g. GDP) to improve the estimates of future transport flows (Port of Rotterdam, 1998; de Jong et al., 2004). Also the aim of the European Commission to decouple the growth of transport from economic growth, encourages researchers to investigate the relation between GDP and transport (EEA, 2006; Kveiborg and Fosgerau, 2007). Among others Meersman and Van de Voorde (2008) utilize a time series approach to research the relation between GDP and the growth of freight transport for a sample of European countries. At the port level, Janssens et al. (2003) employ the import and export of the Belgian Luxemburg Economic Union (BLEU) to estimate the volume of goods unloaded and loaded in the port of Antwerp between 1951 and 1990. In the present paper, we focus on the throughput in the port of Antwerp and elaborate on the geographical area of which economic indicators are used.

1.1 The GDP of Belgium and its neighbours

To predict throughput in the port of Antwerp, it seems logical to use the GDP of Belgium as economic indicator, since the port is located in this country. However, the port area borders the Netherlands, and the port hinterland extends over several countries like Germany, France and Luxemburg. Therefore, we also explore the relationship between the GDP of other countries than Belgium, especially since it is a rather small country, and internal boundaries in Europe has become less important.

We focus on the GDP of Belgium and its closest neighbours, Luxemburg, the Netherlands, Germany, and France. The first question is whether the evolution of these GDP figures differs between countries. The correlation between the raw GDP figures (before any filtering, quarterly OECD data, Q1-1995 to Q3-2009) of Belgium and its neighbours comes close to one, since these time series are not stationary (Vandaele, 1983). In other words, whether you apply the GDP of Belgium, or that of one of its neighbours, does seemingly not have a significant impact on your results. However, when taking into account the growth of GDP, correlations fall to values of around 0.7, and even to 0.3 for Luxemburg. The correlation rises to 0.8 (0.5 for Luxemburg) when applying a moving average (($t_a + t_{a-1}$)/2). Although GDP figures of neighbouring countries are correlated, the differences seem large enough to further explore the impact of economic indicators of other countries in transport models. Note that the relative low correlation between the GDP of Luxemburg and that of Belgium can partly be explained by the variance in the time series, which is 2.0 for Luxemburg, and between 0.2 and 0.5 for the other countries (GDP growth data with moving average).

1.2 The link between GDP and port throughput

In the previous section, we argued that it can be useful to take into account the GDP of other countries to predict port throughput. To test this hypothesis, Table 1 shows the correlation between the growth of total throughput in the port of Antwerp, and the growth of the GDP of the aforementioned countries. Interestingly, the relation between port throughput and the GDP of neighbouring countries, is generally stronger than, or equal to, that between throughput and the GDP of the country where the port is located, i.e. Belgium. In short, it seems that you better can use GDP figures of France or Germany to model the throughput of a Belgian port, instead of the GDP of Belgium itself. Note that we restrict ourselves to an analysis of the data up till 2007Q4 to avoid the effect of the crisis.

Table 1 correlation between total port throughput in the port of Antwerp and the GDP of 5 countries

	1995Q3–2009Q3	1995Q3–2007Q4
Belgium	0.40	0.07
Luxemburg	0.30	0.14
The Netherlands	0.44	-0.02
France	0.45	0.30
Germany	0.40	0.10

Data sources: GDP data: OECD, seasonally adjusted quarterly data, GDP quarterly growth (%), moving average, constant prices; Port data: Antwerp Port Authority, quarterly data, growth of total port throughput, seasonality removed, moving average

Several questions pop up when looking at Table 1. First, there must be an explanation why port throughput reflects better the economic growth of neighbouring countries, than that of the home country (Section 2). Second, the total throughput encompasses a heterogeneous group of commodities, and contains both import and export figures. The question is whether these correlations hold for all types of commodities, or that a particular group of commodities causes the counterintuitive result (Section 3). The third question is what the implications are for a model (Section 4).

2 Why are neighbouring countries more important than the home country?

Table 1 shows that the correlation between the GDP of countries like France and Germany, and the throughput in the port of Antwerp, is higher than that between throughput and the GDP of Belgium. Here, we discuss some reasons why this should be the case. First, we may not overestimate the differences between the GDPs of neighbouring countries, by focusing on the growth figures. A difference in economic growth of 0.5% does not imply that two economies evolve in a completely different direction. In Table 1, however, such differences have an impact on the results.

Second, the economies of the six countries are strongly interconnected. It are no closed economies with ports of which the hinterland coincides with the country. Increasingly regional (or global) supply chains go along with more trade, especially in ‘middle’ goods. Since value is created at different stages in the supply chain at different locations, the link between what is moved through a port and the impact on the economy is complex (Robinson, 2002; Goldfarb and Beckman, 2007; Goldfarb and Thériault, 2008).

Third, we already mentioned the differences between absolute and relative GDP figures. In gravity models of bilateral trade, it is of crucial importance to use absolute figures instead of relative figures, since it is the size of the economy that matters, and not the GDP per capita (Johnston et al., 2003). The structure of gravity models helps us to understand why larger foreign economies can have a larger impact. In general, gravity models analyse the trade between two countries on the basis of two factors, the size of the countries (often measured in terms of GDP) and the distance between them. In summary, trade levels decrease with distance, and the larger the economies, the more trade between them. As a consequence, if the distance between the port and a large neighbouring economy is reasonably small, that economy may impact the throughput more than the relative small economy of the home country.

Fourth, economic development in neighbouring countries can be more important if the domestic (captive) market is relative stable, and growth depends on evolutions in more distant markets.

3 Data exploration

To explore the relation between on the one hand, the GDP of Belgium and its neighbours, and on the other, the port throughput in the port of Antwerp, we set up a simple regression model. Equation (1) estimates the tons unloaded in the port on the basis of GDP ($R^2 = 0.15$). Given the high variance of the GDP of Luxemburg, we add this figure to that of Belgium (BELUX), as is commonly done by researchers (e.g. Redding and Venables, 2004). Note that a time lag of one quarter is used, since we assume that there is some time needed to translate economic growth in the placement of orders, and to ship goods from e.g. Asia to Antwerp. However, some commodities precede economic growth; as a result, this assumption does not necessarily hold for all types of commodities.

$$UNLOAD = -0.003 + 0.77\, GDP_{Q-1,BELUX} - 0.97\, GDP_{Q-1,NED} + 0.12\, GDP_{Q-1,FRA} + 0.15\, GDP_{Q-1,GER} \quad (1)$$

We already mentioned the potential multicollinearity between the GDP figures of different countries. The correlations are given in Table 2. First, these correlations are below 0.8 which is used as a rule of thumb to indicate whether multicollinearity is a serious problem (Gujarati, 2004, p.359). Second, '*if the sole purpose of regression analysis is prediction or forecasting, then multicollinearity is not a serious problem because the higher the R^2, the better the prediction*' (Gujarati, 2004, p.369). Although our final aim is forecasting, we look in this exploratory exercise at the estimates for the different countries. Therefore, we report the correlations in Table 2 to make sure that multicollinearity is not a serious problem (although present).

Table 2: correlation between the GDP of the countries used in the analysis

	BELUX	NED	FRA
NED	0.60		
FRA	0.61	0.62	
GER	0.44	0.72	0.57

GDP: quarterly OECD data (1995Q3-2007Q3), first differences, moving average

The negative relation between the Dutch GDP and the tons unloaded, probably corrects for an overestimation of the other three GDP-variables. Indeed, it is unlikely that there is a strong negative effect between economic growth in the Netherlands, and throughput in the nearby port of Antwerp. Nevertheless, Table 2 indicates that the correlation between the two is negative, but weak. We will here not elaborate on the reasons behind this negative relationship, but add to equation (1) the constraint that estimates cannot be negative. This constraint results in a serious drop of the R^2 (from 0.15 to 0.06). Predictive power can thus come into conflict with the rationale why a variable was chosen.

3.1 Commodity groups

To explore the relation between throughput and GDP, we calculate the correlations between the GDP of the four aforementioned countries, and the throughput of different commodity types. Goods loaded and unloaded are separated since imbalances between the two exist. The correlations are measured for each GDP series separately, to avoid uncontrollable interactions due to multicollinearity or other reasons. The example in the previous section indicates that this can be the case. We take the first differences of the GDP series and apply a moving average of one time period (quarter). Furthermore, the correlation between the GDP of one quarter before (t-1) and one quarter after (t+1) is measured, besides the correlation between the GDP and the port throughput of the same quarter (t). Note that the moving average already causes an overlap between the measures of one quarter earlier. Port throughput is measured in tons, except for the category *containers*, which is measured in TEU (Twenty feet Equivalent Unit). Three sets of port throughput data are used, (1) first differences, (2) first differences and a moving average of one quarter, and (3) seasonal differences. This resulted in a total of 864 correlations (12 (commodity groups) x 2 (inward and outward) x 4 (countries) x 3 (time lags) x 3 (first differences; first diff. + moving average; seasonal differences).

Table 3 summarises the results of this exploratory analysis. The first column gives the NSTR commodity category. We add containers and the total throughput to the 10 basic commodity categories. Note that goods shipped in containers are not classified in NSTR-codes. The next three columns indicate whether the highest correlation was found between throughput and the GDP of the same quarter, or that of one quarter before or after. Next, the order of magnitude of the highest correlation is given per country. Finally, the last column indicates whether strong seasonal effects are present.

Table 3: Relationship between port throughput in the port of Antwerp and the GDP of four countries

Inward Bound (UNLOAD)

commodity group	t-1	t	t+1	BELUX	NED	FRA	GER	seasonality
Agricultural products and live animals (0)	x			++	+++	+++	++	x
Foodstuffs and animal fodder (1)	x			++	+	+	+	
Solid mineral fuels (2)	x			.	.	+	++	(x)
Crude oil and oil products (3)	x			+	+	++	++	
Ores and metal waste (4)	x			++	++	+++++	+++	x
Metal products (5)	x		N	+++	+++	++++	+++	
Crude and manufactured minerals, building materials (6)	F		N,G	.	++	+	+	
Fertilizers (7)	x			+++	.	+++	++	x
Chemicals (8)	B			+	+	.	+	
Vehicles and machinery (9)				+++	++	+++	++	x
Containers (TEU)	x	x		+++	++	+++	+++	x
Total	x			+++	++	++++	++++	

Table 3 (continued): Relationship between port throughput in the port of Antwerp and the GDP of four countries

Outward Bound (LOAD)

commodity group	t-1	t	t+1	BELUX	NED	FRA	GER	seasonality
Agricultural products and live animals (0)	B		F, G	+++++	+++	+++++	+++	x
Foodstuffs and animal fodder (1)	x			+	+	+++	++	x
Solid mineral fuels (2)	G	G	x	+++	+	.	+++	(x)
Crude oil and oil products (3)	B	N	G	+	+++	++	++	(x)
Ores and metal waste (4)	B,G	G,N	F	++	+	+	+++	(x)
Metal products (5)		G	G	.	+	.	+++	
Crude and manufactured minerals, building materials (6)	B	B	F	+	.	+	-	
Fertilizers (7)			x	+++	+	++	+	x
Chemicals (8)	B,N	F,G		++++	++	+++++	++++	(x)
Vehicles and machinery (9)	x			+	+	+	++	(x)
Containers (TEU)	B,G	x	F	+++	+	+++	++	x
Total	B	x	F,G	++	++	+++	+++	x

correlations: . : 0.0<0.1; +: 0.1<0.2; ++: 0.2<0.3; +++: 0.3<0.4; ++++: 0.4<0.5; +++++: 0.5<0.6;
-: negative correlation.
B (BELUX): Belgium + Luxemburg; F (FRA): France; N (NED): the Netherlands; G (GER): Germany
Quarterly data: 1995Q4-2007Q4.

4 Discussion

The exploratory analysis confirms that for several commodity groups, the economy of neighbouring countries has a larger impact on the throughput in the port of Antwerp, than the Belgian economy. Table 3 also indicates which commodity groups are connected with economic trends. Furthermore, the table reveals different time-related effects for different countries, especially in the case of outward bound transport. In general, throughput is influenced by the economic situation in Belgium of one quarter earlier, while it coincides with (or precedes) the economy of the neighbouring countries. In short, when linking economic growth to an increase in transport, one must take into account the economy of neighbouring countries, different time-lags, and differences between commodity groups.

4.1 Transport models

To end, we introduce the classical transport model and the freight model of the Port of Rotterdam, and discuss how such models need to take into account our results. The classical four-stage transport model (de Jong et al., 2004; Blauwens et al., 2008) starts with the *trip generation* phase. Trip generation relates to economic production and consumption, and since transport can be considered as derived demand, economic growth will result in transport growth. This stage thus uses forecasts of economic growth as input. In the next stage, t*rip distribution*, the flows between the different centres of production and consumption are estimated. The aforementioned gravity models are the most common approach to estimate international bilateral trade. The *conversion* of this trade in traffic flows (number of trips, vessel size,…) and the determination of the mode used (seaborne traffic or not), is the third stage. Finally, these trips are *assign*ed to transport infrastructure (including ports). Logically, port choice (port selection) is a crucial issue when modelling port throughput (Leachman, 2008; Wiegmans et al., 2008; Tongzon, 2009).

The Port of Rotterdam Authority developed in the 1990s a freight flow model which contains the major steps of the classical transport model. The seventh version of this model (Goederenstromenmodel 7; Port of Rotterdam, 1998), starts with macro-economic scenarios of the Centraal Planbureau (Netherlands Bureau for Economic Policy Analysis), which contain forecasts of the development of industrial sectors. The second stage transposes the development of different sectors in import and export figures, per commodity group and per country. The third step defines the share of maritime transport in these import and export figures. The fourth step is called regionalisation. This encompasses that for some countries (the Netherlands and Germany), differences in growth between regions are taken into account. The share of the port of Rotterdam in maritime import and export is determined in the fifth stage, while the subdivision in containers, ro-ro, other general cargo, dry bulk and wet bulk is a sixth step. Finally, the modal split of the hinterland transport is modelled.

4.2 Lessons

In what follows, we discuss on the basis of the exploratory analysis and the aforementioned transport models, which factors need to be taken into account when modelling port throughput. First, it is clear that (maritime) trade flows need to be taken into account. Since goods from and towards neighbouring countries can be shipped via the port of Antwerp, insight in trade patterns is necessary. However, trade data are based on Customs data, while ports report the real movement of goods. For different reasons, some moves are reported by ports, but not by Customs. Indeed, some goods categories are excluded from trade statistics, like military goods, goods under operational lease, and waste having no positive value (United Nations, 1998; 2004; United Nations Statistics Division, 2010). Furthermore, a significant amount of traffic is transported via Belgium to a neighbouring country. If these traffic flows are reported by that country, they are absent in Belgian Customs data. Finally, goods transported in containers are not categorised in commodity groups by port authorities, while Customs report trade irrespective of transport mode or appearance.

Second, other economic indicators than GDP can be applied (on the limitations of GDP, see Stiglitz et al., 2009). Therefore, indicators on e.g. business and consumer confidence and measures for e.g. the construction sector, must be considered. Furthermore, indicators at a level below that of the country (e.g. NUTS 2) can reveal which parts of a country best explain evolutions in port throughput (e.g. the industrial Ruhr area in Germany). Distance decay functions can then measure effects at this disaggregate level.

Besides the spatial resolution, also the temporal resolution matters. What will be the result if we employ monthly or yearly data, instead of quarterly data? Will the time-lag with most predictive power increase with increasing distance? Finally, the impact of other ports, in the first place Rotterdam, must be taken into account. Probably, the negative relationship between the Dutch economy and throughput in the port of Antwerp, is influenced by the position of the port of Rotterdam. These two ports are ranked in the European ports top 3, and the distance between them is less than 100km.

5 Conclusion

It is common practice to employ GDP data of a country to model trade or port throughput. However, an exploratory analysis reveals that the GDP of neighbouring countries can predict port throughput better than the economy of the country where the port is located. Furthermore, time-lags between economic and transport growth seem to be different for different countries and different commodity groups. Starting from these observations, we discuss which factors should be taken into account when modelling port throughput.

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