Forecasting Container Throughput:  
A Method and Implications for Port Planning 

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This paper analyses the determinants of transport demand for maritime container transport. Such an analysis is relevant, among others for port planning, since port expansion plans are based on forecasts. Inevitably, different opinions about the future development of (container) transport flows exist, and decision-makers are confronted with uncertainty. This paper analyses the variables of container transport demand. Seven variables are identified, four related to the overall volume of trade and international transport flows (the GDP, export quote of economies, the direction of trade and the value density of trade) and three related to the containerised proportion of transport flows (the containerisable share of transport flows, the containerisation rate and the share of shipping in international trade). The rise of containerised transport flows from 1980 to 1995 is based on different ‘underlying factors’. The future development of the variables is highly uncertain, and a ‘extrapolation’ of the high growth rates of the past, is not likely to lead to a good forecast for the future. Thus, decision-makers confronted with the uncertainty about future trade flows, should try to maximise flexibility in port planning.

I. INTRODUCTION 

This paper analyses the determinants of transport demand for maritime container transport. Such an analysis is relevant, among others for port planning. A continued increase in container traffic is widely expected and ports anticipate this increase by planning port expansion. Port expansion is time consuming, the planning phase generally takes years, and construction can take years as well. For this reason, port expansion plans are based on forecasts. Inevitably, different opinions about the future development of (container) transport flows exist, and decision-makers are confronted with uncertainty. 

This paper analyses the variables of container transport demand. In section two seven variables are identified. Section three explains the economic relevance of each of these seven variables. Section four analyses the influence of each of the variables on the rise of containerised transport flows from 1980 to 1995. Section five discusses the future development of the variables and develops two scenarios for the trade between Europe and the Far East. 

Section six, concludes this paper by presenting the implications for decision-makers confronted with the uncertainty about future trade flows.

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Determinants of maritime container transport flows

The last three decades containerised trade flows have risen rapidly. The global maritime container market has grown faster than most forecasts expected (see for instance RMPM 1998 en Ocean shipping consultants 1998). The container carrying capacity in 1994 was twenty times as much as in 1970 (OECD 1997), an annual growth rate of over 13%. This section analyses what explains this tremendous growth.

Two different types of variables can be distinguished: variables that influence the size of trade flows between countries and variables that influence the proportion of trade transported in containers (see ocean shipping consultants, 1998 and RMPM, 1998). In general, the container volume on the trade between country $I$ and $J$ ($CT_{ij}$) is the containerised proportion of the trade ($\partial_{ij}$) multiplied by the total trade flow between those countries in volume $^1$ (TT$_{ij}$).

$$CT_{ij} = \partial_{ij} \times TT_{ij}.$$

The total trade in volume (TT$_{ij}$) between two countries is determined by:
- The size of the exporting economy ($GDP_i$),
- The openness of this economy ($E_i$),
- The importance of the importing country as trade partner ($DT_{ij}$). The symbol $DT_{ij}$ is chosen as it indicates the direction of trade of country $I$, in this case to country $J$.
- The value density of the trade between country $I$ and country $J$ ($VD_{ij}$).

This can be written as:

$$TT_{ij} = (E_i \times GDP_i \times DT_{ij}) / VD_{ij}.$$

Where;
- $E_i = TT_i / GDP_i$ (The exportquote of country i)
- $DT_{ij} = TT_i / TT_j$ (The share of the trade of country I to country J of the total trade)
- $VD_{ij} = TT_{ij} (val) / TT_{ij} (vol)$ (The value of trade divided by de volume of trade)

The four variables $E_i$, $GDP_i$, $DT_{ij}$, and $VD_{ij}$ can be used to calculate the total volume of trade between two countries.

The containerised share of transport flows is determined by the variables
- Composition of trade, ($\partial_{ij}$) indicating the percentage of trade is containerisable. This percentage can be calculated by dividing the containerisable share of trade ($CS$) by total trade (TT$_{ij}$)
- The competitive position of sea transport ($\partial_{ij}$). This variable can be calculated by taking the share of containerisable trade shipped by sea as a percentage of total containerisable trade ($CS$).
- The containerisation rate ($\partial_{ij}$) that can be calculated by dividing container transport volumes by the total seagoing containerisable transport flows.

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$^1$ This formula might at first sight suggest that the container volume does not depend on the price of transport. This is not the case, because the development of TT$_{ij}$ depends, amongst others, on the price of transport. In the following analysis, the price of transport is not mentioned, but it does have an indirect effect.
This can be written as follows:

\[
(3) \quad \delta_y = \delta_{y1} \neq \delta_{y2} \neq \delta_{y3}
\]

We have split up the two variables 'containerised share of transport' and 'total trade' is seven variables. These seven variables determine the future growth of the container volumes in a direct manner: a 5% rise of one of the seven variables, ceteris paribus, leads to a 5% increase in the container throughput.

This model deals with forecasts between countries (or also possible, between continents or trade zones) and does not deal with a distribution of transport flows over different ports. Portmarket forces determine the distribution of cargo flows over different competing ports, this depends on factors such as geography and port competitiveness. A specific 'module' for such an analysis is needed (see for the layout of such a module Meersman and van de Voorde 1998).

**Fluctuations of the seven variables between 1980 and 1995**

This section analyses the development of the seven variables in the past for the period 1970-1995, at a global scale. The global scale is chosen as the most reliable statistics are available at this scale. The statistics itself are not given, just the results of the calculations. We have to note however, that some of the statistics used, especially the value density and the containerisation rate, are not very reliable. On the basis of collected statistics, we calculated the changing values of the sources of containerisation in three five-year periods between 1980 and 1995. These calculations are compared with real developments in container volumes, in figure 1. This figure shows that this model has a reasonable explanatory power even though some of the statistics used are not reliable.

\[\text{2} \quad \text{Other factors, such as the price of transport, are relevant as well, but the influence of these factors is reflected in the change of one or more of the seven variables. In the case of the price of transport, the variables that are influenced most by changes in this price are the exportquote and the composition of trade.} \]

\[\text{3} \quad \text{In fact, the predictive power depends on the quality of the statistics, not on the quality of the model. The model simply identifies a method to calculate the container throughput. The variables are defined in such a way that the model itself cannot be wrong. The variables 'value density' and 'containerisation rate' seem the most unreliable ones.} \]
The calculation of the trade flows on the basis of available data for the seven variables matches the container transport figures relatively well. The model can be used to analyse the contribution of each of the seven variables to the total container transport growth. Figure 2 shows the sources of containerisation in three periods. Between 1980 and 1985 container throughput grew to about 1.6 its original size, a growth rate of about 9.5% per year and between 1985 and 1990 the total growth was about 45%, about 8.5% per year.

Between 1990 and 1995, the container throughput grew to about 1.8 times its initial size, a growth rate of about 11% per annum. However, the sources of containerisation in these two periods were largely different, as can be seen in the figures.
Between 1980 and 1985, the largest source of container throughput growth was the increasing containerisation rate. The strongly rising value density limited container growth. Furthermore, the opening up of the world economy and the rise in GDP led to growing container transport.

Between 1985 and 1990, the container growth was caused more evenly by six factors, the most important ones being GDP growth, the still rising containerisation rate, the rising share of containerisable trade and the changing direction of trade. The value density had a small negative influence. These figures show that the underlying factors explaining container growth have changed considerably. For container forecasts it is necessary to acknowledge these underlying factors, simple extrapolations are bound to be wrong at some moment in time.
II. PROSPECTS FOR THE FUTURE

The Rotterdam Municipal Port Management (RMPM) has build an extensive model for forecasting the throughput in Rotterdam (RMPM 1998). The general framework is as follows: first the macro economic prospects are calculated, based on two different scenarios for the development of the GDP. Second, these prospects are translated into flows of goods.

Third, for these good flows, the share of maritime transport flows is given and fourth, the share of the port of Rotterdam for each of these maritime good flows is forecasted. Finally, these good flows are translated into flows in means of transport. The RMPM model, deals with specific ports and also has modules that deal with the distribution of container flows over ports and a module that translates cargo flows to flows for specific transport modes. The RMPM model is more sophisticated and more detailed than the model presented in this paper, but essentially the same structure.

OSC basically use two parameters for their forecasts: the relation between GDP growth and trade growth and the relation between trade growth and container growth (just as formula 1 in our model). Both are analysed as elasticities (for instance 1% GDP growth leads to 1.5% trade growth) and explicitly based on observed patterns in the past. The forecasts of OCS do not use any scenarios.

Both the two discussed forecasts, just as Teurelincx et al (1996) who made a forecast for the port of Antwerp claim to be able to forecast the number of containers that result from a given GDP growth. If scenarios are used, these are used for GDP growth and competitive position, not for the size of trade resulting from GDP growth. The discussed forecasts are to a large extent extrapolations (see Meersman and van de Voorde, 1998). Such forecasts cannot incorporate changes in the underlying variables of trade and container transport. Extrapolated forecasts are bound to be wrong, the relevant question is: how wrong? In the next section, each of the seven variables is discussed and scenarios for the future are developed.

Qualitative scenario's for the seven variables

In this section, uncertainties for the seven variables are discussed. We focus on the uncertainties related to patterns of trade and production, because these uncertainties are large, especially in the long run, and because these uncertainties are not widely acknowledged in the port and transport industry.

GDP-growth fluctuates in the short run, but can be predicted relatively accurately in the medium long run. Forecasts that do take scenarios for GDP growth into account, at least in Europe, usually vary between 1% growth (the low growth scenario) and 3% growth. Over the last decade, the global economy has become more open, partly because of GATT-agreements. The increasing efficiency of transport has also contributed to the process of opening up of national economies. The trend of opening up is obviously temporary.

The scenario's of the RMPM deal with GDP even though this variable is more predictable than other factors.
The uncertainty with regard to this variable is relatively large. Ruigrok and van Tulder (1993) show that world trade fluctuates quite volatile over larger periods. The large rise of international trade from the 1950’s onwards is closely related to the rise of Fordist production pattern, based on economies of scale. Such economies of scale lead to global production chains where parts of the production chain are performed at a location where the factor costs are the lowest. In this ‘production regime’ labour intensive activities were relocated to countries where the labour costs were low, such as the NIC’s. New ‘low wage countries’ such as Mexico and Eastern Europe nowadays attract a lot of ‘Fordist production activities’. According to some economists, a new ‘production regime’ is gradually replacing Fordism. This regime is known as Post-Fordism (See Amin 1994). Post-Fordism is a regime where not scale but scope is centre stage. Scope driven production chains are more local and less globally dispersed. A Post-Fordist ‘production regime’ would slow down the growth of international trade. Over the last decades, growth in international trade was more than twice the growth of GDP, but scenarios for the future should not rule out the possibility that the growth of trade will be less than the growth of the GDP.

The direction of trade indicates the relative weight of a country as a trade partner. The direction of trade is not stable over time. For instance, most European countries have witnessed an increasing importance of trade partners from Asia. The reduction of maritime transport costs has contributed to the rise of intercontinental trade. A change of direction of trade influences the demand for maritime container transport. Changes in the direction of trade are relatively uncertain. Trans-National Companies (TNC’s), use rival restructuring strategies (Ruigrok and van Tulder 1993). These TNC’s are very important in international trade. About 40% of the transport volume between continents is intra-company transport. Thus, strategies of TNC’s have a large influence on transport flows. Two important rival strategies are globalisation versus glocalisation. Globalisation favours an intercontinental direction of trade, while glocalisation would result in a more intracontinental direction of trade. This obviously influences maritime trade volumes.

The value density reflects changes in the value/volume ratio. The value density increased due to more sophisticated production and the miniaturisation of components. Furthermore, the rise of trade in intangible goods, such as banking services, leads to an increasing value density of trade. The value density rose sharply in the 1980s and has declined since. It is quite uncertain how this variable will develop in the future. For a number of reasons, such as miniaturisation of products, more non-tangible trade and rising sophistication of products, a further increase in the value density is a realistic scenario. A rising value density would, ceteris paribus, limit container growth.

Whether or not trade is containerised is determined first of all by the characteristics of the goods carried. Most bulk commodities, such as oil, iron ore and grain, are not transported in containers. The share of containerisable goods in trade is not constant. As countries advance from exporting raw resources to exporting (semi-) manufactures, the containerisable share of trade, generally speaking, increases. Furthermore, the share of containerisable cargo rises because products that were once considered to be non-containerisable are containerised.
For instance, fresh fruits were once considered as non-containerisable, but nowadays increasingly transported in containers. Over the last decades, the containerisable share of trade has increased. A further increase is widely expected (see OSC 1997 and RMPM 1998).

The competition between modes influences maritime container volumes. On the intercontinental trade, currently only air cargo has a small market share (3–4% on the Atlantic, De Langen 1999) the vast majority is transported by sea. Some observers claim that air transport is likely to gain market share from sea transport (Containerisation International 1997), others expect a increased use of rail, for instance between Asia and Europe. A further containerisation is widely expected (see OSC 1997, and Teurelincx et al. 1998). However, the size of this increase is uncertain.

**A high- and a low-growth scenario for the Europe-Asia trade**

In this section, two scenarios are constructed for the trade between Europe and the Far East. These scenarios serve as illustrations only and are not the result of a detailed empirical study, but of a qualitative approach. The results indicate that the uncertainty is very large. The low scenario shows a modest increase of container transport, of about 40% in 20 years. We have to keep in mind though, that this growth is likely to be uneven balanced over the 20-year period: relatively high growth in the first years, and diminishing growth later on. This is because the variables that have a positive effect are changing earlier than the variables that have a negative effect on the transport volume.

Figure 3 shows the scenario’s.

The high scenario shows a much higher growth, of 240% in 20 years. This is a growth of 6.3% per year on average, again higher in the first years and slowing down later on. It is impossible to analyse which one of the scenario’s is more realistic. Rather, the uncertainty is large and both scenarios are possible. Which scenario materialises depends on various of factors, such as political developments, trade liberalisation and economic growth.

We conclude that the is higher than most studies suggest. This stems from the fact that most studies extrapolate past developments. The high uncertainty has important consequences, most importantly for ports. These are discussed in the next section.
III. IMPLICATIONS FOR DECISION-MAKERS IN PORTS

The issue of forecasting is very important in the port industry, because planning and constructing port infrastructure takes a lot of time. Various planning and expansion projects are underway in the port industry. Ports, such as the ports of Rotterdam (RMPM 1998) and Antwerp (Teurelincx et al, 1998) and industry consultants. According to our analysis, the uncertainty of transport flows is very high. The following additional uncertain variables increase the uncertainty for ports.

- Transhipment. Currently, transhipment volumes are rising. Complex port hierarchies arise (Robinson 1998). More transhipment increases the demand for port services. It can be doubted if transhipment volumes will remain so high (de Langen 1998). In any case, the share of transhipment in total port services is uncertain.

- Empty containers. Currently, the flow of empty containers consists of some 15-20% of the total throughput. It is the question whether this share will remain so high. In Rotterdam, the share is expected to decline from 16% to 12% in 2020. This expectation is quite uncertain though.

- Competitive position. A final aspect that influences the port throughput is obviously its competitive position. The ‘market share’ of a port is an uncertain variable that depends on market behaviour that cannot be accurately forecasted.

We claim that the uncertainty is so large that ports should try to maintain flexibility in the planning and construction process. Maintaining flexibility is a complex and challenging task for ports. Given the high uncertainty, it is crucial as well.
Flexibility in port planning

Flexibility in port development is by no means easy and not always possible. Ports require specific infrastructure and superstructure that cannot easily be used alternatively. Three ‘sources of flexibility’ can be distinguished; flexibility is size, use and timing. Expansion projects can be designed in such a way as to maximise the flexibility of size. Using a modular approach or breaking up large projects is various steps allow for reconsidering the targeted size if other developments ask for such reconsideration. Projects can aim to add capacity, without determining in advance how much capacity needs to be added. By striving for flexibility in size, ports can reduce the risk of creating overcapacity.

Expansion projects can strive for flexibility of use as well. If land is to be reclaimed or developed, ports can strive for flexibility of use. Expansion plans should be able to accommodate different activities, such as container throughput, other throughput activities, industrial and distribution activities etc. Trying to strive for flexibility of use demands specific attention in the design phase.

A final method to deal with the high uncertainty in the port industry, is to create flexibility in time. Expansion projects can be developed in a way that ensures flexibility in timing. By doing so, the actual speed of development can be adapted to market demand, and the problem of large areas of obsolete land is avoided.

IV. CONCLUSION

In this paper a model was created to analyse future transport demand between two countries. An analysis of the variables used in this model shows that the uncertainty of trade flows is very large. Every forecast is bound to be wrong. This asks for flexibility in port investment decisions.

For that reason, flexibility is useful to be able to adapt to market signals. Three sources of flexibility have been discussed. All three, flexibility in size, use and timing can be used. The practical ways to build in such flexibility differs from port to port.

REFERENCES

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