Linking international trade and transport – what are the determining factors?

Ole Kveiborg,

Danish Transport Research Institute

DK-2800 Kgs. Lyngby,

Phone: +45 4525 6554, Fax: +45 4593 6533, e-Mail: ok@dtf.dk

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Abstract

Historically there have been close relations between international trade and international transport. Development in trade is mirrored in the development in international transport. However, it is also well known that patterns of trade changes. The types of commodities that are traded today differ from the commodities that were traded ten years ago. Trade of services has increased and the trading partners have changed. The opening of the European market towards Eastern Europe has changed the spatial pattern of where commodities are exported to and imported from. It is obviously not straightforward to tell how these changes influence the development in international transport.

This paper investigates the impacts of some of the factors that play a role in the development of international freight transport. The included factors are trade of different commodities and countries, the weight of traded commodities, the model of transport and the weight of the conveyed goods. We do this using a decomposition method on Danish trade data over a period from 1998 to 2003 and a link from these data to data about international transports on heavy vehicles.

We observe that the development in transport is composed of varying changes in the mentioned factors of which some imply increasing transport and some imply declining transport. This finding indicates the importance of taking proper account of the various factors in modelling freight transport and the relation between freight and economic trade.

Keywords:

freight transport, trade, growth, decomposition,

JEL codes: F14, R12, R41

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1. Introduction

Transport on the European road network is growing steadily despite the political awareness of the negative consequences of this growth and the willingness to implement measures to deal with these problems. Capacity is becoming scarcer and scarcer, and congestion can often be observed even for interurban transport in Central Europe. Other externalities are also an increasing negative consequence of transport that must be dealt with. To deal with these problems it is necessary to have an idea of the reasons for the increasing transport. This paper aims at finding indications of which elements that play the most important role for the growth in international freight transport.

Using a Divisia index decomposition methodology we can attribute changes in freight transport to export and imports, the composition of trade partners, the composition of commodities, the weight of the traded commodities, a logistical component and the tons lifted compared to transport. Decomposition is a method that attributes changes to various factors. Here we have chosen to link trade and transport through a model that includes the elements just described. There are obviously many other elements that also play a role in this relationship. Many of these supplementary explanations are not elements that can be added to the factors included here, but are rather the reasons that can be given for the observations made in the included factors. E.g. we use an overall indication of the logistical organisation through a single factor. Changes in this factor are due to changes in mode choice, the use of distribution centres, warehouses etc. Hence, such changes have been included, but not explicitly and separated from the other changes that enter into the logistical factor.

Kveiborg and Fosgerau (2004) has earlier applied the method to national transport and traffic in order to explain the observed decoupling of national freight traffic from economic growth. They find that the primary reason for the observed decoupling is the utilisation of vehicles (average load, larger trucks and reduced empty running). However, they also find that both the demand for transport through increasing economic activity and trip lengths are increasing rapidly. This implies a limit to the potential for further decoupling, because utilisation cannot increase forever and the pressure from demand etc. will force an increase in freight traffic.

The analysis in this paper is very similar to the Fosgerau and Kveiborg (2004), the Kveiborg and Fosgerau (2004) and the Lakshmanan and Han (1997) approaches. It is also related to the

decoupling literature (Stead, 2001, and Tapio, 2005 among others), but the analysis here includes more elements in the analysis. However, the above-mentioned approaches include international trade in many different countries whereas the present analysis focuses on Danish trade. The specific results obtained can thus not be immediately transferred to other countries, but the general picture of which elements are most important should be general.

The data we have used for the study are public data that can be obtained free of charge at the Danish statistical bureau. The data is quite general and many countries have the same data available. This means that the analysis carried out can easily be transferred to other countries.

The paper is organised as follows. In section 2 we illustrate the model applied to link transport to trade. This is followed by a description of the method in section 3. In section 4 we show and discuss the results we obtain and finally section 5 summarises the findings.

2. Linking trade and transport

Most literature recognises that transport is a consequence of economic activities taking place at different geographic locations. This is the general premise for the model used in this study. The model is illustrated in Figure 1. Boxes illustrate volumes and arrows indicate the factors liking different measurement volumes. The analysis is separated for import and export and a separate, but otherwise completely similar model is used for each direction of the flows. For the sake of illustration the import version of the model is used.

The starting point of the model is total import to Denmark. This is separated onto the origin of the trade (the exporting country) and next differentiated with respect to type of commodity. The sequence of country before commodity is arbitrary as good arguments can be given both for the choice made here and for choosing commodity before origin of the product. It has been chosen to use the region before commodity approach because we think it is likely that commodities vary between countries and that the trade relation with other countries plays a more important role. This is also the choice in e.g. the TEN-STAC project where the volume of future trade between countries has been estimated (TEN-STAC, 2003) and in a Danish study providing forecasts of Danish based international trade (Lyk-Jensen et al, 2005). In both these studies factors such as common border and language are very important for the bilateral trade. For the national models it is more common to apply a commodity before region approach and using Armington preferences to distinguish between goods from different regions.

This corresponds to an approach where commodities from different regions are assumed to be close substitutes.

Having accounted for the trade in monetary terms a translation into physical volumes of trade in tons is done using value densities differentiated with respect to region and type of commodity. This is an important translation because we are interested in transport and transport is performed with physical goods and not the value of a good.

Next is an even more important transformation – the handling factor, which is a measure of the number of times commodities are handled from origin to destination. It is measured as the relation between volumes of tons lifted (using truck) and tons traded. It is thus a measure of the logistical structure of not only production logistics, but also transport logistics including choices such as subcontractors, storing facilities, distribution centres, mode choice etc.

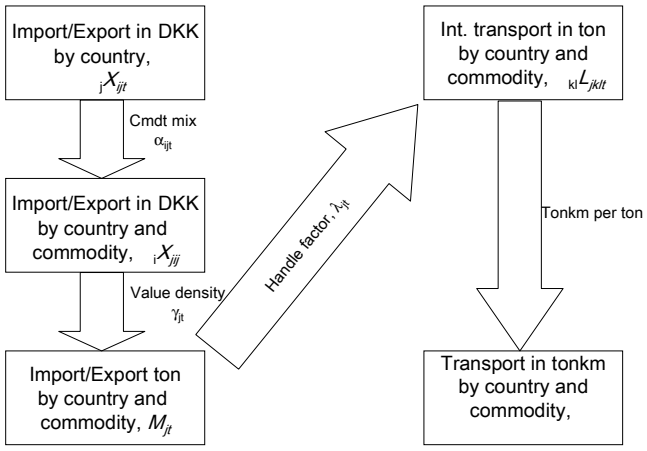


Figure 1. The model applied for the analysis.

We have not included the mode choice element in this analysis since we are only interested in the relation between trade and road transport. However, the division between different modes is crucial in international transport where ship transport has a share of more than 50 per cent of the total amount of tons lifted.

The final part of the model is a link from tons lifted to transport in ton kilometres. This is an approximate measure of the trip length, but only an approximation as explained in Kveiborg and Fosgerau (2004).

3. Method and data

The data we have used for the analysis is based on international trade statistics readily available from the homepage of the Danish Statistical Bureau. The data we use are

X_{ijt} : The export in fixed prices to country *i* of commodity *j* in year *t*.

M_{ijt} : The import in fixed prices from country *i* of commodity *j* in year *t*.

Wx_{ijt} The weight of the export to country *i* of commodity *j* in year *t*.

Wm_{ijt} The weight of the import from country *i* of commodity *j* in year *t*.

Lx_{ijt} : The tons lifted of commodity *j* exported to country *i* year *t*.

Lm_{ijt} : The tons lifted of commodity *j* imported from country *i* year *t*.

Vx_{ijt}: Ton km for export to country *i* commodity *j* in year *t*.

Vm_{ijt}: Ton km for export to country *i* commodity *j* in year *t*.

We have observations for six consecutive years from 1998 to 2003 for all observations. The trade data are total accounts, but rounded to millions, which means that in some *ij*-groups there is a under-representation of the variation actual taking place or amounts being equal to 0 even though there might have been a positive (but very small) amount of trade. To avoid problems with series changing to and from zero we have used two-year averages of all values.

We have not used all Danish trading partners, but selected the most important partners within Europe where road transport is dominant. However, this leaves open the question of the relation between international trade with Asia and North America where large amounts are conveyed to the ports in Hamburg, Rotterdam and Antwerp. We have not included this particular problem in this analysis, but it is an important element that should be taken into account. Another similar problem relates to the CEE countries, where it is expected that trade will increase rapidly. Data for trade and especially transport with these countries were not very good. We have thus chosen not to take these countries into account in the present analysis. The included trading partners are listed in the annex.

We have grouped the commodities into five groups:

Agricultural products including fertilizers

Food and fodder

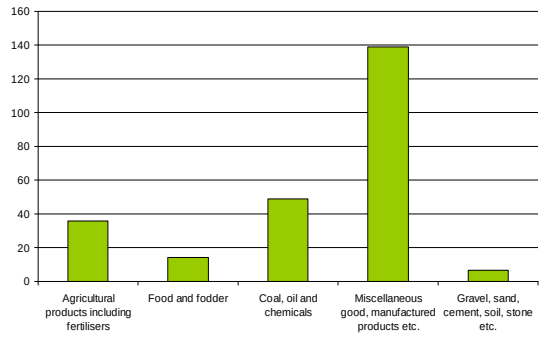
Coal, oil and chemicals

Miscellaneous good, manufactured products etc.

Gravel, sand, cement, soil, stone etc.

Note that these groups do not take services into account, which is also true for the measurement of total trade. The volume of trade of these five groups is shown in Figure 2.

Export



Import

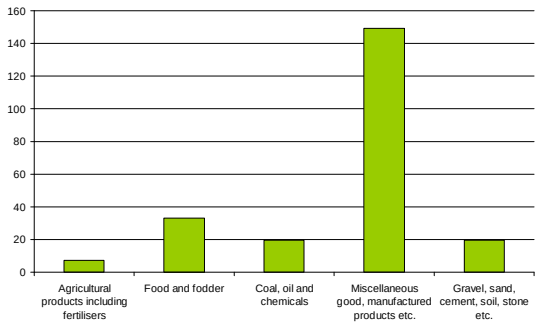


Figure 2. Volume of trade in billions of DKK in 2003.

The most important type of commodity is manufactured goods both with respect to import and export. Imports to Denmark in 2003 were 229 billion and exports were slightly larger with 245 billion DKK. From the figure it is obvious that Denmark has also specialised in agricultural products, but also energy products are very important in volumes of export. However from a road transport point of vies the energy products are not equally important because most is conveyed using pipelines and ship.

We use the data to construct the following variables, which are represented in Figure 1 as the arrows between the boxes:

$\beta x_{ijt} = \frac{Vx_{ijt}}{Lx_{ijt}}$: the amount of ton km per ton lifted by commodity type *j* to export country *i*,

$\beta m_{ijt} = \frac{Vm_{ijt}}{Lm_{ijt}}$: the amount of ton km per ton lifted by commodity type *j* from import country *i*,

$\lambda x_{ijt} = \frac{Lx_{ijt}}{Wx_{jt}}$: the handling factor by commodity type *j* to export country *i*,

$\lambda m_{ijt} = \frac{Lm_{ijt}}{Wm_{jt}}$: the handling factor by commodity type *j* from import country *i*,

$\gamma x_{ijt} = \frac{Wx_{ijt}}{X_{ijt}}$: the inverse value density by commodity type *j* to export country *i*,

$\gamma m_{ijt} = \frac{Wm_{ijt}}{M_{ijt}}$: the inverse value density by commodity type *j* from import country *i*,

$\alpha x_{ijt} = \frac{X_{ijt}}{X_{it}}$: the share of export to country *i* of commodity *j*,

$\alpha m_{ijt} = \frac{M_{ijt}}{M_{it}}$: the share of import from country *i* of commodity *j*,

$\varepsilon x_{it} = \frac{X_{it}}{X_t}$: the share of export going to country *i*,

$\varepsilon m_{it} = \frac{M_{it}}{M_t}$: the share of import coming from country *i*,

Using these factors we can describe the model in mathematical terms as

$$Vx_t \equiv \sum_{ij} Vx_{ijt} \equiv \sum_{ij} \beta x_{ijt} \lambda x_{ijt} \gamma x_{ijt} \alpha x_{ijt} \varepsilon x_{it} X_t \,. \tag{1}$$

Which holds as an identity. Defining the growth rate in a variable as $\dot{Y} = {}^{\partial \ln Y}/_{\partial t}$ we can write $\dot{V}x_t$ as

$$\dot{V}x_t \equiv \sum_{ij} \frac{Vx_{ijt}}{Vx_t} \dot{\beta} x_{ijt} + \sum_{ij} \frac{Vx_{ijt}}{Vx_t} \dot{\lambda} x_{ijt} + \sum_{ij} \frac{Vx_{ijt}}{Vx_t} \dot{\gamma} x_{ijt} + \sum_{ij} \frac{Vx_{ijt}}{Vx_t} \dot{\alpha} x_{ijt} + \sum_{i} \frac{Vx_{it}}{Vx_t} \dot{\varepsilon} x_{it} + \dot{X}_t \tag{2}$$

This approach is similar to the approach used in Jorgenson et al (1987) and Jackson et al. (1989), who also denotes it the Divisia index. This means that we can decompose the growth in traffic into the following factors

$\sum_{ij} \frac{Vx_{ijt}}{Vx_t} \dot{\beta} x_{ijt}$ Growth in the amount of ton km per ton.

$\sum_{ij} \frac{Vx_{ijt}}{Vx_t} \dot{\lambda} x_{ijt}$ Growth in the handling factor.

$\sum_{ij} \frac{Vx_{ijt}}{Vx_t} \dot{\gamma} x_{ijt}$ Growth in the inverse value density.

$\sum_{ij} \frac{Vx_{ijt}}{Vx_t} \dot{\alpha} x_{ijt}$ Changes in the exported commodity mix to each country.

$\sum_i \frac{Vx_{it}}{Vx_t} \dot{e}x_{it}$ Changes in the mix of exporting countries.

$\dot{X}_t$ Growth in total exports.

The model is formulated in continuous time. Our data are discrete, hence we approximate by $\dot{Y}_t \approx {}^{2(Y_t - Y_{t-1})}\!/_{(Y_t + Y_{t-1})}$ because many of the series change to and from zero.

We do not include interaction terms in our decomposition (2). The interaction terms are the joint contribution to growth from the included factors. This can be illustrated by the following example. Assume that the model can be described as $x=yz$. Then the following decompositions are equivalent:

$$\frac{\Delta x}{x_0} = \frac{x_1 - x_0}{x_0} = \frac{y_1 z_1 - y_0 z_0}{y_0 z_0} = \frac{\Delta y z_0 - y_1 \Delta z}{y_0 z_0} =$$
$$= \frac{\Delta y}{y_0} + \frac{\Delta z}{z_0} + \frac{\Delta y \Delta z}{y_0 z_0}$$

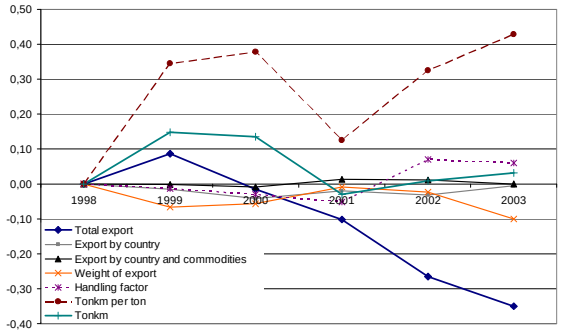
From this we can se that the final interaction term is not included in the discrete approximation we use. Oosterhaven and Hoen (1998) discuss the differences between different decomposition methods including and excluding the interaction terms. They argue that the interaction terms will only be important for long time intervals between subsequent observations of five years and more. This is supported by Lakshmanan and Han (1997). Since we use a time interval of one year we do not include interaction terms.

The model (2) is completely similar for the transport related to import.

4. Decomposing international transport

Using the Divisia index decomposition described above on our data gives the growth patterns illustrated in Figure 3. There are visible similarities between the factors influencing import and export related transport. The average annual growth in the factors is shown Table 1. The most striking outcome from the analysis is that a negative decoupling occurs for both import and export related transports. Export related transport increase by 0.65 per cent even though we can observe a large decrease in exports. Note that the declining export is not the general picture of Danish international trade, but only exports to the selected countries. Import related transport increase by 1.92 per cent on average despite a fall of 4.31 per cent annually.

Export



Import

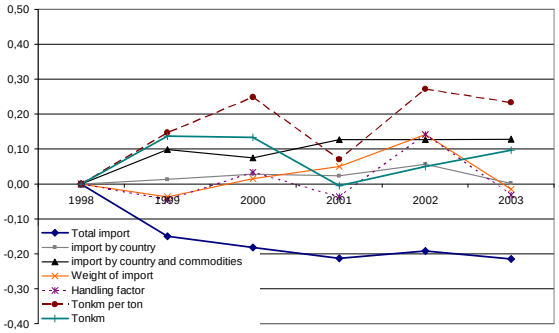


Figure 3. Growth in factors determining growth in tonkm for export and import.

Table 1. The size of the impacts on transport related to exports and imports.

	Export	Import
Total trade	-6,99%	-4,31%
+ Trade by country	-0,11%	0,04%
+ Trade by country and commodities	0,01%	2,56%
+ Weight of trade	-2,00%	-0,31%
+ Handling factor	1,21%	-0,62%
+ Tonkm per ton	8,56%	4,68%
= Tonkm	0,65%	1,92%

Next we observe that the composition of trade by country does not change in a direction that influences transport both for import and export related transport. This is not what would be expected. It would have been more intuitive if exports to countries further away would have influenced transport upwards. However, we cannot observe such changes. We do not observe any impact from changes in the composition of exported commodities. This may be a result of having one very large commodity group dominating (manufactured goods) trade. The same pattern has been observed for national trade (see Fosgerau and Kveiborg, 2004). It is important to note that the analysis does not take trade of services into account. Hence, a change towards trade of knowledge and trade of services should lead to a decline in transport. This will

obviously not be observed here. Changes in import related transport are on the other hand largely influenced by the commodity mix of imported goods.

Turning to the weight of the traded commodities we can observe changes by 2 per cent per year on average for exported commodities and only -0.31 per cent per year for imported commodities. This implies that within the (large) commodity groups there is a change towards commodities with a higher value density, which reduces the demand for transport. Working in the opposite direction is the handling of commodities, which influence transport by 1.21 per cent per year for exports. As explained above, this may be due to many different things such as mode choice, distribution centres, use of subcontractors etc. The analysis shown here does not allow us to say, which of these things are most important. This is left for a more detailed study. However, there has been a trend towards more use of trucks in international transport (Tetraplan 2004). The observation about value densities and handling factors for exports do not apply to the same extent for imports. In fact we can observe a decline in the handling of imported commodities.

Finally the most important factor is the ratio between tonkm and tons lifted. For transport used in relation to exports an average annual increase of 8.5 per cent is observed from 1998 to 2003. This is an indication of longer trip distances, but it is not an accurate estimate of the change in trip distance as explained by Kveiborg and Fosgerau (2004). The very low impact from trading country on transport can be explained by this. The changes in trading partners do not in itself lead to changes in transport, but distances cover this aspect. Hence the observed development in the explanatory factors is actually very much in line with expectations. A similar explanation can be given for import related transport.

5. Conclusions

This paper has addressed an issue that is high on the political agenda in Europe (e.g. CEC, 2001a and 2001b), where the decoupling of transport from economic growth is addressed. The purpose of the paper has been to provide insight in, which factors that play an important role in the development of international freight transport. This has been addressed for Danish based exports and imports to the EU. This was chosen because these are the most important trading partners and because road transport is the main focus of the analysis. A secondary reason for this choice was the limited data available for e.g. CEEC countries.

The results obtained are to some extent similar with respect to export and import. A negative decoupling is observed. It is however, very important to note that the analysis only covers trade with EU15. Trade with these countries is falling. But changes in the trading partners within EU15 are towards countries in Southern Europe, which implies larger transport distances and thus increasing transport. However, the overall growth in export related transport is moderate. This is thus to a large extent caused by the large decrease in exports.

The other factors analysed are the composition of commodities, the value density and the handling factor. These factors are also necessary to take into account (not the country disaggregation though) in the analysis, but with varying importance for export and import related transport. One issue that should be mentioned is the impact of the value density. This factor reduces the demand for export related transport by on average 2 per cent per year. This is a quite large impact, which is contrary to the findings for national transport and traffic (Fosgerau and Kveiborg, 2004). It is thus an indication of a higher specialisation in more manufactured goods in Denmark. The model used in Fosgerau and Kveiborg (2004) actually uses a larger differentiation of commodities, which means that the large value density impact found here may be caused by a lack of differentiation between goods. If a larger differentiation had been used this could have capture changes between goods that are now contained within the same commodity group. Moreover, the manufactured commodity group is very much larger in trade terms than the other groups. Many of the changes in international trade are within this group. It is thus not surprising that such changes appear as changes in the value density. The importance of the commodity classification is thus an issue that should be analysed further.

The handling factor is also an important factor in the analysis as it is an indicator of changes in many different elements in the logistical chains including modal shifts, which we have not included here. The factor is most important in relation to export related transport. The difference between import and export in this respect is also an issue the present analysis identifies as an issue for further analysis. The results show that the way the logistic element is handled in exports lead to more road transport. This result is also found by Lyk-Jensen et al. (2005). Much of this can be attributed to the type of commodity used, but there are other aspects included in this, because the changes related to changes in the commodity mix address this issue.

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Annex

The countries included in the analysis are the most important Danish trading partners in Europe: Belgium and Luxemburg, Finland, France, The Netherlands, Ireland, Italy, Norway, Switzerland, Spain, United Kingdom, Sweden, Germany, and Austria