Determining Factors in the Development of Road Freight Transport[1]

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Introduction

During the last decades demand for freight transport have been growing almost continuously. The reason for this growth is primarily the overall economic growth, but many other factors influence the growth path. Moreover, the type of economic growth plays an important role in the development of freight transport. Growth in the public sector does not have the same impact on the demand for freight transport as growth in the construction sectors does.

But what exactly are the determinants in the development of road freight transport? To help answering this question a macroeconomic model describing the linkage between economic activity and freight transport has been developed. The purpose of the model was at first hand not specifically to be able to answer this question, but rather to develop a model that were able to answer the questions: "What are the environmental impacts of the general economic development?" and "What are the impacts from different specific (economic) policy proposals?" The two purposes of the model go hand in hand. To answer the latter questions it is necessary to find (some of) the determining factors. This paper focuses on this latter question, and less on the actual model system. However, to understand better the ideas and discussions of the different elements in the paper, the model will be described in broad terms in section 2.

As it turns out we will not really be able to answer the questions raised here. This does not mean that we are not able at least partly to give some insight into the complex relationship between economic development and road freight transport. By an appropriate disaggregation of the economic development we are able to describe the structural relationship, and thereby the different levels of the transport demand in different sectors. However the changes over time in these structural relations should also be described in some way. In this respect the message of the paper is only partly instructive, stating elements that *are only partly* determinants in describing the development in road freight transport. The reason for this negative result is primarily due to the fact that the model is an aggregated model, using price variables as describing factors. Many of the structural elements are not related to the price variables in the way they are used here (or perhaps not at all related). To be able to find the real determining factors it is necessary to go even further into detail, and

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[1] This project has been carried out in corporation with Ole Gravgaard and Erik Grib, Statistics Denmark. The Danish Transport Council, The Department of Transport, and the Danish Energy Research Programme financed the project.

work at the micro level using individual transport providers (e.g. haulage contractors), and the firms demanding the transport services (both the transport performed by the firms themselves and the purchased transport). In this respect the time period is also of some importance. Structural changes happen over a longer period and are not related to the change in different prices from period to period. Another almost equally important reason for the conclusions is the very inadequate data concerning freight transport. For the transport modes rail, air and sea transport almost none is available, whereas for road transport some data exists, but it is still very poor.

As already mentioned there are significant gains from the present model development. Some of the analysis that has been carried out can be used in future research in this field, and some of the elements in the model do give some reasoning for the actual development. Existing models describing the relationship between economic development and the development of freight transport are all inadequate in the description of some parts of the development. Most of these models assume a simple relationship between the overall development in GDP and the transport performance (tonne kilometer) without concern to the different influence from different economic sectors and types of goods. The model we have developed take the same starting point, but use the information stemming from a disaggregation on different production sectors and good categories. Hence, we obtain a detailed description of the transport performed.

In section 2 the general outline of the model is presented with a discussion of some relevant influencing factors on each level of the model. A section describing the primary data used for estimations in the model follows this section. A few descriptive analyses of the data, and especially the linking factors are presented. In section 4 the general conclusions of some of the many estimated relations are presented. In most cases these are only the simplest of the regressions we have carried out. They do, however, describe the problems we have faced in this work. In the last section of the paper we give some general comments on the use of the model, some advantages and especially disadvantages, and we give a few recommendations on how to proceed on this work.

This paper is an abbreviated version of an earlier draft (Kveiborg, 2000). Hence, some findings and conclusions are left out.

Modelling freight transport

The set-up used in the present model has been used in an earlier Danish project described in Henriques and Clausen (1998) where some similarities with the present work also can be found. Henriques and Clausen use the same primary data as in this project. There is one major difference between these three projects and the present model. We transform the production values in the different economic sectors to production of a number of different groups of commodities. In this way we avoid the assumption that there is a direct and complete connection from the economic sectors to the transport of different goods. This enables us to make more precise descriptions of the true relationships.

The reason for splitting the calculations into these different steps is to be able to describe the different factors influencing at the different intermediate steps, and also to be able to interpret and analyse the different factors and the development in these factors.

To focus the comparisons further we will now present the general set-up of our model system.

The model

The model is made up of to primary elements: a general macro-economic part and a part calculating the physically performed transport.

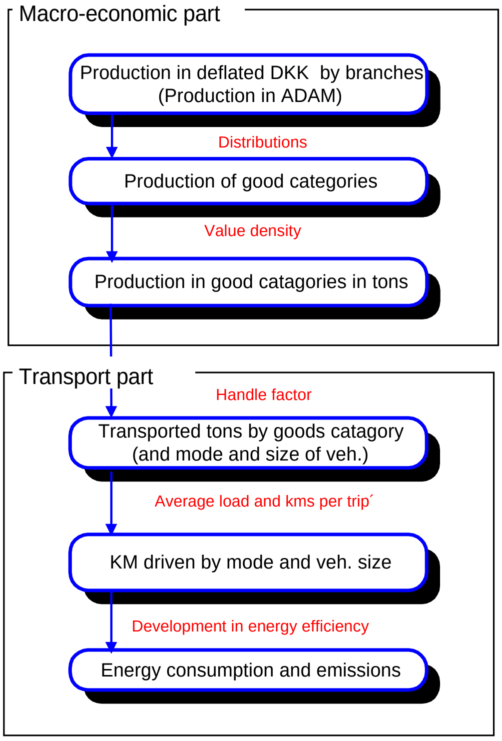

Figure 1 The general outline of the model. The boxes indicate the absolute measures, and the links between are described in between.

The model consists of six overall successive components linked to each other. The input to the model is a forecast of the production values in 19 different production sectors in the Danish economy (including imports and exports). 8 of these primary production sectors only produce services, whereas the remaining 11 sectors produce both services and physical goods. For the freight transport it is only the physical goods that are of interest. The first link is therefore between the production values in the 11 primary sectors to 23 groups of commodities (ranging from living animals and foods over crude oil to machines and construction materials) including the good "services"[2]. This link is merely a distribution of the production in the production sectors. It is assumed influenced by the relative competitiveness in the price of the input factors of the different goods produced in each of the sectors.

The third general element is the production measured in tonnes. We have constructed a dataset where the production of the different good categories is measured in tonnes, making us able to calculate the value density for the different good categories. The value density can be interpreted as an indicator of the group internal composition of goods. A rise in the value density indicates a change towards goods of lower value, where a larger number of goods can be purchased for the same amount of money, or perhaps of changes towards goods with

[2] The good "Services" is only included to secure that the totals in the production sectors add up.

a higher technological level. It is not in all the goods categories that this factor has an intuitive explanation.

In figure 1 the outline of the model is shown. From this figure it is seen, that the measure of production in tonnes is the very last part of the economic part of the model. The succeeding elements concern the actual transport being performed. To connect the two parts of the model the handling factor is used. The handle factor can be interpreted as "*the number of times a specific good is transported from production to final consumption*". The handle factor is the crucial link between the economic development and the actual transport performed. A change in this factor is an indicator of changes in the production strategies of the firms; extended use of subcontractors, and / or changes towards "Just-in-time" production, where goods are transported directly from the production plant to the retailer or perhaps the consumer. This latter change should imply a fall in the handle factor, and the former should imply a rising handling factor. Both things could be happening at the same time rendering the expected change unclear. As we shall se later on, this is actually the case for most of the good categories. Looking at the overall handle factor there is a clear negative trend. It is expected that this negative trend is due to rising relative transport prices, but this conclusion is not very well supported, as we shall se.

Using the handle factor, the number of tonnes transported can be calculated. It is actually possible to calculate the tonnes transported both by the firms themselves (*own transport*) and by haulage contractors as well as on different sizes of the vehicles used. This would imply the development of separate handle factors for each of these categories, and for each of the 22 good categories. The data does not support disaggregation at this level of detail. Instead the aggregate handle factor for each of the good categories is used giving the tonnes transported, and leaving the distribution on own and haulage transport, and on two sizes of lorries as a separate step[3]. It is expected that the distribution on own transport, and transport by haulage contractors is influenced by the relative prices of the average costs within the production sector compared to the prise of haulage transport. Other factors also play an important role in this distribution, and the distribution on the size of vehicles. Among these factors one would expect to find the (de)centralisation of production on fewer (or more) individual firms, the market expansion to markets further away, where use of larger lorries are to be expected. A further influence is the impact of increased demand for flexibility in the producer-customer relationship. In some situations the producers need many small sized vehicles to accommodate a demand with a wide spatial distribution, and in other situations a large vehicle is needed for a large order from one specific customer. To be as flexible as needed, the producers tend to purchase the transport rather than using company owned vehicles. As we shall see in the next subsection it is not possible to describe all these effects in simple price factors, and even the trend does have difficulties in explaining the development.

The penultimate step is to calculate the traffic performance. Multiplying the average length of haul with the tonnes transported, and then divide with the average load does this. This step consists of two calculations: a) calculate the average length of haul, and b) calculate the average load. Again it is expected that the price of transport should have some impact on these measures. A rising transport price, should increase the average load, and perhaps decrease the average length due to increasing efficiency in the use of the vehicles (the average load), and due to lost profitability of the marginal consumer located the farthest away (the average length). Thus, the impact from the transport prices is twofold. First the

[3] An even finer segmentation could have been used, but the data does not support this. Also the calculation of emission factors is not possible on this finer segmentation level.

influences on overall demand for transport, and secondly on the average measures used here. There are of course large interdependencies between the different average measures and the distribution on vehicle sizes etc. and it is very difficult to distinguish one effect from the other. We therefore make no attempt to do so. It is also difficult to distinguish the right way of influence from introduction of larger vehicles with other dimensions etc.

The final step is to calculate the energy consumption and the emissions from the traffic performance. Multiplying the traffic performance with the emission factors does this. We have not introduced exogenous factors influencing the emission factors. However, we have incorporated emission levels for future vehicles that the EU has already agreed upon.

Data and key developments

Two sets of primary data have been used, both specially designed for this particular study. The first dataset is constructed from the National Accounting system and consists of information on the production values in the different production sectors combined with the production values in the good categories each year from 1981 to 1992. The values are also given in tonnes[4], but only in 6 selected years in the period from 1981 to 1992.

The second primary dataset contains information on the amount of transported tonnes, number of trips, traffic performance and transport performance in the different good categories.

Besides these two primary datasets a database linked to a Danish macro-economic model (ADAM) consisting of a number of different macro-economic variables have been used. We will not look further at this database in this paper, but instead refer to Andersen et al (1995) and to Statistics Denmark (1995).

Production in economic sectors and in good categories

In this paper we have chosen not to concentrate on the relation between production in the different sectors and the production of different commodities, to get a thorough analysis of this relation you should consult Kveiborg (2000). The conclusion is that the connection from one sector to one commodity is relatively constant. However, some of these linking coefficients are changing over time. Price relations including a trend can generally describe the changes. The implication is that the assumption that each commodity is produced in one single sector seems reasonable, although not perfect.

The production is measured in 1980-DKK[5] and in tonnes. Changes in the production values (in DKK) are interpreted as real changes in physical production. In this way the development in the production values should be closely related to the developments in the production values measured in tonnes. In figure 2 the overall developments in production in DKK and in tonnes are illustrated. It is clear that there are some (small) variations in the relation

[4] The making of the physical productions is based upon data of the same level of detail as the actual National Accounting system, where the number (either in tonnes, number of individual pieces, litres, or square meter etc.) of a specific produced good is available. In the case where no information on the actual weight has been supplied, it has been guessed, and added up. It is therefore not just a simple factor multiplied on the production in DKK, but a "real" account.

[5] In 1997 and 1998 a change in the National Accounting System has been introduced. These are changes in the good classification system, and more importantly that values are measured in 1990-DKK. However, it has not been possible to generate the historical data using this new classification system in due time to be used in this project.

between these two measures of the production activities. We will not go further into this discussion in his paper (see Kveiborg 2000a and 2000b).

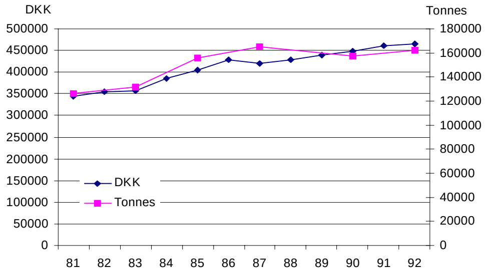

Figure 2 Developments in production in DKK and Tonnes

With the data at hand it has been difficult to find good indicators related to these explanations. If one could hope for anything it is, that a change in the price of the good category could explain some of the variation in the value density. In the next section we will come back to the analysis of prices as explaining factors of the value density.

The transport survey

The transport survey is based on travel diaries from approximately 3000 vehicles per year, spread evenly throughout the year. The selection is made so that the sample should be representative. This has not been achieved completely, and some adjustments are made. Even so, the survey is used for the official statistics covering road freight transport in Denmark. In the survey the driver of a vehicle has to supply information on every single trip during a specific week, what type of good he is transporting, the weight of the load and the length of the transport. The information is then used by Statistics Denmark to calculate the traffic and transport performance, the number of trips made by specific types of vehicles (size of the vehicle), and who performs the transport. The survey have been carried out since 1979 with only very few changes since then.

The amount of tonnes transported has varied quite a lot, and especially more than the traffic performance. This indicates that the goods generally are transported longer distances. This is confirmed in figure 4b, where the average figures are shown. The average length of haul has been increasing whereas the increase in the average load has been more moderate.

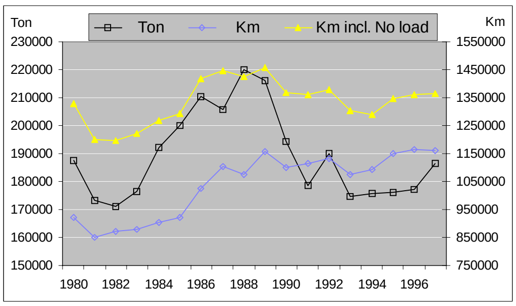

Figure 3a Development in transported tonnes (*Ton*), the traffic performance (*km*), and the traffic performance incl. trips without load (*Km incl. No load*)

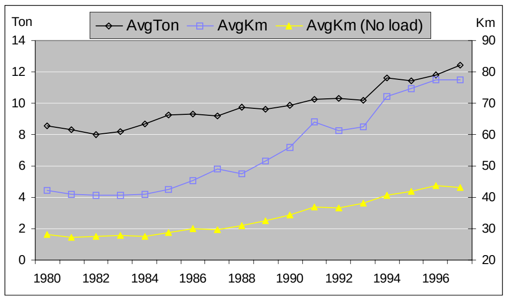

Figure 4b Development in average load (Avg*Ton*), the average length of haul (*Avgkm*), and the average length of haul incl. trips without load (*AvgKm (No load)*)

The implication of the development in the number of tonnes transported is that the handle factor is slightly decreasing over the period, but only slightly as the total number of tonnes produced also has been decreasing (though, slightly less than the number of tonnes transported). When disaggregating on the different good categories the picture becomes quite messy, some handle factors are increasing and some are decreasing, but moreover the handle factors show huge variations. We do not expect to be able to describe these variations with the very simple regressions we are trying to use in the next section. This is due to the many different things influencing the size of the average factors. It should however be mentioned that the size of the average figures are very different in the different types of goods, as expected.

There can be two explanations for these very volatile handle factors: either there are huge mistakes in the transport survey[6], or the variations should be explained by a line of different factors, which we have not any possibility of using with the small number of observations at hand. The influence of some of these factors was described verbally in the preceding section.

Estimation

In this section the estimation of the value density, the handle factor, the distribution on vehicle size, and the average length are presented. All estimations are made by simple regression equations like

$$y_{j,t} = \log Y_{jt} = \alpha_j + \beta_j \log X_{jt} + \varepsilon_{jt}, \qquad (1)$$

where $y_{j,t}$ is one of the factors described in the preceding sections (e.g. the handle factor), $X_{j,t}$ is either a trend, a price relation (typically a price on transport in relation to a price on the good in question) or both. The error term $\varepsilon_{j,t}$ is assumed independent identically distributed, but in all estimations corrections for autocorrelation and heteroscedastic error terms are made if necessary. In most cases these are not of great importance. In some cases it is impossible to correct for these biases because of the small number of observations. The estimations cannot be taken as conclusive as the number of observations is so small, they should only be taken as indications of the right direction. Note that seperate estimations are made for each group *j*.

Estimation of short run relations has also been considered. That is estimation of differences instead of absolute values. This has only in very few cases resulted in better estimates than the estimation in absolute values. Moreover, the use of first differences reduces the number of observations by one, which is very crucial when the number of observations is so small. In the following sections only the results from estimations in absolute values will be described. A thorough discussion of the estimations is given in Kveiborg (2000a and 2000b).

It is important to mention here that the factors α_{ij} are important when conclusions about the overall model are to be made. The parameter is the level description from which the development will happen. Cross sectional (groups) differences emphasise the benefit of

[6] There are definitely some mistakes due to misplacements of the different freight on different categories, as the total handle factor shows a rather nice development without huge variations. A systematic non-response has also influenced the quality of the data. Typical answers to the question “Have the vehicle been under repair in the week in question?” is “Yes”, because the driver then did not have to fill out the questionnaire. The result of this is that based on the questionnaire a constant large part of the Danish stock of trucks is under reparation.

splitting the calculations on the different groups rather than using a single economic measure as a description for the total development. In the tables presented in the following sections we have left out the level variable. This does not mean that we ignore the importance, but just that we in this paper have chosen to focus on the explanation of the development rather than the actual difference in levels.

Value density

As mentioned above the value density describes the difference in the development of the physical production as measured in fixed 1980-DKK and measured in tonnes. There should be no development in the value density as a result of changes in the amount used for producing services, because this "good" has been separated from the production of physical goods already in the very first step of the model. If physical production measured in fixed DKK were adequate measures we would expect the value density to be constant. We saw in section 2 that this was not entirely the case. There are some development. In section 3 we discussed some of the factors that could have influence on the development of the value density. Unfortunately, the very limited number of usable observations for this analysis restricts us. Hence, we cannot describe the development using a long list of different explainable variables. Rather, we use a trend to describe the development not due to impacts from the different costs of production, and a simple relative price of production to describe the latter. Unfortunately we cannot really use the two in the same regression because of the few observations. Due to the restricted space available in this paper we will not comment any further on this factor. For further information consult Kveiborg (2000a and 2000b).

Handle factor

The handle factor is the single most important link in the model, as this is where the coupling from the economic activity to the freight transport is made. The handle factor can, as explained in section 2 be interpreted as the number of times a good is reloaded from start of production to final consumption. The estimation of this factor is also interesting because it links the two different datasets to each other. There seem to be some unexplainable errors in the information on the freight transport. Difficulties in achieving good estimation results are therefore likely to occur.

We want to test whether it is reasonable to assume that the relation described by the handle factor is dependent on a price relation, where the prices on transport (*pxt2v*) on the one side and prices on the commodity (*pX*) on the other. As before the regression relation is

$$\log h_{j,t} = \log\left(\frac{tT_j}{tX_j}\right)_t = \alpha_j + \beta_j \log\left(\frac{pxt2v}{pX_j}\right)_t + \delta_j T + \varepsilon_{j,t}, \qquad (2)$$

where h_j is the handle factor, and tT is the tonnes transported, tX_j is again tonnes produced, *pxt2v* is the price of transport by haulage contractors. It is taken as a general index of the price on transport. pX_j is the price on good type j. The parameter β can be interpreted as the elasticity on the transport price, and α_j is the level of the handle factor in each of the categories. Again we have tested the restrictions that each of the parameters (β and δ) equal zero, and that both equals zero.

As discussed in section 3, there are many factors influencing the handle factor. Most of these factors are only indirectly driven by economic factors; e.g. trying to cut the costs of both transport and production. The attempts to cut costs in the production could result in some restructuring of the localisation of the subcontractors, the production plants etc. This will influence the size of the handle factor, but not directly through the price of the good, but perhaps through the price of the input factors. However, we have not found any evidence of this being the case. A long list of other effects influences the handle factor. It does not seem to be possible to describe the explaining factors through the simple price relation indicated above (δ=0). We have therefore also estimated the handle factor using a trend. This trend covers all the different technical changes influencing the handle factor. Of course this is not a satisfactory way to do this, but the alternative of having to search for adequate descriptive data did not look promising. However, an analysis of the relative importance of some of the influencing factors could bring forward some interesting ideas. Such an analysis has been carried out in Woodburn and McKinnon (1996), and in Cardebring et al. (1998)[7].

The results from the estimations of (2) are shown in table 1 for the three primary tested models.

Table 1 Regression results from estimation of the handle factor in three different models, using a) a trend, b) the price rate between price on transport and production prices, and c) both together.

Good category	Trend model		Price model		Joint model			
	Trend	t-prob	pxt2v/px	t-prob	trend	t-prob	pxt2v/px	t-prob
Food	0,0066	0,2139	0,1782	0,1251	0,0159	0,3879	-0,2814	0,5880
Agricultural products	0,0109	0,3450	-0,3728	0,2585	0,0180	0,6698	-0,8666	0,4865
Fatty subst.	-0,0132	0,6325	-0,2304	0,7652	-0,1092	0,4055	2,8465	0,4479
Coal	0,0331	0,6274	0,5649	0,1967	-0,1754	0,1141	1,6642	0,0593
Crude oil	-0,1043	0,0204	-0,7578	0,0612	-0,1988	0,1611	0,7943	0,4283
Metal semi-products	-0,0189	0,5373	-5,0197	0,1306	0,0303	0,4464	-7,8559	0,1608
Sand, soil etc.	-0,0503	0,0090	-3,7321	0,0724	-0,0498	0,1097	-0,0560	0,9790
Cement, constr. mat.	0,0333	0,0034	1,7262	0,3498	0,0389	0,0168	-0,8981	0,3606
Machines, vehicles etc.	-0,0333	0,4522	0,9689	0,8975	-0,0573	0,3481	6,6716	0,4934
Products from metal	-0,0236	0,0807	-2,8375	0,1160	-0,0145	0,4832	-1,5006	0,5509
Aggregate	-0,0133	0,0008	-0,5055	0,0097	-0,0162	0,0637	0,1250	0,6223

It is evident from this table that the handle factor is not very well described by the included explainable price variables. This is not really surprising as many different factors are influencing. Due to the very limited number of observations, it is not possible to include more than two sets of explainable variables in the regressions, and even this is very problematic. Furthermore, it is not easy to get information on the many important explaining factors, as these are often closely related to the individual firms in the economy, as already mentioned above.

One important thing that should be mentioned here is that looking on the aggregate there appears to be an explainable development both using the trend, and using the price relation. The estimates are very significant in both cases, and the price elasticity on -0,51 is also within expected range. Unfortunately these very promising estimates become less clear when disaggregating on the different good categories. Even a disaggregation on fewer good categories does not lead to better results.

This leads to one of the conclusions of this paper, namely that the amount of false categorisation of commodities in the transport survey is an even bigger problem than first anticipated. Especially in the good categories with very few observations we do have problems if just one single observation is classified in a wrong group of commodities. The huge variations in the handle factor in the individual categories support the suspicion.

[7] The factors of greatest importance were stated in section 2.

However, this dataset is the only information obtainable concerning the freight transport. We therefore proceed with the analysis.

Even though the aggregate estimation result on the price relation looks promising it is still very dubious. The trend model obtains an even higher significance, and the dependence on the trend and the price relation points in the same direction. Hence, the suspicion is that the two are very correlated. This is confirmed both from a regression of the price relation on a trend, and from the joint estimation using both a trend and the prices.

In most of the good categories we find a trend that looks reasonable. However, in some categories there are some relatively high trends. Most of these trends can be explained by specific characteristics of the specific category of goods. We will not give these explanations here.

Distribution on vehicle size

It was mentioned earlier that the data could not support using handle factors separately for individual vehicle sizes and distributed on own transport and transport by haulage contractors. Instead we have used a simple distribution of the total amount of goods transported. We have used only two different sizes of vehicles, as we do not have information on the emission factors on a finer disaggregation.

The distributional pattern is the same throughout all categories, looking over the entire period. A shift from smaller to larger vehicles[8] and a shift from own transport to transport by haulage contractors have occurred. This can be seen in figure 4 for the total amount of transported goods.

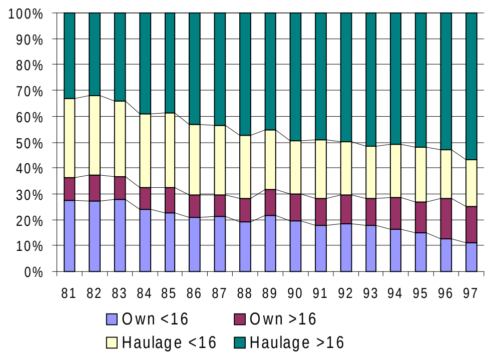

Figure 4 The share of the amount of goods transported by each of the four "modes".

[8] We have only used lorries over and under 16 tonnes, but through the period there have been an increase in the use of lorries over 32 tonnes, and it could be argued that use of three different sizes of lorries will improve significantly on the accuracy of the forecasts.

Table 2 The estimated price elasticity on the share of the total amount of tonnes transported, the shares in 1981, the estimated annual trend, and the shares in 1997.

	Price elasticity			Shares in 1981			Trend			Shares in 1997		
	Own	Haulage	Total	Own	Haulage	Total	Own	Haulage	Total	Own	Haulage	Total
<16	-0,5077	-0,4725	-0,4881	0,27	0,31	0,58	-0,049	-0,034	-0,040	0,11	0,18	0,29
>16	0,1896	0,5301	0,4633	0,09	0,33	0,42	0,030	0,033	0,032	0,14	0,57	0,71
Total	-0,2961	0,1429		0,36	0,64	1,00	-0,020	0,009		0,25	0,75	1,00

Table 2 shows the development in the share of the transports that is carried out by the two sizes of vehicles, by own transport, and by haulage contractors. In the table both the estimated price elasticities, the shares in 1981 and in 1997 as well as the estimated annual trend are shown.

The share of transport in small vehicles has fallen. At the same time there has been a small decline in the share of own transport, but the estimated trends tell us that this effect has been very small. These developments are not surprising as the increased demand for flexible transports by the firms tend to shift transport from own to haulage transport. If the firms choose to do the transport themselves, the transport is of relatively larger load, leading to the increase in the use of large vehicles by the firms. For the haulage contractors the increased use of large vehicles is due to increased efficiency, and lower costs. Whether these effects are due to the price changes are more difficult to say. We have found evidence that this is true, which is indicated by the price elasticities in the table. However, as before these elasticities are somewhat similar to the estimated trends, which once again indicates that he the price changes only can be part of the explanation.

Even thought the tendencies are the same throughout all groups of goods, they are not all of the same size. We have therefore tried to explain the different developments; again using simple trends, and relative prices on transport and production. In general the estimations of the different shares look promising both using the trend, and using a relative price. However, as before the development of the trend and the relative prices are very correlated. We therefore conclude that care is to be taken if the relative prices are used as descriptions of the distribution in forecasts. We will not look further at the estimation of these relations, but instead turn towards two other important and interesting factors.

Length of haul and average load

The last two factors we will look at in this paper are two factors describing the development in how the transport is performed. That is the development of the average length of the transports (length of haul), and the average load. Of course the distribution on the different vehicle sizes and on own- and haulage transport are also very informing with regard to the actual performing of transport. However, the average size of the two factors in question is of greater importance with regard to the traffic performance. The implication of a shift towards a larger share of own transport does not have large impact on total traffic and thus on emissions and energy consumption. On the other hand the distribution on sizes of vehicles is of greater importance. There is a large difference in emissions stemming from large and small vehicles.

We have chosen to estimate the average length and average load using fewer good categories. The amounts of goods transported are in many of the categories relatively small. Hence, it is assumed a minor error to use the same factors for more of the groups. We have also considered not to disaggregate on own and haulage transport, as the differences between these are relatively small. However, some differences are present, and we have thus kept this disaggregation.

The reasons for expecting developments in the average figures are once again changes in the localisation of production plants, distributors, subcontractors, etc. Changes in the production plans of the individual firms (and therefore supposedly in the individual good categories). The implication of an increase in the use of e.g. subcontractors is ambiguous, and could be both an increase and a decrease in the average load depending on the category. The implication for the average trip length is even harder to presume. There will obviously be an increase in the number of trips, but whether these trips will be longer or shorter than the average is hard to tell. A guess is that it will tend to decrease the average length, as subcontractors often localise close to the industries demanding their service or product[9]. It is obvious that as legislations on the maximum size of vehicles has allowed larger vehicles here has gradually happened a change towards larger vehicles, and hence an increase in he average load of especially the large group of vehicles.

In general the factors mentioned above are all to some extent structural changes happening over a longer period of time. Using only macro related variables not all the tendencies are likely to be captured. However, it is likely that an increase in the relative price on transport may lead to a decrease in the average trip length, and to an increase in the average load. Both these effects occur as an attempt to cut the costs of transport. However, we have not been able to use separate prices for each of the vehicle sizes or separate for own transport and purchased transport (we have tried to use proxy variables for the latter without significantly better results).

Discussion and conclusions

What we have achieved in this paper is a rather negative message: (almost) nothing can be said about the changes in the determinants of road freight transport. Is that bad? Of course yes, but on the other hand we have ruled out some possibilities on the path to greater clarity and knowledge. We have developed a model system that is an improvement on the existing (Danish) model describing the road freight transport (CowiConsult, 1990, and Andersen et al. 1995). The improvement is due to the structural relationship introduced in the proposed model. The results on the other hand are not satisfying, and more effort should definitely be put into improving on our results.

One great disadvantage when trying to describe freight transport is the extreme lack of information. The information is either very aggregate, or very disaggregate, where the latter furthermore is very difficult to get, as it often is contained within the different firms, and is considered as business secrets. We have tried to use the obtainable aggregate data to describe the development. Besides having difficulties finding adequate explainable factors for the analysed factors, we[10] have indicated that rather serious errors in the data concerning transport of the different goods are likely to occur.

[9] Agglomeration effects are also likely to be of importance.
[10] And others before us. See for example Henriques and Clausen (1998).

Our recommendation is that use of data at a macro level should only be used for very simple correlations. At this level it does not look promising to split the calculations into many separate parts, however promising and intuitive appealing it may seem. On the other hand, it can lead to some improvements and further insight to disaggregate into some intermediate steps, and the results in this paper could help in determining these steps. To describe the developments of freight transport we recommend use of data at the micro level, where the determinants for the individual acting firms etc. can be exploited.

Another factor playing an important role is the spatial distribution of where production and demand are located. In a model like the present it is not possible to incorporate the spatial resolution. Hence, we loose important information that may give better descriptions of the actual developments. This is another kind of disaggregation instead of disaggregation to the micro-level. A combination of the two could possibly result in further informational gains, but also in larger problems with obtaining adequate data.

A question that could be raised in connection with the development of the model, is whether it necessary to use all the included intermediate steps. It has in this paper been reasoned that some short cuts may be reasonable. First of all, with certain grouping of the production sectors (and the goods) it is not completely unreasonable to assume that the specific goods are only produced in this group of production sectors. Secondly, we have indicated that there exists a high degree of correlation between production measured as tonnes and production measured in fixed monetary values. The two points could together advocate the use of a direct link from production in the different sectors to the transport of the goods measured in tonnes. One serious objection to this direct linkage is that each of the production sectors produces more than one single group of commodities. Even with an ingenious grouping of both commodities and sectors we cannot create an unambiguous link between production in sectors and production of a specific group of commodities. Conclusions based on this form of biased links can be seriously misleading. One has to bear this in mind when following this path of development.

By the removal of more intermediate links the results are likely to be available, but at the cost of unambiguity of the interpretation of the estimates. E.g. using only the transport performance instead of both the average length of haul and the average load, reduce the number of factors to be estimated, but it becomes unclear whether the development is due to changes in the length of the transports or due to changes in the number of tonnes transported (it might even be both, and they could be leading in opposite directions). In the end it has become harder to describe what is actually happening. The removal of the transformation of production in DKK to production in tonnes is an example, where there is (almost) no loss of transparency.

In general we cannot recommend removing any of the suggested steps, but data quality may induce the use of fewer categories, sectors and perhaps also steps. There do not seem to be a clear-cut answer to this.

We would have liked to be able to present results from using our model. Unfortunately we have not yet completed the actual programming of all the individual elements. It is therefore not possible to carry out these calculations. However, in near future we hope to be able to do this. So far we can only indicate the magnitude of the forecast errors of the model. Looking at the individual elements presented in this paper, we saw that the regression results of some of the elements seemed very poor, and thereby leading to very large errors when model calculations are compared to the actual historical developments. On the other hand, some factors were described very well, and especially the factors of greatest importance when considering the actual transport mostly had very high explainable power.

In general we suspect the worse, but do have hopes for something better. Only extended use of the model can bring us closer to an answer. Of the same reasons we cannot specifically say anything of the accuracy of this model compared to other similar models. As we have indicated we do think this model have some advantages.

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