Explaining the decoupling of freight traffic growth and economic growth

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Abstract

In recent years we have in many European countries seen a decoupling of the growth in freight traffic (vehicle km) from economic growth. A similar decoupling has not been seen in freight transport (tons km).

In this paper we analyse the historical development in freight transport and freight traffic using a decomposition methods described in Fosgerau and Kveiborg (2004). The growth in freight traffic can be attributed to various factors with economic growth as an important factor, but there are also important explanations caused by the development in vehicle size, average load and average length of trips as well as the logistical element of freight transport described by the handling factor, which links produced amounts in tons to tons conveyed.

Through the analysis we point out the impact these factors have on overall development in freight traffic and freight transport. We further demonstrate that overall freight traffic growth is a consequence of often opposite pointing growth effects in the underlying factors. We find that the primary reason for the decoupling of freight traffic growth and economic growth can be attributed to growth in vehicle sizes, increasing average load and less empty running with the vehicles.

Introduction

The interest for freight transport has grown simultaneously with the increasing traffic load on European roads. Many countries use large resources to describe and analyse freight transport through modeling exercises (e.g. Ivanova et al, 2002, Samplan, 2001, Tavasszy et al. 1998, Rand Europe and Transek, 2001, Cascetta, 1997, etc.) and/or through analysis of the impacts of regulation on transport by using kilometer based charges on trucks. For both these purposes it is important to get information about the factors that are most important to describe in more detail and where to focus the efforts in the work. Moreover, decision makers are often interested in getting simple overviews and explanations of what is happening. Many countries have furthermore seen that freight traffic (vehicle km) is growing at a slower pace than economic growth – a decoupling of freight traffic from economic growth.

In this paper we present a simple decomposition method on a model that links economic activity with freight transport (ton km) and freight traffic (vehicle km). The model is similar to the models used in NEI et al (1999) and MacKinnon and Woodburn (1996) and works on a macro economic level. The decomposition method we apply enables us to analyse the importance of a number of different factors that potentially influence freight transport. The decomposition method is described in Fosgerau and Kveiborg (2004).

The analysis is carried out using a unique data set giving information about the economic activities in sectors combined with commodity groups over a period from 1981 to 1997 together with the annual freight transport survey data giving transport volumes (tons, ton km, vehicle km, trips etc.). Moreover, we have information about the economic activities measured in tons. This gives us the possibility to analyse the value density, which is often stated as one of the weakest points in current freight transport models (de Jong et al 2004, Me&P-WSP et al, 2002). The time series forms the basis for our analysis of the development in the various factors influencing freight transport. By this we are able to give some answers to what are the causes for the decoupling mentioned above.

The paper is organized as follows. In the following section we present the basic data sources and the model linking economic activity to freight transport. The section further presents the decomposition method. A section describing the results of applying the decomposition on our data follows this. This leads to a discussion about the decoupling factors. We sum up our findings in the conclusions.

The model

The data we use are

X_{ijt} : The production value in fixed prices in industry *i* of commodity *j* in year *t*.

M_{ijt} : The weight of the production in industry *i* of commodity *j* in year *t*.

L_{jklt} : The tons lifted of commodity *j* in truck size *k* owned by *l* in year *t*.

T_{jklt} Trips with truck size *k* owned by *l* carrying commodity *j* in year *t*.

K_{jklt} Vehicle km with truck size *k* owned by *l* carrying commodity *j* in year *t*.

The data gives production values and values for import and export in fixed prices for 19 industries and 26 groups of commodities in the Danish economy. This information is given for a period covering 1981 to 1997. All values are total accounts based on national make tables. The make tables classify production according to the producing industry and the commodity produced. Similar use tables classify inputs according to commodity and the using industry. The combination of make and use tables leads to the input-output tables. The make table comprises 2900 commodities at the fundamental level; in our data set it has been aggregated according to the NST/R-24 classification used in international trade statistics. These data has been extensively used in other model exercises in e.g. Madsen and Jensen-Butler (1999 and 2002).

The groups are linked to 19 aggregate industries, corresponding to those used in the ADAM model of the Danish economy (Statistics Denmark, 1995), which, i.a., forecasts production values by industry.

The national accounts data are supplemented by information about the production in industries and of commodities measured in tons. This data has been produced by Statistics Denmark (Pedersen, 1999) by looking at each of the 2900 commodities and using available information about the weight of each of these commodities. Often this information is directly available from the national trade statistics, but sometimes assessments have been made, for example of the weight of 100 square meters of carpet etc. This is very time-consuming work, which is why this data is only constructed for six years (1981, 1983, 1985, 1987, 1990 and 1992). We have constructed data for the intermediate years by linear interpolation.

The data also contains transport volumes (tons lifted, trips, ton kilometers and vehicle kilometers) by the same types of commodities. These data are recorded in an annual survey of a sample of Danish trucks. The recorded vehicle kilometers include both transport by own-account and hire-and-reward transport. We do not directly include transport with empty vehicles within the current analysis. However, empty running is included via a mark-up on the vehicle kilometers with loaded vehicles.

We use the data to construct the following variables:

$\omega_{jklt} = \frac{K_{jklt}}{T_{jklt}}$: the average trip length,

$\kappa_{jklt} = \frac{L_{jklt}}{T_{jklt}}$: the average load per trip,

$\varepsilon_{jklt} = \frac{L_{jklt}}{L_{jkt}}$: the share of tons lifted per vehicle size and ownership,

$\sigma_{jkt} = \frac{L_{jkt}}{L_{jt}}$: is the share of the tons lifted per vehicle size,

$\lambda_{jt} = \frac{L_{jt}}{M_{jt}}$: the handling factor,

$\gamma_{jt} = \frac{M_{jt}}{X_{jt}}$: the inverse value density,

$\alpha_{ijt} = \frac{X_{ijt}}{X_{it}}$: the share of production of commodity *j* in industry *i*,

$X_{it} = \sum_j X_{ijt}$: production of commodity *j* by industry *i*.

We can decompose the growth in traffic on these variables. The following calculation of vehicle kilometers (K_t) holds by definition:

$$K_t = \sum_{jkl} K_{jklt} = \sum_{jkl} \frac{\omega_{jklt}}{\kappa_{jklt}} \varepsilon_{jklt} \sigma_{jkt} \lambda_{jt} \gamma_{jt} \sum_i \alpha_{ijt} X_{it} \ . \tag{1}$$

Defining the growth rate in a variable as $\dot{Y} = \partial \ln Y / \partial t$ we can write $\dot{K}_t$ as

$$\begin{aligned} \dot{K}_t = & \sum_{jkl} \frac{K_{jklt}}{K_t} \dot{\omega}_{jklt} - \sum_{jkl} \frac{K_{jklt}}{K_t} \dot{\kappa}_{jklt} + \sum_{jkl} \frac{K_{jklt}}{K_t} \dot{\varepsilon}_{jklt} + \sum_{jk} \frac{K_{jkt}}{K_t} \dot{\sigma}_{jkt} \\ & + \sum_j \frac{K_{jt}}{K_t} \dot{\lambda}_{jt} + \sum_j \frac{K_{jt}}{K_t} \gamma_{jt} + \sum_{ij} \frac{K_{ijt}}{K_t} \alpha_{ijt} + \sum_{ij} \frac{K_{ijt}}{K_t} (\dot{X}_{it} - \dot{X}_t) + \dot{X}_t \ . \end{aligned} \tag{2}$$

This means that we can decompose the growth in traffic on the following factors starting from the left:

$\sum_{jkl} \frac{K_{jklt}}{K_t} \dot{\omega}_{jklt}$ growth in average trip length,

$\sum_{jkl} \frac{K_{jklt}}{K_t} \dot{\kappa}_{jklt}$ growth in average load, this term influences traffic growth negatively,

$\sum_{jkl} \frac{K_{jklt}}{K_t} \dot{\varepsilon}_{jklt}$ growth in the share of tons lifted by ownership,

$\sum_{jk} \frac{K_{jkt}}{K_t} \dot{\sigma}_{jkt}$ growth in the share of tons lifted by vehicle size,

$\sum_j \frac{K_{jt}}{K_t} \dot{\lambda}_{jt}$ growth in the handling factor, this term increases if the logistical chain is increased in number of stops between production and final consumption,

$\sum_j \frac{K_{jt}}{K_t} \dot{\gamma}_{jt}$ growth in the inverse value density, this term is positive if value densities increase,

$\sum_{ij} \frac{K_{ijt}}{K_t} \alpha_{ijt}$ growth in commodity mix in the industries, this term is positive if an increase in the production of transport intensive commodities occurs,

$\sum_{ij} \frac{K_{ijt}}{K_t} (\dot{X}_{it} - \dot{X}_t)$ growth in the industries production, and finally

$\dot{X}_t$ growth in overall production value.

The model is formulated in continuous time. Our data is discrete, hence we approximate by $\dot{Y}_t \approx {}^{Y_t - Y_{t-1}} / {}_{Y_{t-1}}$ for most of the series and by $\dot{Y}_t \approx {}^{2(Y_t - Y_{t-1})} / {}_{(Y_t + Y_{t+1})}$ when the series change to and from zero; the weights K_{jklt}/K_t are furthermore replaced by two year averages in the latter type of series.

We can apply the same type of decomposition to growth in transport (ton kilometer). This model is somewhat simpler as the first four factors are left out and replaced by a single factor β_{jt} relating transport performance to tons lifted.

$$\dot{K}_t = \sum_j \frac{K_{jt}}{K_t}\dot{\beta}_{jt} + \sum_j \frac{K_{jt}}{K_t}\dot{\lambda}_{jt} + \sum_j \frac{K_{jt}}{K_t}\gamma_{jt} + \sum_{ij} \frac{K_{ijt}}{K_t}\alpha_{ijt} + \sum_{ij} \frac{K_{ijt}}{K_t}(\dot{X}_{it} - \qquad (3)$$

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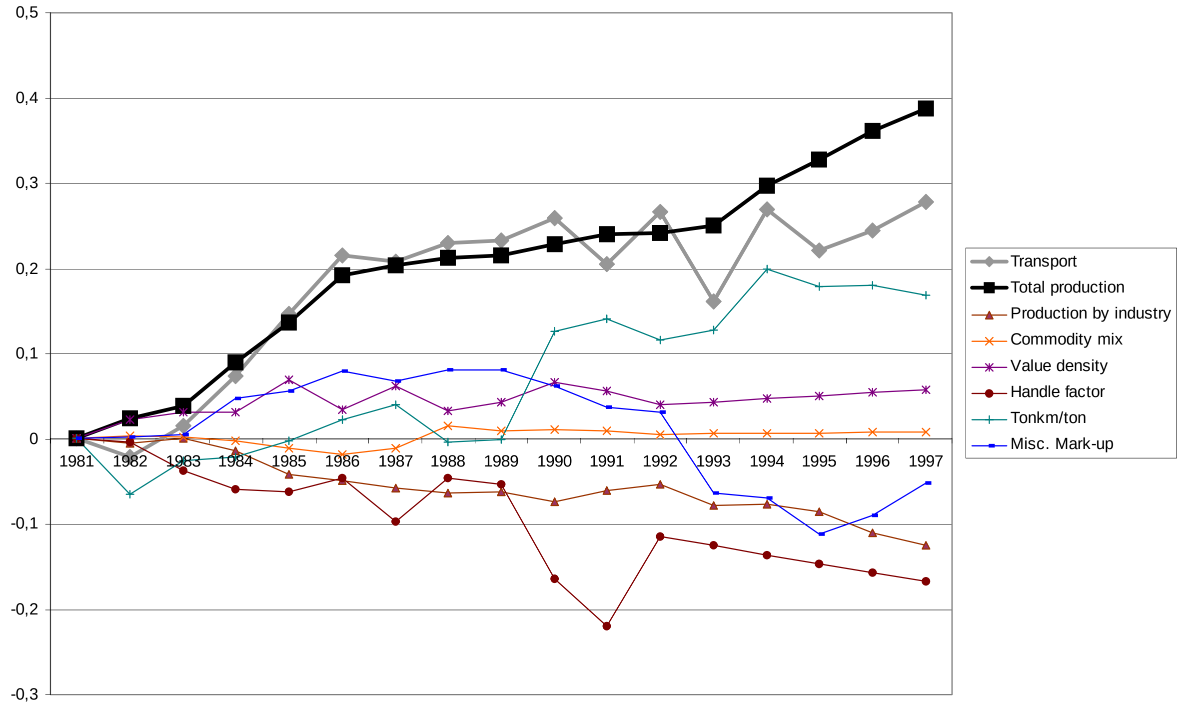

Figure 1 Growth factors contributing to the growth in freight transport.

Decomposing transport and traffic

Transport is measured as a combination of the amount of goods lifted and the distance they are conveyed in the approximation by ton-kilometre. The development in the factors contributing to the growth in freight transport is shown in figure 1. Transport and total production are visibly correlated. However, from the early 90'ties we can see that transport develops slower than total production. The explanations for this tendency are found in the remaining growth factors.

The average annual growth for each of the included factors is shown in table 1.

Table 1 Average annual growth percent for the factors explaining growth in freight transport, 1981 to 1997

Factor	Avg. annual growth Percent	Avg. annual growth Share of tonkm
Total production	2.43	125
+ *Production by industry*	-0.78	-40
+ *Commodity mix*	0.05	3
+ *Value density*	0.36	19
+ *Handling factor*	-1.05	-54

+ *Tonkm / ton*	0.32	49
+ *Misc. mark-up*	-0.02	-1
= *Tonkm*	1.94	100

The most important factor is obviously the total production (2.43 per cent), but the composition of the production across industries is also an important factor (-0.78 per cent). The development in this factor has reduced the growth in freight transport as the production has shifted towards less transport intensive industries (increasing service production). Having accounted for the production across industries we can see that the changes in the commodity mix within the industries only have a minor impact on the development on freight transport (0.05 per cent). We similarly find that the inverse value density only has a minor influence on the growth (0.36 per cent) and that most of this growth can be attributed to 1981 to 1983.
The remaining two factors are both relatively important in explaining the transport growth. First we can observe that the handling factor is decreasing (-1.05 per cent). This is an indicator of a more smooth logistical chain. The produced goods are involved in fewer individual trips, which reduce the amount of transport. There are many elements that influence this particular factor. The production and the transport logistics with the use of further sub-contractors, distribution centers etc. are some of these elements. However, there are also two issues related to the data quality. First we note that the handling factor combines the two different data sources; national accounts and travel diaries. The first is the product weight without wrapping whereas the latter includes wrapping. This affects both the size of the handling factor and the development as the amount of wrapping changes. Secondly, note that the transport statistics contain only national transports and not transports crossing Danish borders. This also influences both the size (through a lower handling factor, when some products are transported directly to abroad) and the development due to changes in the amount going directly to a destination abroad. The decreasing handling factor influence could thus indicate that more transports go directly from producer to its final destination and crossing a border on the way. We cannot say anything about this development using our data, but only indicate that this is a problem that should be investigated further.
The penultimate factor in table 1: *tonkm per ton* is a proxy for the trip length. It is increasing and is thus leading to a higher growth in transport. However, the factor is only a proxy for this. *Tonkm* are found as a calculation per trip (*ton* times *km*), and a calculation of total tonkm divided by total tons does not give the same amount of vehicle kilometers. The influence from this factor is also minor (0.32 per cent).
Finally, we note that the changes in the transport performance with miscellaneous goods do not influence the aggregate transport performance with an average annual growth rate of only -0.02 per cent.
We noted above that freight transport measured as ton kilometer, is a composite measure combining both weight and distance. But both the total tons lifted and the total distances are increasing so we need to go into more details to get some indications of the importance of the two. This can be accomplished by looking at the vehicle kilometer (freight traffic). Applying

the decomposition in (1) we get the average annual growth rates shown in table 2. The related historical accumulated growth is shown in figure 2.

Table 2 Average annual growth percent for the factors explaining growth in freight traffic (vehicle km), 1981 to 1997.

Factor	Avg. annual growth Percent	Avg. annual growth Share of veh.km
Total production	**2.43**	**301**
+ Production by industry	**-0.95**	**-118**
+ Commodity mix	**-0.22**	**-27**
+ Value density	**0.39**	**49**
+ Handling factor	**-1.11**	**-138**
+ Truck size	**-1.09**	**-135**
Small trucks	-2.52	-312
Large trucks	1.43	177
+ Ownership	**0.52**	**64**
Own account, small trucks	-0.16	-20
Own account, la rge trucks	0.42	52
Hire and rew., small trucks	0.36	44
Hire and rew., large trucks	-0.10	-13
+ Average load	**1.06**	**-131**
Small trucks	0.93	-116
Large trucks	0.13	-16
+ Average length	**2.04**	**253**
Small trucks	1.78	221
Large trucks	0.26	32
+ Miscellaneous mark-up	**0.15**	**18**
+ Empty running mark-up	**-0.28**	**-35**
= Vehicle km	**0.81**	**100**

The table contains a division of the effects on the size of the vehicle in the categories where this is relevant to enable us to go into more depth of this part of the analysis. However, in figure 2 we have not included this differentiation to avoid to many curves and to ease the reading of the figure.

Again we find that the total production has a strong influence on the development of freight traffic (vehicle km). Having accounted for the composition across industries we find that the composition of the individual commodities only contributes by a small amount to the overall growth. We further find that the average growth rates for the *handling factor* (-1.11 pct.), *the truck size* (-1.09 pct.), *the average load* (1.06 pct.) and *the average length of haul* (2.04 pct.) are larger than the average growth rate in freight traffic (0.81 pct.). This emphasizes the importance of accounting for the influential factors when explanations for the developments in freight traffic (and transport) are to be found. Failing to account for the development in the underlying factors, when they are of this magnitude could lead to misleading forecasts.

We find as expected that the handling factor has a negative impact on the vehicle kilometers because the number of trips per unit of a good is reduced and thus leading to fewer kilometers. We also find that the truck size has a significant reducing impact on the vehicle kilometers. The factor is calculated as the share of the tons lifted by small and large trucks respectively. We see that the influence from the share of tons lifted by small trucks is negative while the influence from large trucks is positive. This implies that small trucks lift relatively fewer tons. The factor remains to have a significant impact because the total load on small trucks is still very large. We do not see changes in the growth factor for neither the small nor the large trucks (figure 2); they both show a relatively steady pattern over time with negative growth rate for small and positive for large trucks.

We do not see similar clear patterns with respect to the growth rates in vehicle ownership. There is a small shift from small company owned trucks to small hire-and-reward trucks and an opposite shift from large hire-and-reward trucks to company owned large trucks.

The two remaining influential factors are the average loads and average length of haul. The average load is increasing with a reduction in the vehicle kilometers as the outcome. However, the increase in the average load is more than offset by the growth in the average trip length where the small trucks contribute by most of this growth.

It is interesting to note that the growth in empty running is negative. Hence, the utilization of the vehicles is increasing. However, the growth is moderate.

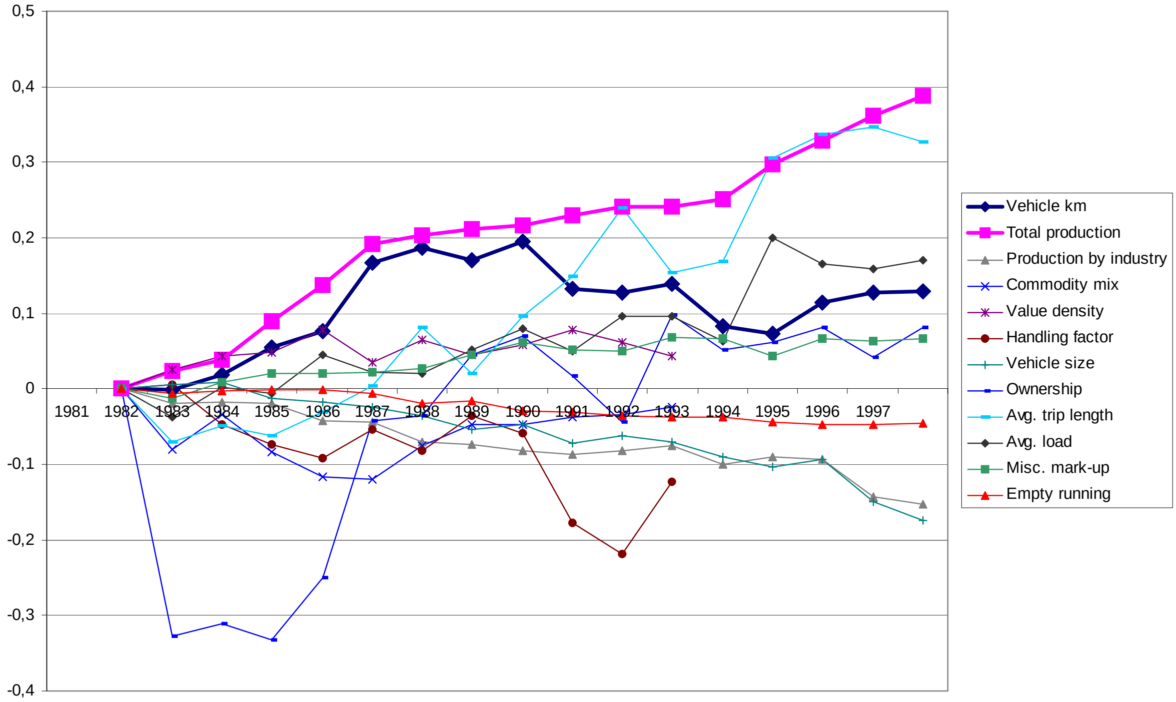

Figure 2 The historical decomposition of freight traffic (vehicle km) 1981-1997.

Decoupling freight traffic

The comparison of table 1 and 2 can help us understand the apparent decoupling of freight traffic from economic growth. The main difference in the growth rates in the two measures of transport (vehicle kilometers and ton kilometers) lies in the factors not included in the decomposition of the ton kilometers, as the first economic growth factors are similar in size.

In the previous section we noted that the moderate growth in vehicle kilometers was not caused by a large reduction in empty running vehicles. However, the utilization of the vehicles is increasing both due to reduced empty running and due to a larger average load having controlled for the size of the vehicles. The latter effect is primarily seen within the group of small vehicles. We should note here that the increasing load factor could be the result of a shift towards larger vehicles within the group of small vehicles. We cannot use our data to verify this conjecture. Nevertheless, the outcome is the same, namely that fewer kilometers are registered in order to convey the same amount of goods. Note also that the vehicle size does not have an effect on the ton kilometers where 10 tons conveyed 1 km on one truck leads to the same number of ton kilometers as 10 tons conveyed 1 km by 10 vehicles carrying one ton each. Hence, the utilization of the vehicles does not influence the transport performance (ton km).

We further note that also the average distance per trip is increasing for small vehicles. This could be an indication of a centralization of distribution centers or storage facilities, where smaller vehicles are used for local distribution. However, as fewer distribution centers are used this increases the average distances. This is an effect that is contributing to maintain the high influence from the growth rate in the share of tons lifted by small vehicles, because the relative share of vehicle kilometers on small trucks weighs this growth rate.

Conclusion

In this paper we have applied a decomposition method first described in Fosgerau and Kveiborg (2004) on a Danish data set in order to analyse factors driving the development in freight transport and freight traffic. The decomposition methodology is a simple way to get useful insight in the different factors that determine the development in an aggregate measure.

We have found that the development in freight transport (ton km) is highly driven by the economic development, whereas freight traffic (vehicle km) shows a moderate growth rate compared to the economic development. The decomposition methodology applied in the paper enables us to show that this difference can be attributed to the utilization of the vehicles (empty running decreasing and average load factors increasing) as well as a shift towards the use of larger vehicles. None of these factors would influence the ton km directly[1].

We have further found that some factors are less influential on the development of freight transport and traffic. Especially the commodity mix in the industries and the value to weight ratios are two of these factors. It is interesting to note that the commodity mix has so little influence especially because it is the difference between various commodities that are the

[1] A minor indirect effect could be that using larger vehicles would introduce some free loading capacity which could be sold at very low prices and hence induce more demand for transport and thus increase the number of ton km.

reason for different transport solutions. This is a result of the distribution of the production by industry, where the changes in the commodity production within the industries are relatively small and thus without influence on the changes in transport. An implication for this is that industries are close proxies to the actual commodity groups.

The relatively unimportant changes in the value densities are the result of a clever price-quantity deflator. In the Danish national accounts the Passche index is used, which ensures that the deflated fixed prices are very good quantity measures. Hence, it may not be that necessary to put huge efforts into the calculation of appropriate value densities contrary to the suggestion by De Jong et al. (2004). This applies especially to the freight models based on either input-output and to CGE economic modeling as the basis for the demand for freight transport. Such models involve a transformation from trade flows in monetary terms to transport flows in tons. This transformation involves both the value densities and the handling factor. Our analysis indicates that it may not be so problematic to use a composite transformation factor.

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