

Pastowski, Andreas

Working Paper

Decoupling economic development and freight for reducing its negative impacts

Wuppertal Papers, No. 79

Provided in Cooperation with:

Wuppertal Institute for Climate, Environment and Energy

Suggested Citation: Pastowski, Andreas (1997) : Decoupling economic development and freight for reducing its negative impacts, Wuppertal Papers, No. 79, Wuppertal Institut für Klima, Umwelt, Energie, Wuppertal,
<https://nbn-resolving.de/urn:nbn:de:bsz:wup4-opus-5651>

This Version is available at:

<https://hdl.handle.net/10419/49149>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.



Andreas Pastowski

**Decoupling
Economic Development
and Freight
for Reducing its
Negative Impacts**

No 79 · September 1997
ISSN 0949-5266

Wuppertal Papers

Acknowledgement

This is the extended version of a paper entitled "Sustainable Freight Transport: Ideas on Decoupling of Economic Development and Freight Transport" which has been presented at the Workshop "Environmentally Sustainable Transport Systems" that was organised by the Foundation for Strategic Environmental Research and held in Amsterdam, 3 - 4 December 1996. The author is grateful to Richard Gilbert (Centre for Sustainable Transportation, Toronto), Allan McKinnon (Heriot-Watt University, Edinburgh), Lee Schipper (IEA, Paris), Peter Wiederkehr (OECD, Paris), Stefanie Böge, Friedrich Hinterberger, Rudolf Petersen and Hartmut Stiller (all Wuppertal Institute) for comments on earlier versions. Gunnar Gohlisch and Michael Strogies (both Federal Environmental Agency, Berlin) were helpful in providing current data on emissions. All remaining errors are entirely the author's responsibility. Further comments are particularly welcome to the coordinates given below.

Andreas Pastowski, Wuppertal Institute for Climate Environment and Energy, Döppersberg 19,
D-42103 Wuppertal, Germany

E-mail: a.pastowski@wupperinst.org or: a.pastowski@t-online.de

Phone: +49 (0)202 2492-118

Facsimile: +49 (0)202 2492-108

Abstract

This paper takes a look at the development of freight transport and its further perspectives in the light of environmental sustainability. It clearly challenges the traditional view that further growth in freight transport is indispensable whatever stage of economic development an individual economy has achieved. Moreover it suggests measures to be taken into consideration in sectors other than the transport sector which may help to break the trend of continuing freight transport growth. Current developments of freight transport volume and modal split are rather counterproductive as regards curbing the unwanted environmental impacts. As growth in volume is a major contributing factor for most adverse effects caused, a substantial decoupling of economic growth and freight transport would be extremely helpful. While freight transport activity is almost entirely derived demand there can be no sufficient solution for the resulting environmental problems within the sector itself. Therefore, it is necessary to examine potentials for reducing demand for freight transport in all sectors of the economy. Contrasting to the widely held view that freight transport is in general an inevitable prerequisite of economic development, there are potentials for reducing the freight intensity of the economy which could be far more exploited. Such potentials are increasing the share of regional production, slowing down the metabolism of materials in the economy, and substituting transfer of information for transport of physical products. While each of these potentials on its own may appear to offer limited effects, a proper combination might yield substantial results. The presented preliminary ideas suggest that the notion of everlasting freight transport growth is misleading and hint at the necessity for further research.

Decoupling Economic Development and Freight for Reducing its Negative Impacts

Andreas Pastowski

„Whether for freight or for personal mobility,
demand for traffic, as for energy or water
or weapons, is not fate but choice.“

Amory B. Lovins (1995)

1 Introduction

The seemingly unlimited growth of transport that is taking place in many industrialised and highly motorised countries is not in tune with the objective to achieve an environmentally sustainable economy. These countries cannot serve as examples for the so-called least or less developed countries if the natural environment is not to be sacrificed for a misleading kind of mobility. In the past the transport sector has played the role of an exceptional case with respect to many adverse impacts on the environment. Achievements which have been made in other sectors were by large counterbalanced by the ever growing contributions from the transport sector. Thus, the part played by transportation in causing many environmental problems has grown considerably.

Freight transport imposes a variety of significant burdens on society and the environment. There is no doubt that a further increase of freight transport activity will induce additional environmental pressures that nobody wants. Improvements within the freight transport sector like increasing vehicle energy efficiency, upgrading of emission tail pipe technology, and increasing capacity utilisation as well as shifting transport demand to more environmentally sound modes, will be necessary but not sufficient to tackle the problems that will arise from a continuation of growth in freight transport activity.

In order to pave the way to sustainability a shift from the old paradigm of continuing transport growth as a so-believed prerequisite of economic and societal development to managing transport demand is required. There are fundamental barriers in terms of economic structure and people's attitudes that need to be overcome to accomplish such a change. Therefore, it is necessary to demonstrate that economic restructuring in the direction of a substantially reduced transport intensity is not only imaginable but socially preferable and may even yield economic advantages.

The idea to reverse the trend of growing freight transport activity is rather controversial in a world that only experienced growth during the preceding decades and that will be further shaped by increasing economic globalisation during the decades to come. There is a widespread belief that freight transport is a necessary prerequisite of economic development and that, consequently, the adverse impacts of freight transport are the price we have to pay for its benefits. This belief is strongly suggestive of the state of discussion we had about fifteen years ago as regards energy consumption and economic development.

At that time it was argued that further growth in energy consumption would be indispensable for economic development (Häfele et al., 1981). Until now it has been practically demonstrated that decoupling of economic growth and energy consumption is possible. This happened even though energy use in the transport sector grew significantly. The underlying assumption of this paper is that there are decisive analogies between both the derived demands energy and transport which suggest that a decoupling of freight transport and economic growth is possible in a way similar to that demonstrated for energy consumption (Peake, 1994).

Some previous work defines decoupling of traffic growth and economic development as reducing the overall costs, including those associated with the adverse environmental effects of a given volume of transport activity (p-km, t-km), by taking measures which make transport more efficient mainly in terms of reducing the required vehicle-kilometres (Baum, 1995). In the light of persistent growth in freight transport activity, such an approach is necessary but not sufficient to achieve major improvements in the environmental balance of the transport sector. In contrast, decoupling of freight and economic development is defined in this paper as reducing freight transport activity per unit of gross domestic product in a way that leads to a diminished growth in freight or even a reduction of overall freight transport activity measured in tonne-kilometres. While the former definition is based on the notion that curbing freight transport activity in t-km can only be achieved at the expense of reduced economic efficiency, the latter definition assumes that economic efficiency can be achieved to the same extent or can even be increased through economising on freight.

Following this introduction, section 2 gives a brief overview of current trends in freight transport taking Germany as an example, while section 3 sheds light on the significance of growth in freight in the determination of the transport sector's increasing share in causing environmental problems. Section 4 briefly discusses the part that freight plays in the economic process and argues that its economic significance may vary according to the stage of development an individual economy has achieved. In order to underscore this, section 5 gives some examples where freight transport currently occurs but appears to be inessential from a macroeconomic perspective. Section 6 enumerates the main potentials for economising on freight and section 7 draws some preliminary conclusions.

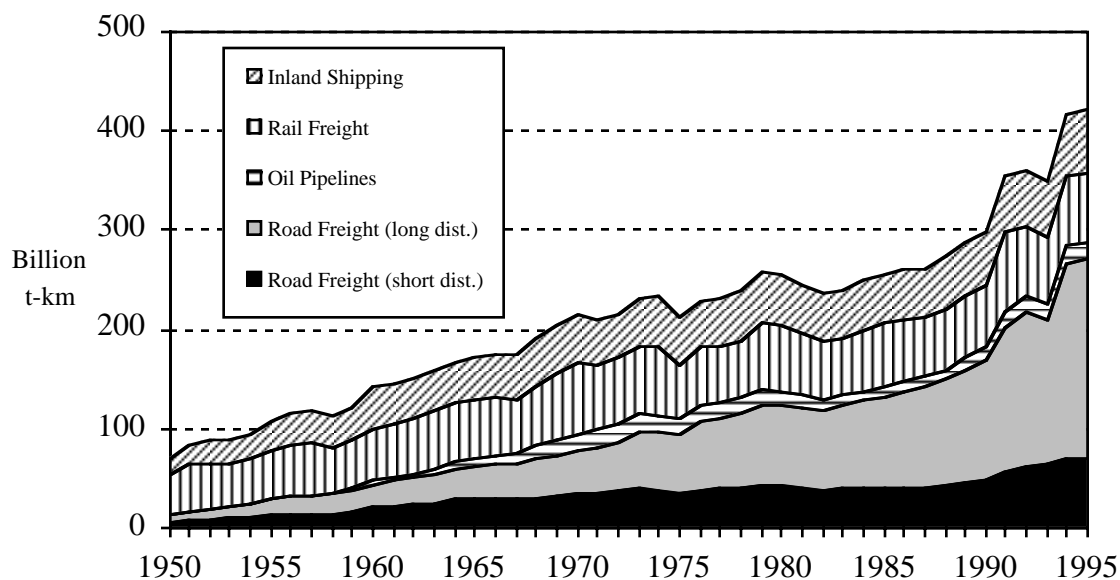
2 Trends in Freight Transport

During the decades following World War II freight transport was more or less on a similar growth path as GDP in real terms in most industrialised countries even though modal shares vary substantially between countries (Schipper et al., 1997). Owing to the similarities between the various countries regarding the freight intensity, the brief analysis of freight transport development and its environmental consequences in this section is mainly based on German data.

It needs to be noted that German data on freight transport activity are slightly distorted (starting with the 1991 figures) owing to the reunification of the formerly separated parts of the country, but provide some understanding of the potential results of the broader process of economic integration between western and eastern Europe. Further data and analyses which are useful for international comparisons are available elsewhere (ECMT, 1997a, 1997b, Schipper et al., 1997).

Air cargo and freight transport by maritime shipping are disregarded. Air cargo, although rapidly growing and being a problem in its own right owing to excess radiative forcing caused by aviation, still makes up only a minor share in freight. As such hauls must not necessarily touch domestic ports and airports, the usability of available data is substantially reduced. Moreover, contrasting to personal travel which may easily be allocated to countries according to the nationalities of people travelling, international freight is difficult to allocate.

Figure 1. Growth of freight transport activity in Germany *

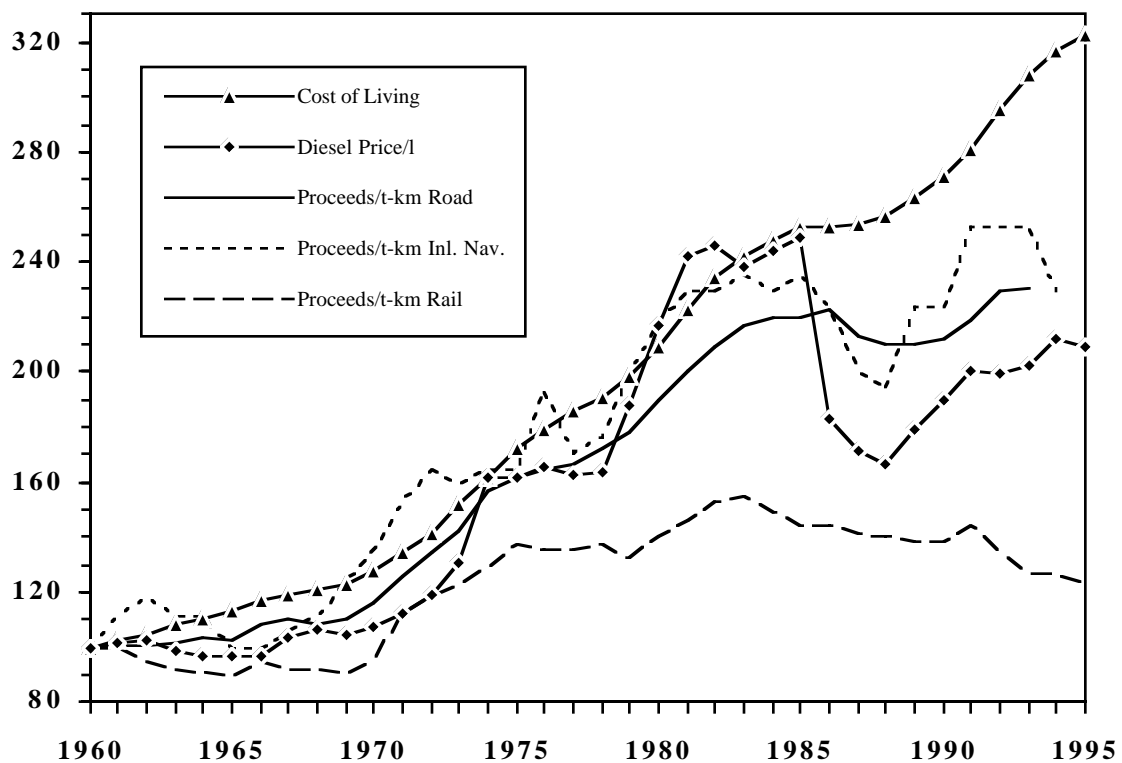


* Air cargo and freight transport by maritime shipping are disregarded. Since 1991 figures refer to the new territory. 1993 figure for short distance road freight is interpolated. Source: DIW (1991; 1996).

In the case of Germany inland freight transport to a certain extent comprises international freight not related to inland activities, while at the same time some portion of freight related to such activities is taking place abroad. In this paper it is assumed for reasons of simplicity that related transport activity abroad approximately equals that of such hauls which only travel through the German territory in transit. Thus the following considerations are restricted to freight transport within the German borders excluding air cargo.

Figure 1 reveals that inland freight transport activity in Germany as defined above in tonne-kilometres has roughly reached six times the amount of 1950 in 1995. Growth in freight has largely been a steady development except for fluctuations resulting from the business cycle and a rapid increase to a higher level following reunification. The share of road freight and notably long distance road freight, which is an important determinant for freight energy use, has grown considerably. However, modal share in freight is not the focus of this paper.

Figure 2. Economic trends in freight transport (indices 1960 = 100) *



* Cost of living index estimated for 1960 and 1961. All other indices are based on nominal monetary figures. Average price for Diesel at the filling station including VAT and mineral oil tax. The statistical figures of the proceeds per t-km of long distance road freight, rail freight and inland navigation are used as proxies for the costs of these modes of freight transport. Source: Various sources; own calculations.

One important reason for the continuing growth in freight transport activity is that its real cost has shrunk during the last decades. Figure 2 shows that the average cost of living has increased at a higher rate than that for Diesel fuel at the filling station, or the proceeds of different modes in freight which serve here as proxies for unavailable cost figures. The proceeds of inland navigation started from a very low level so that the increase is not very high in absolute terms. The increase in the proceeds from road freight was more profound than for rail because road freight offered more and more services which are complementary to freight forwarding. During recent years the proceeds from all modes have come under pressure owing to the gradual liberalisation of freight transport markets in the European Union. This cost development works as an incentive for deploying freight transport to an increasing extent and is not in tune with the growing significance of freight in terms of externalities caused.

According to Figure 3 transport intensity of GDP in real terms and for all inland freight transport dropped slightly in Germany between 1960 and 1990. While GDP in real terms grew by 152% during that period of time, growth of inland freight lagged behind at 111%. Thus, freight transport increased at a slightly lower rate than GDP in real terms, a development that is fairly in tune with what has been observed for the U.S. between 1970 and 1991 (Lakshmanan, Han, 1997) and various other industrialised countries (Schipper et al., 1997). After the German reunification with the former German Democratic Republic (GDR) in 1989 transport intensity of GDP rapidly reached roughly the 1960 level again. This can partly be explained by the reunification itself even though similar increases in freight transport activity and in GDP might have been expected which would not have influenced transport intensity.

In contrast, activity in the construction sector rose significantly, be it for the demolition of obsolete industrial plants or for new industrial plants, housing and infrastructure. Moreover, consumers in the former GDR largely shifted demand to products being produced with overabundant production capacities in the western part of Germany, which to a certain extent contributed to the decline in production in the eastern part. Simultaneous to economic integration within Germany economic integration on a larger geographic scale started in Europe, partly resulting in more freight transport related to economic activity in Germany or in transit through the German territory.

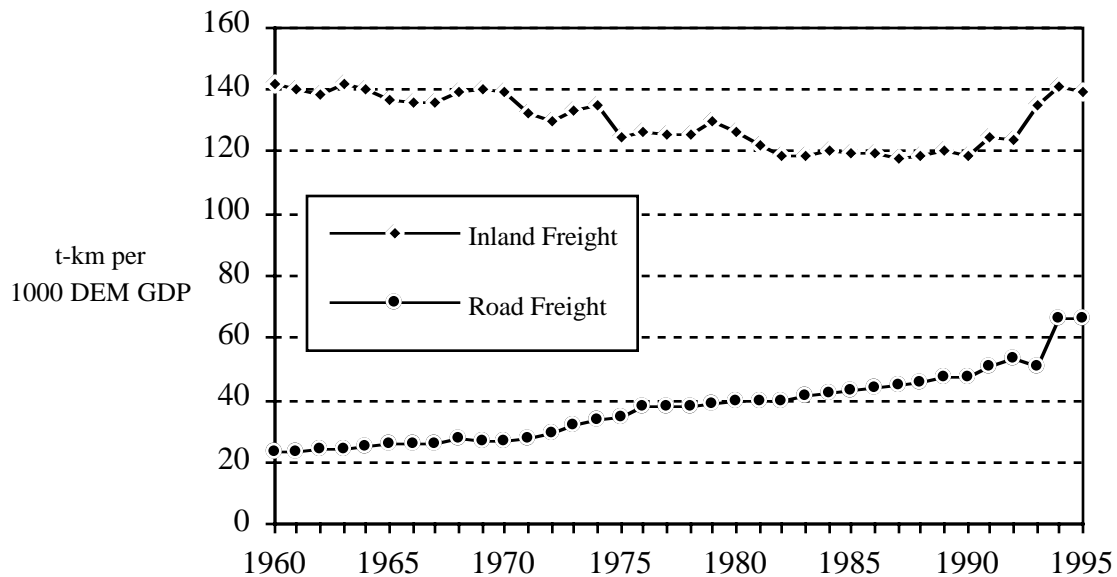
The fact that GDP forms part of a transport intensity indicator may be criticised owing to the severe shortcomings of GDP as an indicator for welfare. However, GDP in real terms is used here as a measure for economic activity which should not be confused with welfare and, moreover, offers the advantage of broad availability. Nevertheless, it needs to be noted that using an indicator for transport intensity based on net economic welfare instead of GDP would result in an increase in transport intensity due to the substantial externalities arising from economic activity in general and notably those caused by freight. As externalities have increasingly caused net

welfare to fall short of GDP during the past decades, it is obvious that transport intensity based on net welfare must have increased. Therefore, proper interpretations of both types of indicators for Germany are as follows: While transport intensity in terms of economic activity has decreased slightly until the German reunification, it has increased in terms of net welfare.

Disregarding the extraordinary development following reunification, the long-term trend for Germany has been that freight transport activity grew at a smaller growth rate than GDP in real terms. However, there has been steady and substantial linear growth in freight. These trends demonstrate that up to now a decoupling of economic activity and freight transport cannot be observed. In contrast decoupling of freight transport and economic activity would mean that increases in the latter do not result in increases in the former. Ideally, the decoupling should be such as to allow economic activity to grow and the amount of freight transport to decline.

A development that is in tune with decoupling might have been expected for Germany owing to the structural change of the economy towards smaller contributions of the primary sector (agriculture, production and processing of raw materials) and the secondary sector (industrial products), and larger contributions of the tertiary sector (services) to overall GDP assuming that freight transport intensity is significantly lower for services.

Figure 3. Freight transport intensity of GDP in Germany *

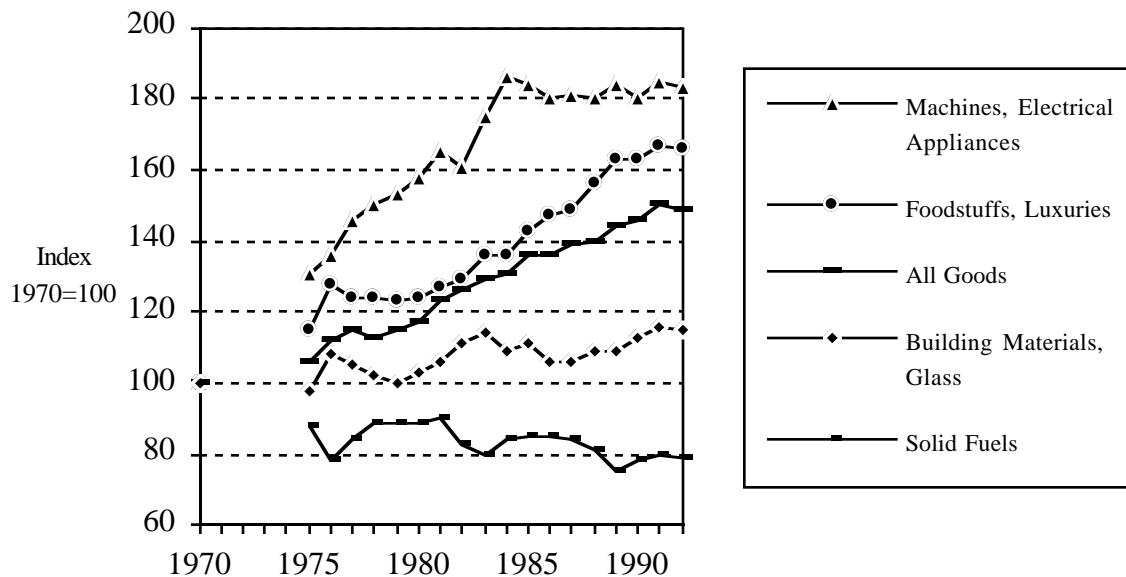


* GDP in real terms at 1991 prices. Since 1991 figures refer to the new territory. The category road freight excludes short distance hauls. Source: DIW (1991, 1996); Statistisches Bundesamt (1996); own calculations.

The outcome of related research is that there has been a slight decrease of transport intensity resulting from changes in the sectoral composition of the economy. The elasticity of transport intensity as related to the share of the tertiary sector has been calculated to amount to - 0.3. This means that an increase of the share in the tertiary sector by 1% results in a decrease in transport intensity by 0.3%. However, this did not significantly influence transport intensity because other influencing factors dominated (Baum, 1995; WEC, 1995). A reason for this may be that transport intensity per unit of product rose for most industrial branches of the economy (see Figure 4 and Rommerskirchen, 1997).

Statistical trends provide evidence for the hypothesis that freight transport is on a growth path closely related to increasing GDP in real terms. However, results of statistical analyses of time-series cannot be taken as laws of nature, and relationships between macroeconomic aggregates can quite well change over time. Although there has been a strong statistical relationship between GDP and freight transport activity in the preceding decades, this is no proof that a continuation of this trend is to be expected or even that no other paths of development are conceivable and will be feasible if proper measures are taken.

Figure 4. Changes in the transport intensities of different products *



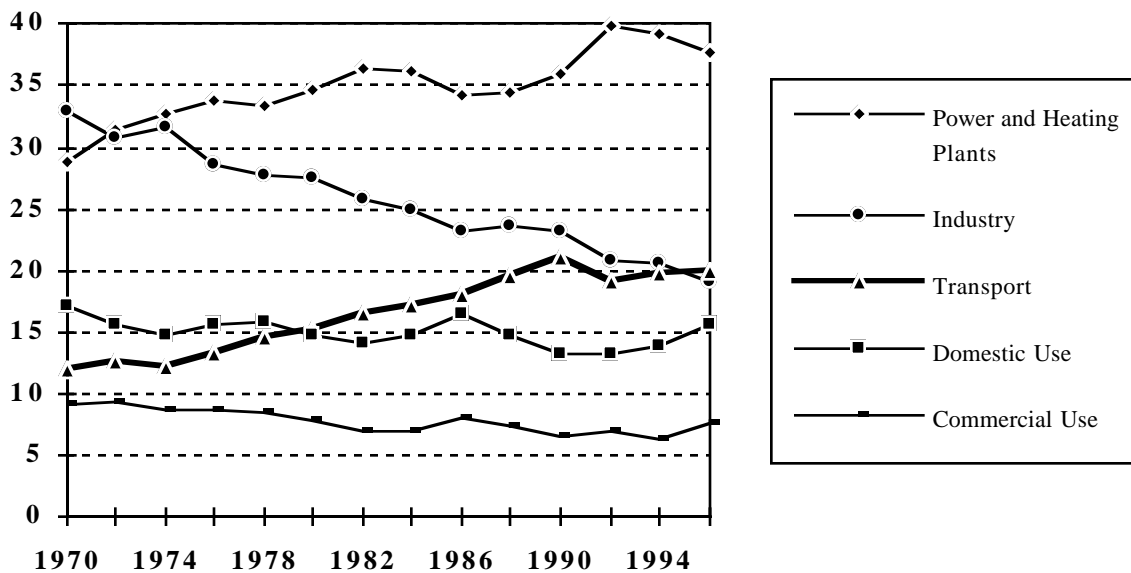
* T-km per unit of product including rail freight, inland navigation, pipelines and long-distance road freight. All figures refer to the territory of the former FRG. Source: DIW (1996).

3 The Environmental Significance of Growing Freight

Freight transport contributes to global warming and various forms of air pollution which are environmental or health concerns, it is a major source of transport related noise, affects the quality of life in cities and increases the risk of citizens to suffer from accidents. Most of these adverse effects can only be mentioned here without going into the details. Although we will see substantial improvements in the future regarding pollutants like NO_x, CO, VOC and particulate matter stemming from the operation of vehicles through upgraded emission tail pipe technologies, this will not help in tackling problems like emissions of CO₂, resource use, noise, accidents, and land use for transport in conurbation.

Figure 5 reveals that the share of transport in overall man-made CO₂ emissions has steadily grown in Germany. It needs to be taken into account that the figures for transport completely exclude international transport that is related to Germany. This is particularly important in case of aviation which is rapidly growing. In 1996 the transport sector already accounted for a higher share of overall CO₂ emissions than the industrial sector. It needs to be noted that the decline of the transport sector's share in 1992 is due to the reunification and lower per capita transport energy use in the former GDR.

Figure 5. Changes in the shares of various sectors in man-made CO₂ emissions in Germany (shares in per cent) *

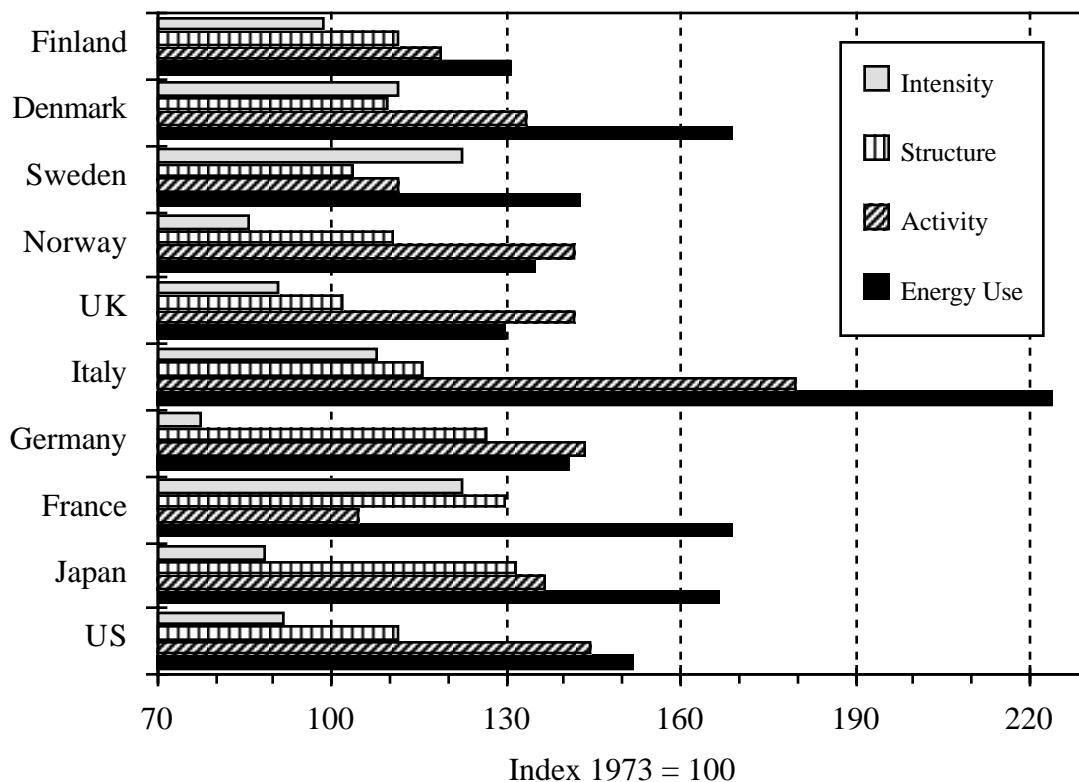


* CO₂ emissions resulting from energy use and industrial processes. Figures for transport exclude international aviation, coastal and maritime shipping. Since 1992 figures refer to the territory after the reunification. Source: DIW (1996) and personal communication with the Federal Environmental Agency (1996 figures).

In 1996 the share of freight transport (excluding the use of light duty vehicles which cannot easily be allocated to personal travel and freight) accounted to roughly 24 % of the total CO₂ emissions of the transport sector in Germany. Its contribution to overall growth in transport-related CO₂ emissions is substantial owing to higher growth rates in freight than in personal travel during the nineties. Most transport forecasts also predict higher growth rates in freight than in personal travel. Moreover, the potential for reducing energy use per vehicle-kilometre through introducing technical measures for improved energy efficiency is smaller for vehicles used in freight than for passenger cars.

The mentioned negative side-effects of freight are more or less closely linked to transport activity, which has also been the dominating determinant of increasing energy use for freight in the past. Figure 6 is the result of a Laspeyres decomposition, indicating the relative changes in freight energy use in ten industrialised countries, and identifying the parts the three major influencing factors have played in the past (Schipper et al., 1997).

Figure 6. Changes in freight energy use in selected industrialised countries and influencing factors (1973 to 1992)



Source: Schipper et al. (1997)

The indexes for energy use show how overall freight energy use grew in relative terms for the countries and period considered. The figures for activity, structure and intensity reveal how overall energy use would have changed resulting from variations of each factor if the respective other factors had remained unchanged as compared to the base year. Activity refers to variations in transport activity in tonne-kilometres, structure to changes in the shares of transport modes used, and intensity to changes in energy efficiency related to technological features of used vehicles and operational factors.

The message is that with the exception of Sweden and France growth of freight transport activity has been the most important driving force for increased energy use for freight. Changing structure in terms of modal share mostly in favour of less energy efficient road freight has also contributed to higher freight energy use. Increases in energy efficiency of modes being used have not been overwhelming but in the case of Norway, the UK, Germany, Japan and the US have to a varying extent offset some effects of changes in activity and structure. The resulting changes in CO₂ emissions are comparable in magnitude for most of the considered countries but CO₂ emissions also vary according to the composition of energy carriers used for freight.

Even though the environmental consequences of freight transport are directly determined by kilometres travelled by vehicles deployed under certain operational conditions, freight transport activity is an important indirect determinant of negative environmental side-effects of freight. It can be expected that besides energy use and CO₂ emissions the environmental consequences of freight transport are by no means curbed by growing freight transport activity. Efforts being made in terms of upgraded vehicle technology, improved operation of transport modes and a (potential) shift of demand towards more environmentally sound modes can easily be counter-balanced by growth of freight (OECD, 1995). Notably for the attainment of reduction targets for CO₂ emissions it can be argued that delinking economic growth and freight transport activity will be necessary (Silvestrini, 1996). This underscores the significance of freight transport activity in tonne-kilometres for achieving future reductions of environmental problems related to freight transport.

4 The Role of Freight Transport in the Economic Process

Transport of freight is essentially a derived demand which means that it is not demanded in its own right but as a consequence of decisions basically related to production or consumption of goods or services (Cole, 1987). The same applies to transport infrastructure which in most cases forms part of public capital and complements private capital (vehicles) in producing transport services (Bell, Feitelson, 1991). As an intermediate service, freight transport activity is often felt to be a side-effect of a variety of causes which cannot easily be grasped. Conse-

quently, growth in freight transport is more or less considered as being society's fate and something that cannot be influenced beyond what is taken into account based on market prices and quality of service. Therefore, a fatalistic view on the further growth of freight dominates, and most efforts to improve the environmental performance of the freight transport sector concentrate on introducing less polluting technologies and changes in operational conditions, or on shifting demand towards more environmentally sound modes (Pastowski, 1996).

The necessity of transport may not be overestimated more than by saying that "restricted mobility is inevitably a brake on development, in every sense" (Hoyle, Knowles, 1994). In tune with such reasoning there is a widely-held belief that freight transport contributes to the performance of an economy in a unique manner that is not relevant in the case of other sectors. Most recently it has even been calculated for Germany that the contribution of passenger and freight transport to overall economic growth in the period 1950 - 1990 amounted to 48.8 per cent (Baum, 1997), which seems to be rather unlikely in an intensely interwoven economy in which the performance of all sectors is highly dependent on that of others. For instance, since most economic activity and most notably that of the transport sector in some form or another is dependent on the utilisation of energy, it might be claimed in a similar way that at least as large a portion of total GDP (including all activity of the transport sector) is entirely due to the performance of the energy sector. This clearly reveals that it doesn't make sense to allocate economic growth to single sectors unless it directly takes place there.

Even though it is clear that freight transport is necessary in principle, this does not serve to legitimate any volume of freight that may arise in a laissez-faire situation, i.e. in the absence of its negative external effects being internalised and moreover, contrasting to laissez-faire, with significant public funds being dedicated to subsidise transport infrastructure in general and most notably for road freight. Although most of the mentioned notions in favour of freight transport are not completely wrong, they will become rather flawed if used to discredit any considerations that aim at reducing demand for freight transport for environmental reasons in industrialised countries.

Taking a look at human history reveals that freight transport has been something extraordinary for most of the time. In the ancient hunter and gatherer society it was up to human beings to move from one place to another in order to provide for the things they needed for themselves or for their cattle. In ancient history, following the neolithic revolution with growing numbers of human beings living in settlements, freight transport was still rather exceptional owing to the difficulty and cost of long-distance traffic. Thus for most of the time in human history transport of goods simply did not exist or was limited to greatly needed but not easily accessible goods (e.g. salt, water) or selected luxury goods (e.g. spices, silk). In an economy that is largely

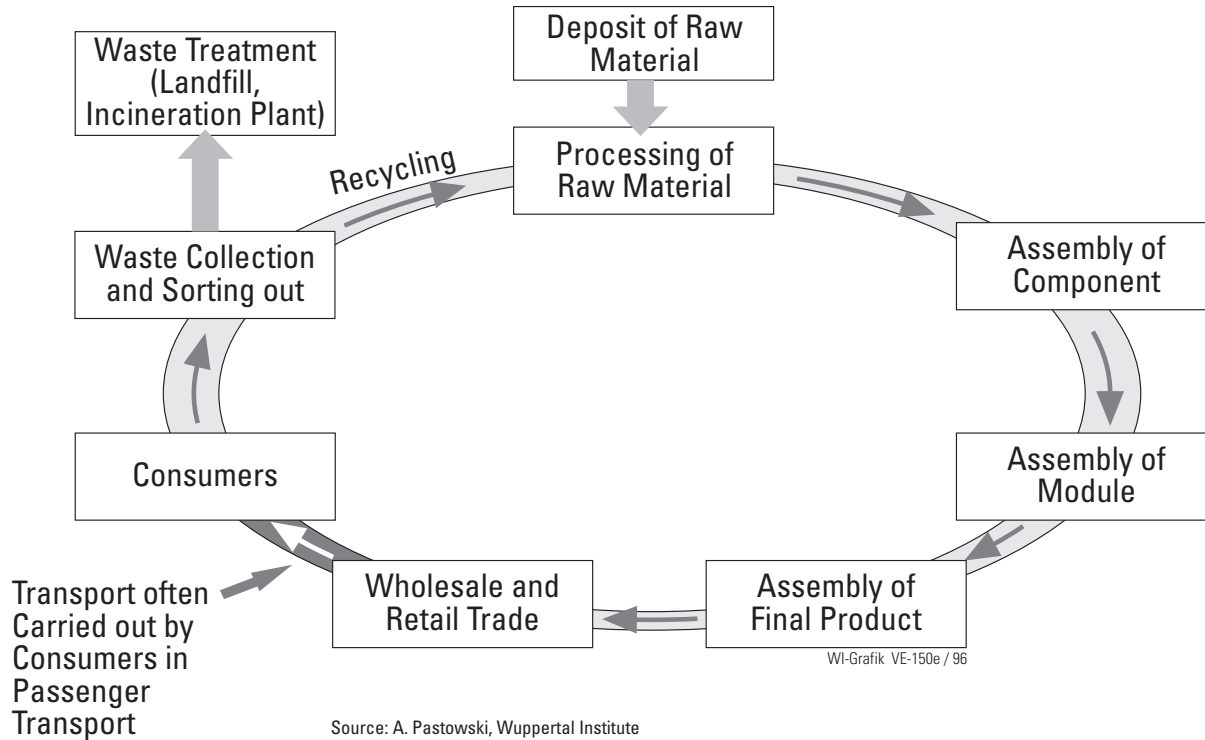
based on self-support and on material inputs being supplied from within the vicinity of settlements, freight transport is rather superfluous.

With the development of a more differentiated division of labour and the related increase in the scope of products being used for every-day life, as well as with human settlements spreading into areas not apt to provide for all the things necessary for production and consumption, society became more dependent on freight transport. Thus, if certain levels of division of labour as well as spatial distribution of population are to be maintained, a related quantity of freight transport will be indispensable. However, this does not serve for arguing that today's volume of freight transport activity or even any larger volume of freight which could be imagined for the future is reasonable from a macroeconomic point of view.

The intensification of the spatial division of labour—a process heavily speeded up by the industrial revolution and still going on under the headings outsourcing and globalisation—is an important determinant of freight transport activity. Figure 7 provides a simplified overview of how today's economic processes work and how far freight transport has become a necessary prerequisite of production and consumption. It needs to be noted that the indicated vertical differentiation of the process varies very much according to the complexity of the product considered and the kind of spatial organisation of its production. In reality the horizontal differentiation (number of suppliers) may be much more complex than indicated by the simplified flow model. Moreover, waste collection and sorting out is not restricted to the remains of consumption but accompanies the whole process.

The current development towards more recycling of waste can be expected to cause more freight transport activity than formerly deployed methods of waste treatment, like deposition or incineration in the vicinity of the places where the waste was generated. In the case of freight transport within countries this applies even taking into account that transport for recycling purposes and that of secondary raw materials partly substitutes for hauls of primary raw materials. Taking a global view, it needs to be noted that freight transport activity may quite well be lower with increased recycling instead of, for example, importing bulky primary raw materials from distant places for producing a particular product.

A more environmentally favourable economic structure regarding the material intensity and spatial organisation of production and consumption would be designed in such a way that the resulting overall tonne-kilometres necessary between all the different locations involved in the economic process to meet the needs for products and services for a given period of time would be at a minimum.

Figure 7. The role of freight transport in the economic process

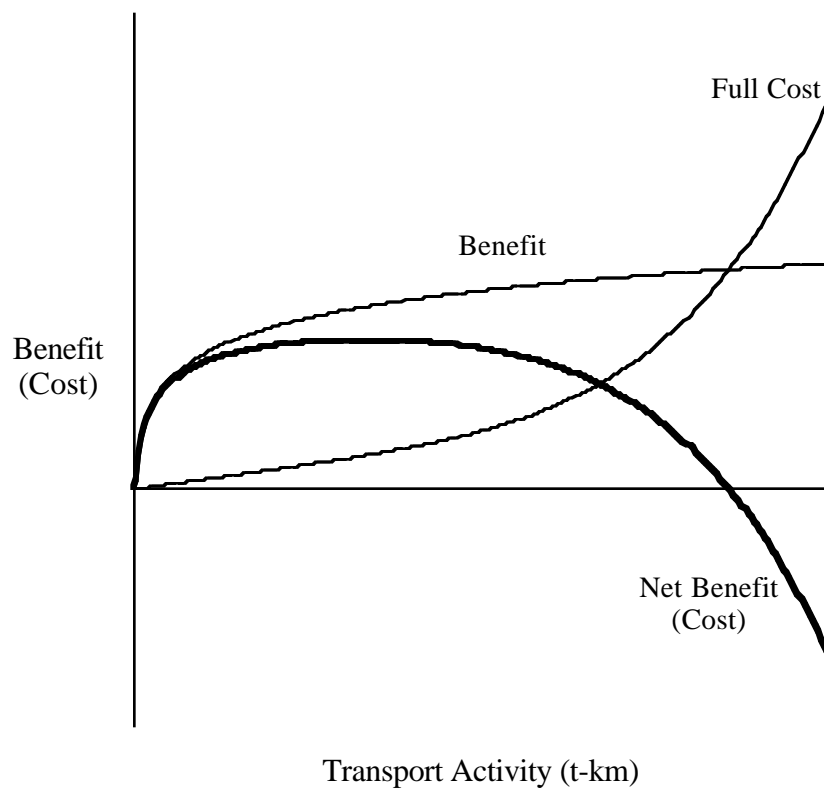
From a market economy point of view freight transport will occur if the spatial availability of goods does not meet the demand. One reason for this may be that there are limitations in producing, e.g. agricultural goods or those goods which are directly dependent on agricultural production. In such cases prices for these goods will be lower in regions where they are abundant and higher in regions where they are scarce as compared to demand. Thus regional differentiation in the availability of goods works as an incentive to transport the goods from regions where they are abundant to those where they are scarce. Such transactions will be profitable as long as the costs involved, and notably the transport costs, do not exceed the spatial price differences (Pastowski et al., 1994). Apart from spatial price differentials, changes in consumption patterns may be an influencing factor too in the case of goods being used for end-use (e.g. Mexican beer in Germany).

Besides spatial availability of goods the spatial availability of immobile productive resources like land or infrastructure, and hence the prices which need to be paid for making use of them, are other important reasons for an intensified division of labour between regions. While the former price incentives and changes in consumption patterns directly influence freight transport activity, the latter price incentives tend to influence decisions on the location of industry and, by that, indirectly contribute to determining the volume of freight transport activity. Besides, there are numerous other reasons like economies of scale and economies of scope in the production

of specific goods which may give rise to additional freight, but these can only be mentioned here.

From a microeconomic perspective, freight transport will be considered as being reasonable if the price paid for it is below cost reductions which can be achieved by making use of it elsewhere. Another cause for deploying more freight transport may be that market entry that it allows for is considered as being of overriding importance for strategic reasons. Taking a macroeconomic point of view the question arises as to which extent freight transport can contribute to a more efficient allocation of resources. Taking into account the numerous negative external effects being caused by freight transport and their cost characteristics (e.g. damages arising from a rapid change in the climate system through steadily rising concentrations of greenhouse gases in the atmosphere), an unlimited growth can by no means contribute to higher economic efficiency.

Figure 8. Macroeconomic evaluation of freight transport



Source: Own considerations.

In an economy that does not completely rely on self-support and on materials being available in the vicinity, a certain volume of freight transport activity is essential. However, the volume can be smaller or larger depending on transport cost and the structure of the economy. In some least developed countries local or regional famine following crop failure occurs essentially because foodstuffs cannot be transported from neighbouring regions with better harvests. In such cases freight transport may be enormously beneficial even though the necessary purchasing power is not there. It can be expected that the benefits achieved per unit of freight transport activity are substantially higher in such cases than for marginal freight transport in economies which are already run with a much higher freight transport intensity.

Today's situation as well as foreseeable trends of freight transport development in most highly industrialised countries tend to exceed the volume of freight transport which may be considered as being environmentally sustainable by far. This assessment will be particularly applicable if the negative external effects of transport are taken into account. Contrasting to this a positive view of freight transport dominates the scientific and public debate based on overestimating its benefits and underestimating its negative side-effects (Enquete-Kommission, 1994).

Figure 8 demonstrates the way in which the volume of freight transport activity may influence economic efficiency and prosperity, depending on the stage of economic development an individual economy has reached and the volume of freight transport that is already used to run the economy. The above reasoning on the different effects which can be expected to result from marginal freight transport activity may indicate that the marginal benefits of freight transport are decreasing with the growing prosperity of an economy. While freight transport provides large benefits in a situation where it is lacking, the benefits per volume of freight transport tend to decrease with growing freight transport intensity.

In contrast, the full costs per unit of freight transport activity can be assumed to increase disproportionately more. The pure supply costs can quite well be linear for a certain volume. However, arising malfunctions of the system in the form of congestion owing to a large transport volume, or rising costs resulting from increasing land use for transport purposes, may cause increasing marginal costs of supply. Moreover, significant increases in marginal costs can be expected from the external effects caused by freight transport, notably for air pollutants and noise nuisance in conurbation or for radiative forcing.

As a result, marginal costs of freight transport may quite well exceed its marginal benefits, which means that the net benefits of freight transport become negative if the adverse side-effects are taken into account. However, freight transport tends to grow beyond such a borderline as long as suitable policies which allow for a proper internalisation of the caused external costs are

not in place. From this point of view the notion that demand for freight transport is intangible in character seems to be rather flawed.

5 Is Freight Transport always Necessary?

In traditional economic thinking demand for products and services that becomes real in market transactions at prices determined by the market mechanism reveals the given preferences of consumers or the carefully taken decisions of commercial actors and is considered as being intangible in character. From such a perspective it appears to be unreasonable to question the volume or structure of a given demand. However, examples like demand for drugs or weapons clearly indicate that demand for goods and services cannot be considered as being intangible, but remain within the domain of what needs to be determined by society beyond what is taken into account during market transactions. Even though freight transport is not fully comparable to the aforementioned examples, it may be evaluated differently depending on its volume and structure, and its contribution to negative side-effects on society and the environment. From such a point of view it is insufficient to consider demand for freight transport as given.

While trends in personal travel and freight transport seem to be on similar growth paths, the reasons for growth differ substantially. In case of personal travel there are plenty of situations when transport is not a means but more an end in itself. This is particularly true for vacation trips which are mainly undertaken for sightseeing purposes. Sometimes, even driving a car without having the slightest idea where to go (cruising) is a leisure activity. Although the purpose of most personal travel is to reach a particular location which is suitable for a certain activity, a considerable share of trips is not even related to such activities. Furthermore, there are various complementary needs associated with car use, like representation of social status, addiction to high speeds etc., which don't have anything to do with getting around from location A to place B.

In the case of freight transport this looks rather different. It will hardly be possible to find cases comparable to the ones mentioned for personal travel in which freight transport is largely performed for its own sake. Normally a shipment of goods is demanded because the goods are needed at a certain place for end use or because they are to be processed further at this place. Moreover, specific features of transport like the mode of transport and in particular the type of vehicle used, are considered by companies which demand the shipments as being extremely unimportant as long as their goods arrive undamaged at a predetermined location and time. Thus, at first glance, freight transport appears to be governed by more rationality than one may find for personal travel. Taking a deeper look at what happens in freight and what may be unreasonable in freight growth, reveals that freight transport can be questioned in particular

cases and for several reasons. The following examples highlight certain cases but are not intended to give a complete overview.

Firstly, if consumers ask for products from distant places which are also produced in their region at comparable or even better quality and lower prices, long distance freight transport seems to be rather superfluous. An example of this is Mexican beer that to a certain extent has become popular in Germany, a country which is famous for its tradition in brewing a large variety of high quality beers. What is essentially being done in this case is to ship a bottle containing mainly water over a large distance to a place where there already are plenty of bottles and water. However, Germans who buy and drink such a beer at relatively high prices do so because they want to give themselves a certain image that is associated with drinking a beer that was brewed in Mexico and not, for example, in Bavaria. In this respect, the scope of similar products being consumed which are differentiated only regarding their particular image that fits to a certain kind of life-style is an important feature. Even though today's production techniques allow for a larger variety of products, product differentiation tends to make production more costly as long as it is not shifted to a more centralised production plant to allow for economies of scale. Unfortunately, more centralised production in most cases will only be possible at the expense of higher freight transport activity. Thus, although still a lot of people have never thought about it, personal habits and consumption patterns are important determinants of the volume of freight transport activity.

Secondly, freight transport may result from particular regulations and subsidies which are aimed at achieving other objectives but—as a side-effect—generate a substantial volume of freight. An example of such regulations are those in the European Union which limit the production of specialities of certain regions to these regions if the name of the region is intended to be used as part of the brand name (EC, 1992; 1996a; 1996b; 1997). This might make sense for products like special wines where the grapes are grown on soils with particular physico-chemical properties and in a very special micro climate which give the wine tastes and smells that cannot be achieved at any other place. But this is completely unreasonable for products that may easily be produced according to the same recipe in any other region.

An example of this that has become quite famous is the Parma ham, which is exclusively produced in the Italian town, Parma, and which many consumers in Europe like for its particular taste. Although companies from Parma may easily be able to set up production plants in other European countries to prepare and smoke the ham in exactly the same way, they are not allowed to do so and sell it using the name Parma ham afterwards. As a consequence, pigs from, for example, Germany or the Netherlands are transported across the Alps for supplying the production of Parma ham and, as such, partly come back again to the parts of Europe situated north

of the Alps. The reason for this is that the regional supply of pigs in Parma falls short of regional demand, plus that for Parma ham all over Europe.

Thus, regulations which are intended to protect regional specialities based on a characteristic recipe that in principle can be reproduced anywhere, unnecessarily restrict the location of plants for producing these goods. As soon as such products have become popular on a wider geographic scale, a considerable volume of freight transport is induced that is not essential from a macroeconomic point of view. In such cases, like the Parma ham, the particular properties of which are not bound to the place of its production but to producing it according to a specific recipe, measures similar to patents may be more appropriate to look after the interests of the companies involved in production.

The mentioned list of protected regional specialities currently comprises 401 products stemming from various member countries of the European Union. With at least one other product there seems to be evidence that some additional freight transport arises from its production: mozzarella cheese, which is also fairly popular in Europe and is included in the list of products (Short, 1995). It would require further research to find out how many other products included on the list are similar to the Parma ham and how much additional freight transport is caused by that. Whether or not subsidies in the European Union which are not directly aimed at the transport sector constitute additional incentives for freight transport, is also an interesting issue but has not yet been explored to date.

Thirdly, economic integration and intensified spatial division of labour allows profit to be made from marginal differentials in costs of productive resources which results in more freight transport. This mainly refers to natural resources and labour. As long as the substantial negative external effects of freight transport are not internalised and, therefore, are not taken into account by commercial decision makers, then economically inessential freight transport and an inefficient allocation of resources will result.

However, economic integration may also cause a more intense division of labour in regions along borders which were formerly impossible or costly to cross, and thus may partly contribute to reducing the volume of freight transport activity by substituting short distance international for long distance inland hauls. Notwithstanding this, economic integration on balance can be expected to give rise to further expansions in freight. Thus economic integration may be beneficial, but not if increased efficiency is offset by the direct costs associated with it, plus the external effects that result from the induced volume of additional freight transport activity (Neumann, Pastowski, 1994).

It is self-evident that the examples given above are not intended as proof for the hypothesis that freight transport is superfluous in general. Nevertheless, they provide some evidence for ques-

tioning the volume of freight transport that has developed in industrialised countries for several reasons. In order to assess the situation in various countries it is necessary to take their specific conditions (e.g. population density, urbanisation, spatial availability of resources) into account. However, there are cases in which freight transport will be inevitable or useful even if the overall environmental consequences are taken into account.

Freight transport may be the only way to ensure access to natural resources which are essential for human beings but which cannot be provided in the vicinity of settlements. Moreover, economies of scale in production may be based on higher efficiency in the use of natural resources that is so tremendous that sacrificing a certain amount of natural resources for additional freight transport can be justified. Notwithstanding this, taking a look at today's situation in freight transport reveals that only a minor share can be based on such basic considerations. Therefore, it can be stated that we will not be considerably worse off if freight transport is reduced.

6 Decoupling Economic Development and Freight

Decoupling of economic development and freight transport activity is something that has not been observed so far and is, therefore, a rather unusual concept. However, what has been presented so far in this paper clearly hints at the overriding importance of addressing freight transport demand for curbing its unwanted side-effects. Work to date on the issues involved has hardly tried to figure out how far reducing transport activity offers potentials to curb unwanted side-effects. Even in such pieces of scientific literature which clearly advocate to reduce the negative side-effects of freight, there is no mention of restraining freight transport activity as a means to accomplishing this objective (U.S. OTA, 1994, Royal Commission on Environmental Pollution, 1994, O'Rourke, Lawrence, 1995, Michaelis et al., 1996), or it is handled with substantial scepticism (Kohlhaas et al., 1994, Schipper et al., 1997). Thus, reducing the freight transport intensity of the economy and, even more, introducing restraints upon the overall volume of freight transport activity as a means to attenuate emissions of greenhouse gases and to cope with other environmental consequences of freight, have remained to be a terra incognita. The main reason for this is that a reduction in freight transport activity is believed to be necessarily associated with losses in productivity, competitiveness and economic growth.

However, there is some work on the influence of spatial production, sourcing and distribution concepts on the volume of freight transport which advocates more proximity in the economic process through an orientation that is more focused on the region as an economic entity (Böge, 1995; Hesse, 1996). Several studies carried out on behalf of the Enquete Commission of the German Bundestag "Protecting the Earth's Atmosphere" on the influences of spatial structures

on freight transport activity hardly touched the core issue (Baum et al., 1994), or concentrated on current trends in the production of some high quality products for which proximity of suppliers and major companies may be important to allow for intensive face-to-face communication in order to reduce transaction costs (Gleich et al., 1994). However, the latter business relationships cover only a limited part of the whole economic process, and business of that kind makes up only a minor share of the economy since many markets are dominated by price competition.

The examples given in section 5 of what currently happens in freight transport have demonstrated that a certain share of today's volume of freight transport activity results from inadequate regulations, or will be considered as being economically inefficient if the full costs are taken into account. Thus the question arises as to whether it is possible to identify major potentials which allow to economise on freight transport in the various sectors of the economy in order to reduce the negative environmental impacts caused by freight.

The following enumeration of options for decoupling of economic development and freight transport activity is preliminary in character and not necessarily complete. It is obvious that the quantitative potentials of each of these fields of action differ for the various sectors of the economy and different products. Moreover, it is clear that optimising the processes involved cannot solely be done along the lines of reducing the transport intensity, but needs to take likely trade-offs in other areas into account which are important for the environmental performance of the economy.

Potentials for economising on freight transport activity which are closely related to changing the economic structure to being more environmentally sound in general are (see also Jänicke et al., 1993, Bradel, 1995, Bleijenberg, 1996):

- Increasing the share of supplied parts for production and products for end use which are produced locally or regionally, and reducing the number of spatially separated production stages (the kilometres and the tonnes);
- Reducing the volume of materials which circulate in the economy for a given unit of gross domestic product (the tonnes); and
- Substituting transfer of information for transport of physical products (the tonne-kilometres).

As has been described by the flow model in section 4 the spatial configuration of the different stages of the economic process is crucial for determining how often and how far freight needs to be transported to provide a certain level of access to goods and services for end use. Important structural changes currently taking place mostly hint in the opposite direction than at what might reduce the overall transport intensity of the economy. This notably refers to outsourcing of certain stages of production which is likely to induce additional volume of freight, and to

European or global sourcing which tend to increase the average distance of hauls. However, such trends cannot be taken as being irreversible, rather they are subject to further changes of technology, demand and the general set-up of economic activity.

Increasing the share of products which are produced locally or regionally directly influences freight transport activity. A higher share of products which originate from local production will easily be possible for products of everyday life if there are no physical barriers which exclude producing them in a certain region or which give rise to extremely higher production costs. Good examples of this (at least for countries like Germany) are agricultural products or food-stuffs, and the "well-travelled yoghurt" (Böge, 1995) has become famous for this.

Most world trade in terms of the value of the traded goods consists of intra-industry trade, which is trade in similar industrial products between industrialised countries. Freight transport is often an alternative to producing inside a regional market which may easily be done. Of course we will not see the locally produced micro chip entering the market but there are plenty of products which may be produced more decentralised. It has already been argued that more flexible production technologies being introduced in industrial production may result in production becoming a much more local matter (Bell, Feitelson, 1991). The necessity to change one-way material flows in the economy towards establishing material cycles for environmental reasons (less waste and more recycling) clearly hints at the closer proximity of locations of the different stages in the economic process too.

Reducing the volume of materials which needs to be handled for a unit of gross domestic product in a given period of time significantly influences demand for freight transport. Freight transport to a large extent results from the material intensity of the economy. Thus if we are able to reduce the material requirements of the benefits achieved by physical products, this will give rise to related reductions in freight transport activity. There is evidence that there has been a decline in the material intensity of industrial economies in the past two decades (Adriaanse et al., 1997). However, this did not substantially influence the transport intensity because the average distance of hauls increased during the same period of time.

Moreover, the total material requirement in tonnes quoted in the above cited publication is not fully compatible with the volume of freight in tonnes. On the one hand, not all material included in the calculation of the above cited publication is moved in a way that fits the definition of freight transport, which, for instance, does not include movement of materials on sites used for extracting resources (e.g. covering material or overburden in mining). On the other hand, a certain volume of material can quite well be shipped several times in the economic process (as primary raw material, processed material etc.), thus contributing disproportionately to transport activity in tonnes (McKinnon, Woodburn, 1996). Notwithstanding this, dematerialisation of the

economy, besides reducing resource use, can serve a great deal to curb the transport requirements associated with the economic process.

Besides frugality, which might restrain economic growth and related freight transport, the main strategies for dematerialisation are (Giarini, Stahel, 1993):

- Increasing the intensity of the utilisation of a physical product by concepts of shared use (the same quantity of benefits with less units of a product);
- Increasing the durability of a physical product or its components (more benefits per unit of product);
- Reducing the material requirements of a given product (less volume of materials for the same product); and
- Designing products in a way that enhances remanufacturing and recycling (reuse of components and materials for the same or other products).

Shared use and intensification of shared use of infrastructures, buildings, cars etc. allows the same benefits to be achieved from their utilisation with smaller quantities of these items in use. As long as the increased intensity of utilisation does not reduce life expectancy proportionately or shared use itself generates substantial additional passenger or freight transport, it will be simultaneously beneficial in terms of reducing the volumes of materials circulating in the economy and in decreasing related freight transport.

Increasing product durability will work particularly well in the case of products which are not subject to major technological changes (e.g. furniture). Another option is designing products in a way that enhances the potential for technological upgrading without all components of the product becoming obsolete (e.g. computers) (Haake, 1996). Increasing energy efficiency in general and substituting regenerative primary energy carriers for fossil fuels is another example of how the material intensity may be substantially reduced while at the same time reducing the volume of freight transported. Moreover, transport of fossil energy carriers is to a considerable extent the result of transport energy use and is, therefore, likely to shrink with transport activity and increased energy efficiency in the transport sector (Dalkmann, 1997). It appears that reducing the material intensity and the transport intensity of the economy are to some extent mutually reinforcing.

Substituting transfer of information for transport of physical products may be another alternative. In principle this can be done in the case of all products where consumers are mainly interested in their information content and not their physical properties. For example, no one really needs a video cassette for watching a particular movie which is not available on TV, provided the movie can be distributed electronically to the household (video on demand). Similar distri-

bution techniques are imaginable for products like telephone directories, encyclopaedias, magazines etc. If used in a suitable manner the Internet will serve a great deal to reduce the amount of written material that is delivered physically over the globe (Weizsäcker et al., 1997). This paper will to a considerable extent be delivered via Internet in order to reduce the volume of freight transport that is associated with its distribution. As an added advantage distribution will proceed faster than by normal mail.

How far the aforementioned potentials for decoupling of economic development and freight will become reality as a result of a business-as-usual course of action, is rather uncertain. Based on data of past and current trends a development in such a direction may be likely to a certain extent in the case of substituting transfer of information for transport of physical products, owing to recent reductions in costs and increases in performance of computers and telecommunication facilities, and the high probability of a continuation of these trends in the foreseeable future.

However, a substantial move towards decoupling beyond this appears to be unlikely within such a scenario. Thus, a suitable political framework is necessary to exploit the mentioned potentials to an extent that may significantly contribute to decoupling of economic development and freight. An ecological tax reform may play a key role in such a new framework in that it may simultaneously lift the costs of freight transport nearer to its social costs, and shift the tax burden from labour to primary resources in order to reduce the materials intensity of the economy.

7 Conclusions

Based on the statistical trends of freight transport and on the extensive role of freight for the growing contributions of the transport sector to various environmental problems, the traditional view that demand for freight transport is intangible in character was challenged. It was argued that the evaluation of the economic significance of freight may vary according to its volume and structure, and to the stage of economic development an individual economy has achieved. In order to underscore the variability of the macroeconomic assessment of freight, some examples were given to emphasise that the contributions of a certain share of existing freight to economic efficiency may be negligible or even negative if the external effects of freight are taken into account.

Finally, more proximity in the spatial allocation of production, final demand and waste treatment, as well as reducing the material intensity of physical products and substituting transfer of information for production and distribution of physical products, have been identified as the main potentials which may allow an increased decoupling of economic development and freight transport. However, it cannot be expected that these potentials will be fully exploited as a result

of a business-as-usual development. Rather, it is necessary to change the framework of economic activity in a way that makes alternatives to increased physical transport of goods a viable economic option too. An ecological tax reform that increases the cost of freight and the cost of primary resources in the economic process will play a key role in this respect.

Figuring out the mentioned potentials for decoupling of economic development and freight transport in more detail would be helpful in demonstrating that the notion of everlasting growth in freight transport is misleading. Such research may clearly show that viable alternatives to freight transport are available for numerous cases, which allow the same prosperity and degree of consumer satisfaction to be reached with a considerably smaller freight transport intensity, and are thus more environmentally sound by far.

References

- Adriaanse, A., Bringezu, S., Hammond, A., Moriguchi, Y., Rodenburg, E., Rogich, D., Schütz, H. (1997): *Resource Flows: The Material Basis of Industrial Economies*. Washington, D.C.: World Resources Institute.
- Baum, H. (1995): Entkopplung von Verkehrswachstum und Wirtschaftsentwicklung. *Zeitschrift für Verkehrswissenschaft*, Vol. 66, No. 1, pp. 13-32.
- Baum, H. (1997): Der volkswirtschaftliche Nutzen des Verkehrs. *Zeitschrift für Verkehrswissenschaft*, Vol. 68, No. 1, pp. 27-51.
- Baum, H., Pesch, S., Weingarten, F. (1994): Verkehrsvermeidung durch Raumstruktur - Güterverkehr. Enquete-Kommission "Schutz der Erdatmosphäre" des Deutschen Bundestages (Ed.), Studienprogramm, Bd. 4 Verkehr, Teilband II, Studie B/III. Bonn: *Economica*.
- Bell, M.E., Feitelson, E. (1991): U.S. Economic Restructuring and Demand for Transportation Services. *Transportation Quarterly*, Vol. 45, No. 4, pp. 517-538.
- Bleijenberg, A.N. (1996): *Freight Transport in Europe. In Search of a Sustainable Course*. Delft: Centre for Energy Conservation and Environmental Technology.
- Böge, S. (1995): The Well-Travelled Yoghurt Pot: Lessons for New Freight Transport Policies and Regional Production. *World Transport Policy & Practice*, Vol. 1, No. 1, pp. 7-11.
- Bradel, A. (1995): *Industriebetrieb und Verkehrsproblematik. Industrielle Maßnahmen zur Verringerung, Verlagerung und Verbesserung des Güter- und Personenverkehrs*. Wiesbaden: Deutscher Universitäts-Verlag.
- Cole, S. (1987): *Applied Transport Economics*. London: Kogan Page.
- Dalkmann, H. (1997): *Der Transport von Energieträgern und dessen ökologische Effekte - Stand und Entwicklung*. Diplomarbeit am Fachbereich VI der Universität Trier. Trier: Universität Trier.
- DIW (Deutsches Institut für Wirtschaftsforschung) (1991; 1996): *Verkehr in Zahlen 1991 (1996)*. Berlin: DIW.

- EC (European Commission) (1992): Verordnung (EWG) Nr. 2081/92 DES RATES vom 14. Juli 1992 zum Schutz von geographischen Angaben und Ursprungsbezeichnungen für Agrarerzeugnisse und Lebensmittel. Official Gazette of the European Communities, No. L 208, July 24 1992, pp. 1-7.
- EC (European Commission) (1996a): Verordnung (EG) Nr. 1107/96 DER KOMMISSION vom 12. Juni 1996 zur Eintragung geographischer Angaben und Ursprungsbezeichnungen gemäß dem Verfahren nach Artikel 17 der Verordnung (EWG) Nr. 2081/92 des Rates. Official Gazette of the European Communities, No. L 148, June 21 1996, pp. 1-10.
- EC (European Commission) (1996b): Verordnung (EG) Nr. 1263/96 DER KOMMISSION vom 1. Juli 1996 zur Ergänzung des Anhangs der Verordnung (EG) Nr. 1107/96 über die Eintragung der geographischen Angaben und Ursprungsbezeichnungen gemäß dem in Artikel 17 der Verordnung (EWG) Nr. 2081/92 des Rates vorgesehenen Verfahren. Official Gazette of the European Communities, No. L 163, July 2 1996, pp. 19-21.
- EC (European Commission) (1997): Verordnung (EG) Nr. 123/97 DER KOMMISSION vom 23. Januar 1997 zur Ergänzung des Anhangs der Verordnung (EG) Nr. 1107/96 der Kommission über die Eintragung der geographischen Angaben und Ursprungsbezeichnungen gemäß dem in Artikel 17 der Verordnung (EWG) Nr. 2081/92 des Rates vorgesehenen Verfahren. Official Gazette of the European Communities, No. L 22, January 24 1997, pp. 19-20.
- ECMT (European Conference of Ministers of Transport) (1997a): Statistical Trends in Transport 1965 - 1992. Paris: ECMT/OECD.
- ECMT (European Conference of Ministers of Transport) (1997b): Trends in the Transport Sector 1970 - 1995. Paris: ECMT/OECD.
- Enquete-Kommission "Schutz der Erdatmosphäre" des 12. Deutschen Bundestages (1994): Mobilität und Klima. Wege zu einer klimaverträglichen Verkehrspolitik. Bonn: Economica.
- Gleich, A.v., Hesse, M., Lucas, R. (1994): Unternehmen und Industriebeziehungen im strukturellen Wandel - Raumwirtschaftliche Ansatzpunkte zur CO₂-Reduktion im Handlungsfeld Verkehr. Enquete-Kommission "Schutz der Erdatmosphäre" des Deutschen Bundestages (Ed.), Studienprogramm, Bd. 4 Verkehr, Teilband II. Bonn: Economica.
- Haake, J. (1996): Langlebige Produkte für eine zukunftsfähige Entwicklung. Eine ökonomische Analyse. Wuppertal Paper No. 62. Wuppertal: Wuppertal Institute for Climate Environment and Energy.
- Häfele, W. et al. (1981): Energy in a Finite World: Report by the Energy Systems Program Group of the International Institute for Applied Systems Analysis. Cambridge: Ballinger.
- Hesse, M. (1996): Zentral oder dezentral? Zur Verkehrsvermeidung durch regionale Wirtschaftskreisläufe. Boes, H., Hesse, M. (Eds.), Güterverkehr in der Region. Technik, Organisation, Innovation. Marburg: Metropolis, pp. 381-400.
- Hoyle, B., Knowles, R. (1994): Transport Geography: an Introduction. Hoyle, B., Knowles, R. (Eds.), Modern Transport Geography. Chichester: Wiley, pp. 1-10.
- Jänicke, M., Mönch, H., Binder, M., et al. (1993): Umweltentlastung durch wirtschaftlichen Strukturwandel? Eine explorative Studie über 32 Industrieländer (1970 bis 1990). 2nd edition, Berlin: Edition Sigma.
- Kohlhaas, M., Voigt, U., Ewers, H.-J., Allemeyer, W., Gerwens, S. (1994): Gesellschaftliche Kosten und Nutzen der Verteuerung des Transports. Enquete-Kommission "Schutz der Erdatmosphäre" des Deutschen Bundestages (Ed.), Studienprogramm, Bd. 4 Verkehr, Teilband 1, Studie A. Bonn: Economica.
- Lakshmanan, T.R., Han, X. (1997): Factors Underlying Transportation CO₂ Emissions in the U.S.A.: A Decomposition Analysis. Transportation Research Part D, Vol. 2, No. 1, pp. 1-15.

- Lovins, A.B. (1995): *Hypercars: The Next Industrial Revolution*. Sperling, D., Shaheen, S.A. (Eds.), *Transportation and Energy: Strategies for Sustainable Transportation*. Washington D.C., Berkeley: American Council for an Energy-Efficient Economy, pp. 77-96.
- McKinnon, A.C., Woodburn, A. (1996): *Logistical Restructuring and Road Freight Traffic Growth. An Empirical Assessment*. *Transportation*, Vol. 23, pp. 141-161.
- Michaelis, L. et al. (1996): *Mitigation Options in the Transportation Sector*. Watson, R.T., Zinyowera, M.C., Moss, R.H. (Eds.), *Climate Change 1995. Contribution of Working Group II to the Second Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge: Cambridge University Press, pp. 679-712.
- Neumann, L. F., Pastowski, A. (1994): *Umweltschutzorientierte Sektoralsteuerung in der EG: Die EG-Güterverkehrspolitik zwischen Deregulierung und umweltschutzorientierter Reregulierung*. Jarass, H. D., Neumann, L. F., *Leistungen und Grenzen des EG-Umweltschutzes*. Bonn: *Economica*, pp. 44-79.
- OECD (Organisation for Economic Co-operation and Development) (1995): *Motor Vehicle Pollution. Reduction Strategies Beyond 2010*. Paris: OECD.
- O'Rourke, L., Lawrence, M.F. (1995): *Strategies for Goods Movement in a Sustainable Transportation System*. Sperling, D., Shaheen, S.A. (Eds.), *Transportation and Energy: Strategies for Sustainable Transportation*. Washington D.C., Berkeley: American Council for an Energy-Efficient Economy, pp. 59-76.
- Pastowski, A. (1996): *Trends im Güterverkehr und Perspektiven eines ökologischen Strukturwandels*. Pastowski, A., Petersen, R., (Eds.), *Wege aus dem Stau. Umweltgerechte Verkehrskonzepte*. Berlin, Basel, Boston: Birkhäuser, pp. 151-162.
- Pastowski, A., Petersen, R., Schallaböck, K. O. (1994): *Verkehrsvermeidung durch Raumstruktur. Schlußbericht. Enquete-Kommission "Schutz der Erdatmosphäre" des Deutschen Bundestages (Ed.), Studienprogramm, Bd. 4 Verkehr, Teilband 1, Studie B*. Bonn: *Economica*.
- Peake, S. (1994): *Transport in Transition. Lessons from the History of Energy*. London: Earthscan.
- Rommerskirchen, S. (1997): *Zukunftsszenarien für den Güterverkehr*. Riedl, C., Schwedt, B., Tidler, P., Steger, U. (Eds.), *Mobilität statt Ökologie? Workshopberichte über konsensfähige Wege zur Lösung eines Dilemmas*. Bern: Haupt (forthcoming).
- Royal Commission on Environmental Pollution (1994): *Eighteenth Report. Transport and the Environment*. London: Her Majesty's Stationery Office.
- Schipper, L., Scholl, L., Price, L. (1997): *Energy Use and Carbon Emissions from Freight in Ten Industrialised Countries: An Analysis of Trends from 1973 to 1992*. *Transportation Research Part D*, Vol. 2, No. 1, pp. 57-76.
- Short, J. (1995): *Freight Transport as an Environmental Problem*. *World Transport Policy & Practice*, Vol. 1, No. 2, pp. 7-10.
- Silvestrini, G. (1996): *Road Construction and Economic Growth from a Southern European Perspective*. *Transport & Environment (Ed.), Roads and Economy*. T&E publication 96/1. Brussels: Transport & Environment, pp. 33-39.
- Statistisches Bundesamt (1996): *Statistisches Jahrbuch 1996*. Wiesbaden: Metzler-Poeschel.
- U.S. OTA (U.S. Congress Office of Technology Assessment) (1994): *Saving Energy in U.S. Transportation, OTA-ETI-589*. Washington, DC: U.S. Government Printing Office.
- WEC (World Energy Council) (1995): *Global Transport Sector Energy Demand Towards 2020*. London: World Energy Council.
- Weizsäcker, E.v., Lovins, A.B., Lovins, L.H. (1997): *Factor Four. Doubling Wealth - Halving Resource Use. The New Report to the Club of Rome*. London: Earthscan.

Wuppertal Papers
Abteilung: Verkehr
Direktor: Dr. Rudolf Petersen
ISSN 0949-5266

Nr. 2 · Dezember 1992 - Markus Hesse (IÖW, regen e.V.), Rudolf Petersen, Meike Spitzner: **Mobilitätszentrale und Verkehrswende**. Überlegungen zu weitergehenden Funktionen von Mobilitätszentralen (MZ) in einem stadtverträglichen und menschengemäßen Verkehrssystem

Nr. 9 · Februar 1994 - Andreas Pastowski, Rudolf Petersen (Hrsg.): **Umwelt und strukturelle Entwicklungen im Güterverkehr**. Ergebnisse studentischer Praktika (1)

Nr. 10 · Februar 1994 - Rudolf Petersen: **Verkehrsvermeidung - Aufgabe heutiger und zukünftiger Verkehrspolitik**

Nr. 16 · Mai 1994 - Ulla Terlinden: **Frauengerechte Stadtplanung**. Vortrag am Wuppertal Institut, 24. Mai 1994

Nr. 19 · Juli 1994 - Andreas Pastowski: **Sponsoring im öffentlichen Personennahverkehr**. Ein Beitrag zur ökologisch-ökonomischen Partnerschaft in der Region

Nr. 20 · Juli 1994 - Andreas Pastowski, Rudolf Petersen (Hg.): **Potentiale und Probleme ökonomischer Anreizinstrumente im Verkehr**. Ergebnisse studentischer Praktika (2)

Nr. 21 · August 1994 - Stefanie Böge: **Die Transportaufwandsanalyse**. Ein Instrument zur Erfassung und Auswertung des betrieblichen Verkehrs

Nr. 43 · Oktober 1995 - Dietrich Brockhagen: **Der Flugverkehr der Stadt Köln und das Klimabündnis**. Eine Konfliktanalyse

Nr. 44 · Oktober 1995 - Karl Otto Schallaböck, Markus Hesse (IÖW): **Konzept für eine Neue Bahn**

Nr. 45 · Oktober 1995 - Martin Hüsing: **Schieneverkehrskonzept Region Münster**

Nr. 47 · Dezember 1995 - Dorothee Lichtenthäler, Andreas Pastowski: **Least-Cost Transportation Planning**. Probleme und Potentiale der Übertragung von LCP auf die Mobilität

Nr. 50 · Januar 1996 - Lucie Hamelbeck: **Umweltgerechte Straßennutzungsgebühren für den Güterverkehr**

Nr. 52 · Februar 1996 - Gudrun Mildner, Stefanie Böge: **Früher gab es einen Laden um die Ecke...** Eine vergleichende Transportanalyse von konventionellem und alternativem Handel

Nr. 56 · Mai 1996 - Stefanie Böge: **Freight Transport, Food Production and Consumption in the United States of America and in Europe** or how far can you ship a bunch of onions in the United States?

Nr. 67 - Januar 1997 - Volker Leifert: **Air Pollution and Transport in Tehran**

Nr. 78 - August 1997 - Klaus-Dieter Schlünder: **Bewertungskriterien für eine integrierte Betrachtungsweise des Ökosystems "Stadt"**

Bestellregelung: Wir erbitten von allen Bestellern **einen mit 3,- DM frankierten A4 Rückumschlag**. Fürs Ausland gibt es den "Coupon-Réponse International" - internationalen Antwortschein. Aus diesem Grund ist es nicht möglich, Bestellungen von Papers per Telefon oder FAX an das WI zu richten. Schicken Sie bitte Ihre Bestellungen an das Wuppertal Institut **nur schriftlich**: Wuppertal Institut für Klima, Umwelt, Energie GmbH, Döppersberg 19, 42103 Wuppertal.