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A Closer Look at Road Freight Transport and Economic Growth in Sweden

Are There Any Opportunities for Decoupling?

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A Closer Look at Road Freight Transport and Economic Growth in Sweden

Are There Any Opportunities for Decoupling?

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Report 5370

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FOREWORD

This paper was written between September 2003 and February 2004 by Max Åhman at Lund University as a case study for the OECD project on decoupling transport impacts and economic growth. It was funded by the Swedish Environmental Protection Agency with Sven Hunhammar as Project Leader.

Comments on earlier drafts have been received from Bengt Johansson, Lars J. Nilsson, both at Lund University, and from Sven Hunhammar, EPA. Comments on the statistics were given by Lennart Thörn, SIKA and Kerstin Forssén, SCB.

The views in this report are those of the author and not necessarily the views of the EPA.

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SUMMARY

Historically, the development of freight transport has been closely correlated with the economic development measured in GDP-growth. Freight transport growth causes a number of societal problems such as congestion, regional air pollution, accidents and emission of CO_2 contributing to the risk of climate change. Decoupling the problems that freight transport growth cause from economic development is currently on the policy agenda both within the EU and the OECD.

The aim of this report is to review the statistics available and to analyse the links between Swedish freight transport and the Swedish economy with a special focus on what causes the *demand* for freight transport. Thus, the primary meaning of decoupling in this report is to shift to a less transport intensive economic growth. Transport activity and logistical indicators are presented together with economic data of GDP-growth. From these numbers transport intensities (transport activity/GDP) are calculated. The report gives some numbers on total freight activity but focuses on road freight transport. Special attention is given to freight activity measured in tonne-km. The growth of tonne-km[1] is strongly correlated to the emissions of CO_2, the most difficult problem facing the transport sector in the long-term.

In Figure S1, the developments of freight activity, economy and CO_2-emissions from road freight in Sweden are summarised.

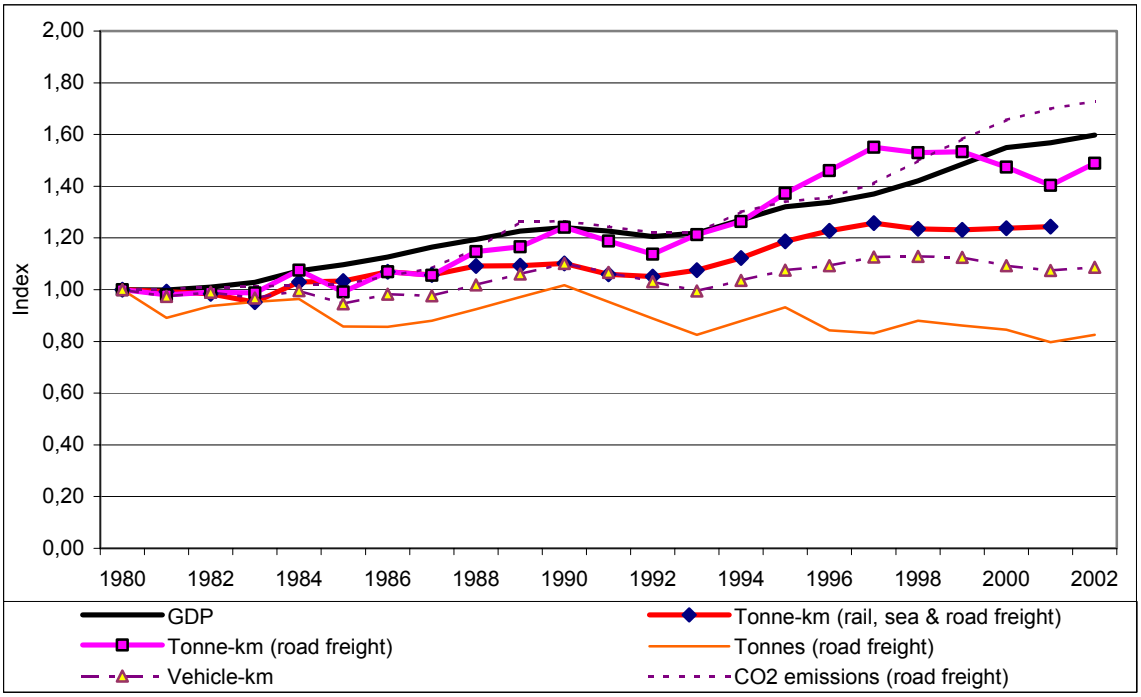

Figure S1. Development of freight activity, economy and CO_2-emissions from road freight in Sweden.

A minor trend of decoupling freight activity measured in tonne-km from economic growth could be seen in Sweden if we focus on the *total* freight activity including both sea, rail and road freight activity whereas *road* freight activity has followed the GDP-growth quite well. This illustrates a development where road transport has

[1] Freight activity measured in tonne-km means that every tonne transported is multiplied with the distance it is transported.

gained shares from the other modes of freight transport the last 20 years. Road freight activity measured in vehicle-km driven has increased only slightly (much less than the GDP-growth) and the weight of tonnes transported by road has actually been decreasing. Thus, the road freight intensity measured in tonne-km/GDP has been fairly constant while the road freight intensity measured both in vehicle-km/GDP and in tonne/GDP has been declining. The CO_2-emission from road freight follows the development of tonne-km.

The main *factor* currently contributing to the growth of tonne-km is the fact that goods are transported longer distances. The *driving forces* that currently are pushing towards more freight transport measured in tonne-km are the increasingly geographically dispersed production systems and the global markets for products. The globalisation of both markets and production systems demand more transport but not necessarily more tonnes lifted. The decreasing intensity vehicle-km/GDP can be attributed to an increasing efficiency in the transport system including less empty running and larger trucks with greater carrying capacity. The intensity measured in tonnes/GDP has declined as the sector contributing most to freight weight, the construction sector, has declined.

Moving towards sustainability requires that we "level the playing field" in terms of costs. Internalising the external costs, by e.g. higher taxes on fuel or road pricing, and making the polluter pay is important for attaining a socio-economic efficient transport system. Higher costs for road freight transport will stimulate better logistics management and make alternative modes (rail and sea) more competitive. This will increase the efficiency of the transport system but will not be enough to curb the current growth trend. The long-term structural demand is primarily determined by business location decisions that are not, to any major extent, influenced by the current transportation costs. The taxation level needs to be very high in order to influence this long-term structural demand. Currently, no "natural" level of saturation can be seen for this trend of steadily increasing activity measured in tonne-km. However, this does not mean that such a level does not exist nor does it mean that any such "natural" saturation level would be compatible with what society currently regards as sustainable.

1. INTRODUCTION

1.1 Background

Transport growth measured in tonne-km or vehicle-km has historically been closely related to economic growth. The main explanation is to be found in the reduction of "geographic friction" that enables trade and thus specialisation and division of labour. This leads to higher efficiency and thus enables greater economic activity in society.

The growth of transport activity has produced a number of problems as well. The transport system uses a large share of the worlds´ current energy supplies and in a world with finite fossil energy resources and limited availability of low cost renewable energy, the continued growth will inevitably lead to conflicts. Furthermore, the need for improved and extended infrastructure leads to conflict over how to use available space and e.g. intrusion in cultural landscapes. In areas with much traffic the efficiency of the transport system is decreasing due to congestion causing economic cost to society. The emission to air of CO_2, ozone precursors (HC and NOx), particulate matter, lead, and rubber, causes health problems and environmental degradation.

A number of the problems mentioned above can be partly mitigated with new technologies, such as fuel cell vehicles, or with policy instruments aimed at increasing the user efficiency, such as road pricing. However, a continued growth of transport activity will make a future shift towards a sustainable transport system more and more unlikely despite new promising technologies.

The current "decoupling debate" is primarily motivated by the emissions of CO_2, see e.g. EU White paper (2001). The decoupling of CO_2 emissions from economic growth could essentially be achieved in the following ways:

- Shifting to non-carbon fuels
- Shifting to less carbon intense modes of transport (e.g. from road to train)
- Shifting to more energy efficient vehicles
- Shifting to more efficient logistics system (less empty running vehicles e.t.c.)
- Shifting to less transport intensive economic growth

The transport system is socially and economically embedded into society. Changing large-scale "infrasystems" like the transport system is a slow process usually spanning over decades (Grübler and Nakicenovic 1991).

Current planning tools in Sweden are motivated primarily by the need to maintain the efficiency of the transport system. The time frame is usually 10 to 15 years and within this time frame it is reasonable to expect current trends valid as a planning tool. However, the major problems facing the transport system are on the longer term (20-50 years ahead at least). Given the long time frame of infrastructure, planning decisions taken today will have an impact on the long term also. There is, thus, a need to take a strategic look at the future and to explore a future beyond what is currently the trend.

1.2 Aim and scope

The aim of this report is to review the statistics available and to analyse the links between freight transport activity and the economy in Sweden. The report has a special focus on what causes the *demand for freight transport* in the economy. Thus,

the meaning of decoupling in this report is to shift to a less transport intensive economic growth. However, different indicators focussing more on increasing the efficiency of the transport system are also presented and discussed.

The study focuses on freight transport in Sweden. We have furthermore chosen to narrow down the study to look at road freight transport.

1.2 Outline of report

This report begins by presenting the available statistics on freight in Sweden (chapter 2) and the relevant statistics on the Swedish economy (chapter 3). In the 4th chapter, the report aims at linking the economic and freight statistics by developing a number of indicators. In the two last chapters (chapter 5 and 6) the scope is widened and an overview of currently debated phenomena relating to freight transport and economic growth are discussed from a Swedish perspective. Conclusions, based on not only the presented statistics but also on the discussion, are drawn explaining freight and economic growth further.

A full description of the available statistics is presented in the Appendix A1. After the first reading it is advisable to also read the descriptions on the quality of the statistics in order to fully assess the value of this report and its conclusions.

2. ROAD FREIGHT TRANSPORT IN SWEDEN

2.1 Development of road freight transport

Road freight activity from the beginning of the 1980s is presented measured in tonne-km and in tonnes, distributed on length of haul and into commodity groups transported. Statistics on vehicle-km, average length of haul, truck capacity and other logistical indicators are also presented. However, first an overview of the total freight transport activity in Sweden is presented.

2.1.1 Freight development measured in volume

In Figure 1, the total freight transport activity measured in tonne-km in Sweden is shown. Figure 1 includes thus also freight activity by rail and sea. The transport activity has been relatively constant for railway and sea transport along domestic shores whereas the road transport and international sea transport has increased, especially the last 12 years. Road freight transport is the only mode that shows a clear and sustained increasing trend over the last 20 years. This is the main reason why this study focuses on road freight transport for decoupling. The numbers on road freight activity given in Figure 1 are the official numbers on transport activity for *Swedish* road freight activity done in *Sweden*.

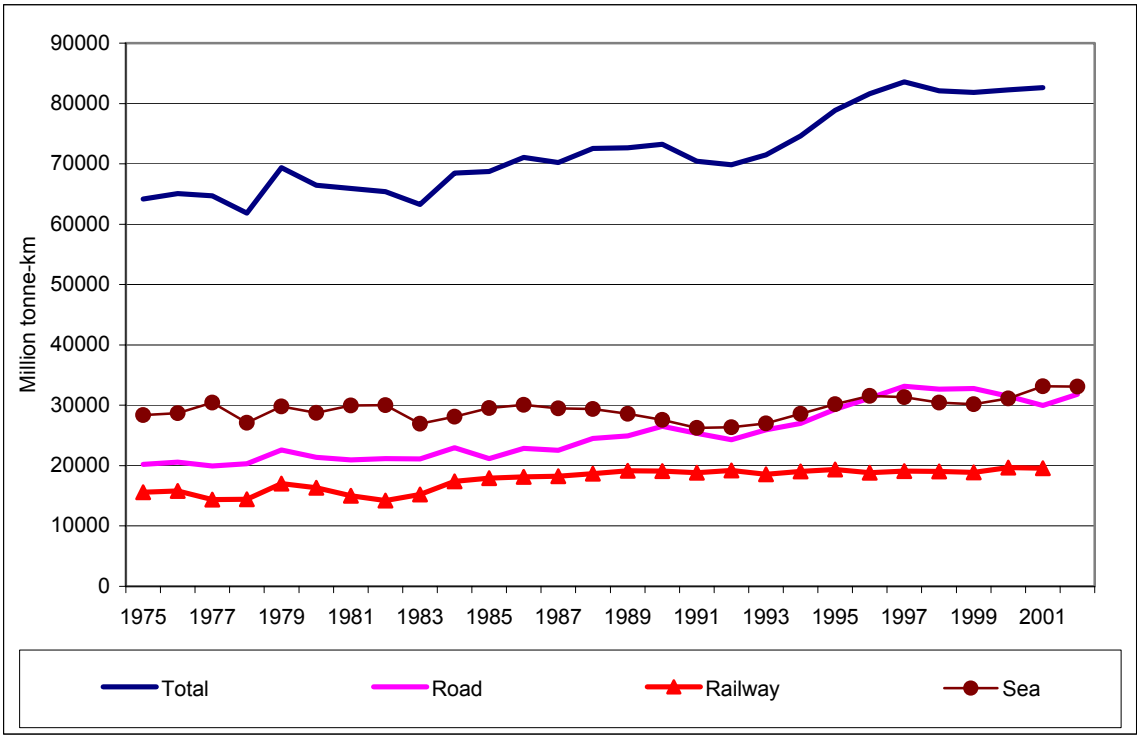

Figure 1. Freight transport activity in tonne-km in Sweden.
Source: SCB, Note: Sea includes maritime transport by both domestic and foreign ships along the Swedish coast

The following Figures in this study are more detailed and will thus almost exclusively be based on the official SCB numbers (Swedish trucks within Sweden). The years

1988-89, 1991-92 and 1994 no detailed road freight statistics were available from SCB[2].

2.1.2 Road freight development distributed on length of haul

In Figure 2, the road freight activity measured in tonnes between 1975 and 2002 is shown[3]. The weight volume of goods transported on road has decreased over time. The volume of transported goods by road is dominated by goods moved less than 99 km. One important difference is that goods moved more than 100 km have increased whereas as the goods moved less has decreased since the 1970s.

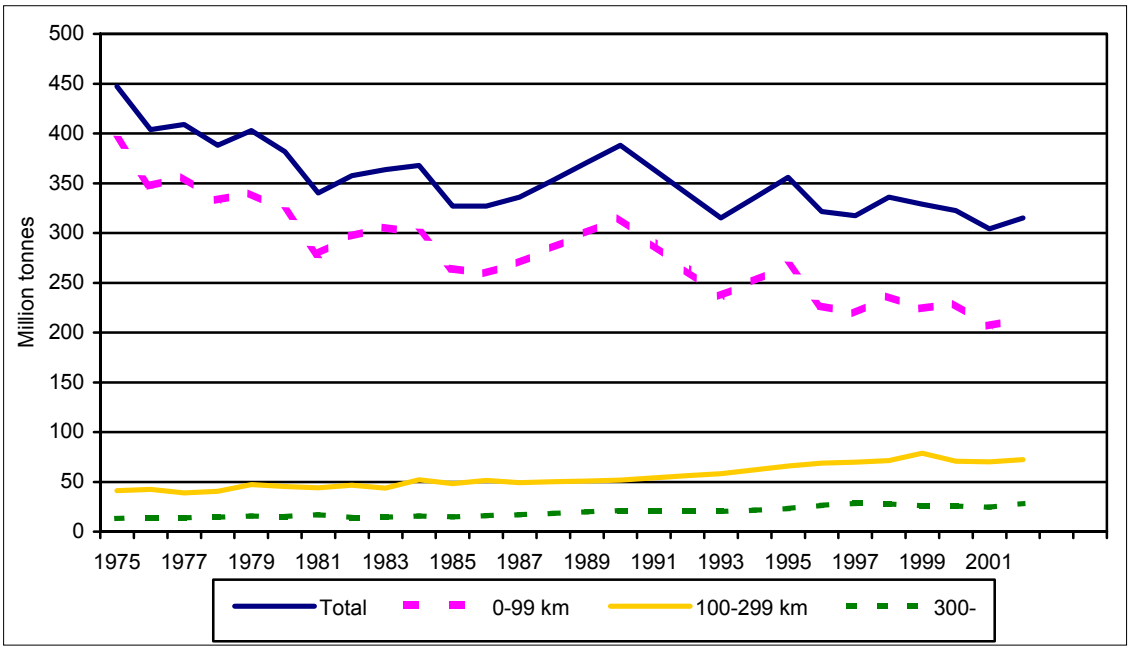

Figure 2. Road freight activity measured tonnes distributed in length of haul.
Source: SCB

In Figure 3, the road freight activity measured in tonne-km is given distributed on length of haul. The same trend can be seen as in Figure 2, that the main growth of transport activity is transport with a length of haul further than 99 km.

[2] The estimates of ton-km was not prioritised and instead estimates of light trucks, foreign trucks and road traffic (km) was made these years. In Figures 3 to 6 the graph is intrapolated over these years.

[3] The numbers on tonnes in Figure 2 could be a slight overestimation since there is a risk of "double accounting" as the numbers are based on tonnes lifted. No such risk is however present when looking at ton-km in Figure 3.

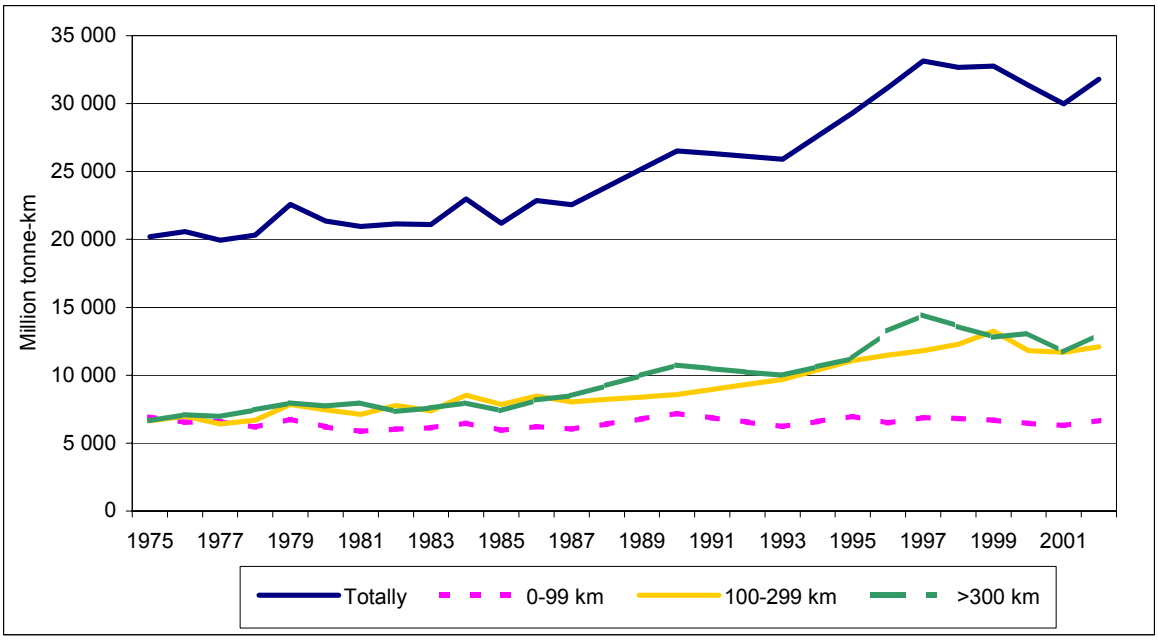

Figure 3. Road freight activity measured in tonne-km distributed on length of haul
Source: SCB

The conclusions from Figure 2 and Figure 3 are that the growth of activity the last 20 years has primarily been due to goods transported longer trips, not more goods (in tonnes).

2.1.3 Road freight development distributed on commodity groups

In Figure 4 and Figure 5, the freight activity measured in tonne-km and in tonnes is shown distributed into commodity groups. The division of commodity groups is based on NST/R groups[4] . In Figure 4 and 6, only the three groups of goods that have grown the most are shown separately together with a group consisting of "the rest". The commodity group "Miscellaneous", "Wood and Cork", and "Agricultural products" have grown substantially the last years and represents a large share (62 % year 2000) of the total road freight transport activity measured in tonne-km. The group "Miscellaneous" contains mostly mixed goods (styckegods). "Wood and cork" is totally dominated by wood (rundvirke) in Sweden and the group "Agricultural products" is dominated by food products.

There is an interesting peak of tonne-km activity for "Miscellaneous" around 1997 in Figure 4. However, the numbers around 1995-1996 must be handled with care. A new system for categorising goods was introduced (from CTSE to NST/R) and this most likely meant that a number of previously categorised goods were, at the start, simply categorised as "miscellaneous". No other data can explain why the commodity group miscellaneous suddenly peaks around 1996 and slowly decreases until year 2000. The "peak" is thus most likely due to flawed statistics.

[4] From 1983 to 1995 the data has been transformed from CTSE commodity groups to NST/R commodity groups. The group "Waste products, snow etc" have been excluded as they are not a part of the NST/R groups. "Packaging" have been included in group 24, Miscellaneous.

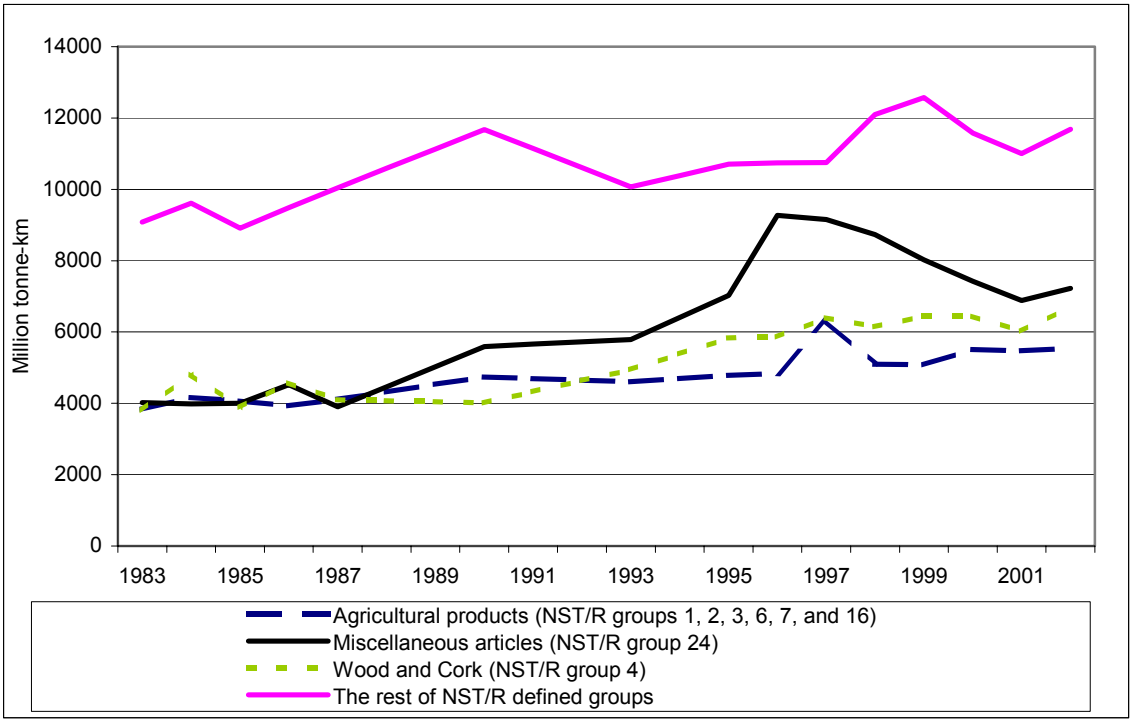

Figure 4. Road freight activity measured in tonne-km distributed on commodity groups.
Source: SCB

In Figure 5, the road freight activity measured in tonnes transported is given distributed on commodity groups. “Wood and cork” have increased from 48 million tonnes in 1983 to 69 million tonnes in 2002. “Miscellaneous” has also increased some from 23 million tonnes to 34 million tonnes. Agricultural products show a fairly constant development and the rest of the commodity groups are decreasing. This decrease is mainly due to a decrease in “Crude and manufactured minerals” (NST/R group 15) used mostly for construction such as gravel, rock e.t.c.

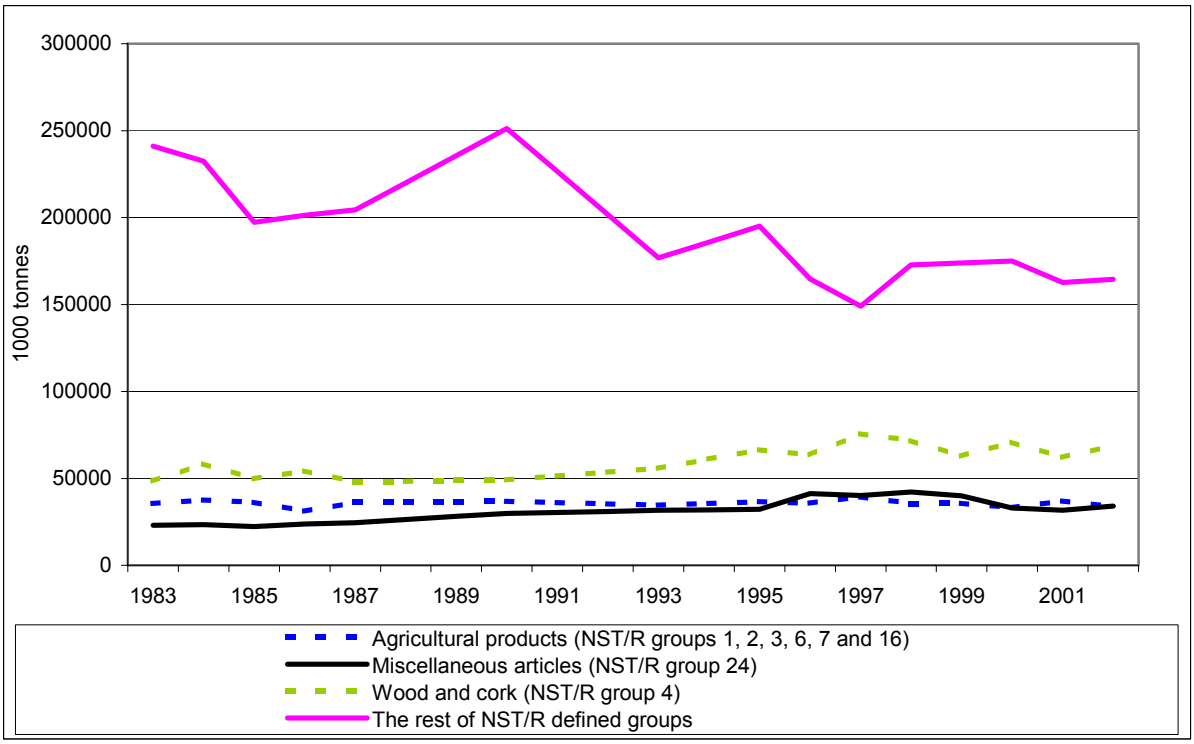

Figure 5. Road freight activity measured in tonnes distributed on commodity groups.
Source: SCB

The conclusions that can be drawn from Figures 4 and 5 are that the groups "Miscellaneous" and "Agricultural products" have increased by increasing the average length of haul and that the group "Wood and cork" has grown both in tonnes transported (+43% since 1983) and in the length of haul (+76% in tonne-km since 1983). The rest of the commodity groups have declined in tonnes and increased slightly in tonne-km, thus follows the trend of fewer tonnes travelling longer trips from raw material to final customer.

2.1.4 Development of some logistic indicators

In Figure 6, the vehicle-km driven by heavy trucks in Sweden is given. Vehicle-km driven has increased with only 8% since 1980 and should be compared to the 49% increase of tonne-km during the same time period. The explanations could be that the average payload of trucks has increased and thus every truck carries more weight. This is also confirmed for the period 1985 to 1995 in Table 2, see below.

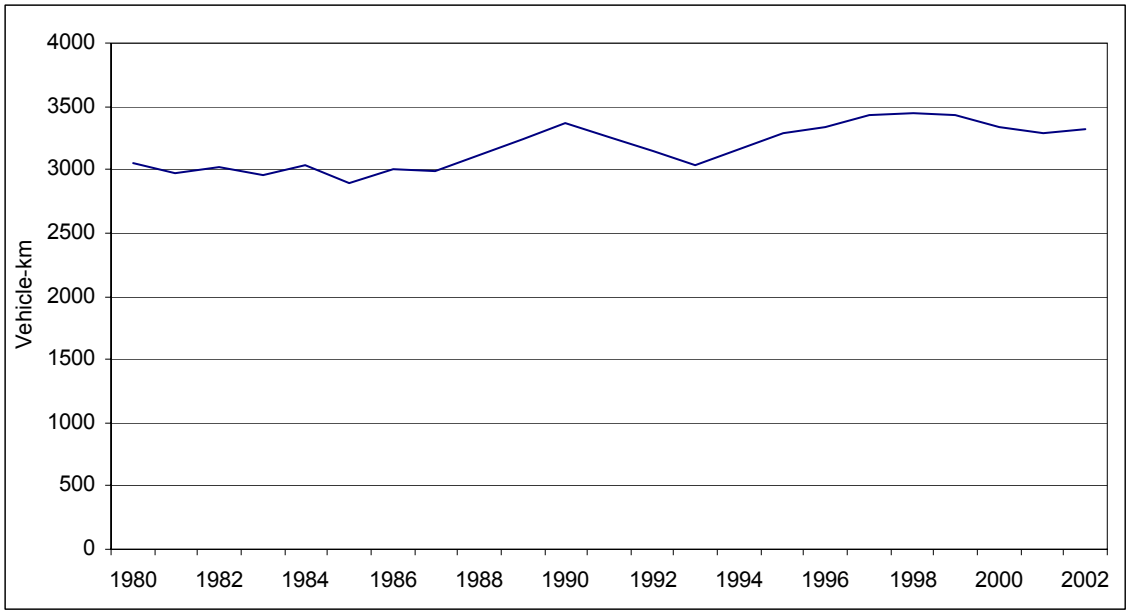

Figure 6. Vehicle-km for heavy trucks (>3.5 tonne).
Source: Numbers from SCB calculated according to Edwards et al (1999, p.54). Includes Swedish road freight activity in Sweden and foreign trucks activity in Sweden. Numbers on activity also incl. activity ”not in duty”.

In Figure 7, the average length of haul is given. The length of haul has increased since 1993 from 82 km to 98 km in 2001. The peak was reached in 1997 when the average was 104 km. This corresponds well to previous figures where the increase in transport activity measured in tonne-km did not result in an increase in tonnes transported. From Figure 2 and 3 it can be derived that it is the growth of length of haul beyond 100 km that has driven transport activity growth in Sweden the last 15 years.

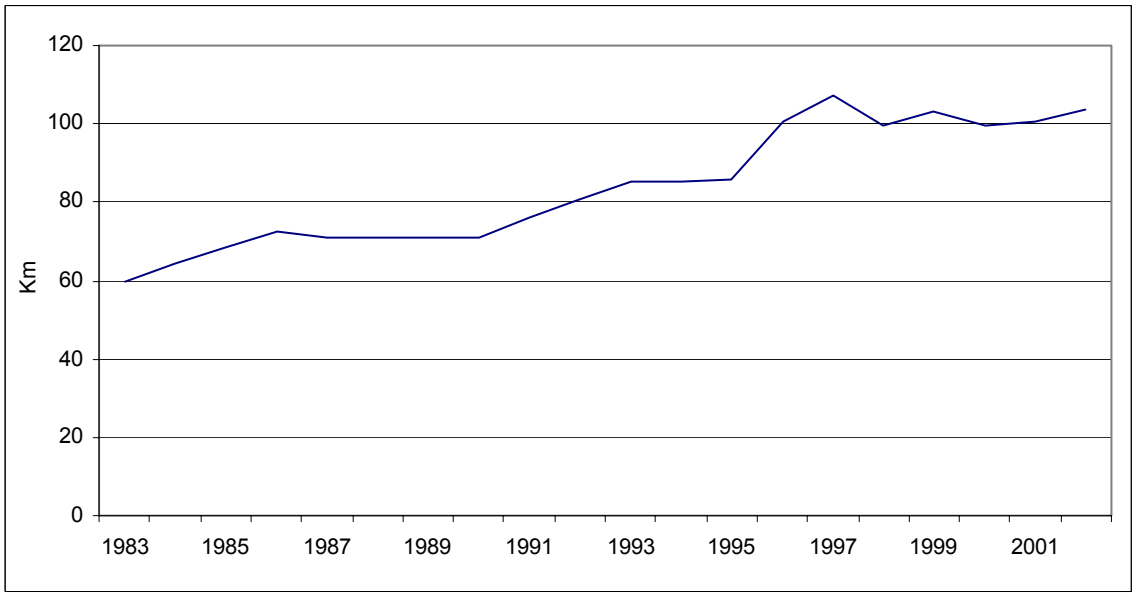

Figure 7. Average length of haul.
Source: Calculated from previous figures

In Figure 8, the numbers of registered trucks are given distributed on the vehicle carrying capacity. The numbers of light trucks has increased substantially the last

years and the numbers of trucks carrying over 24 tonnes has also increased a lot and to some degree replaced some of the trucks in the range 16 to 24 tonnes

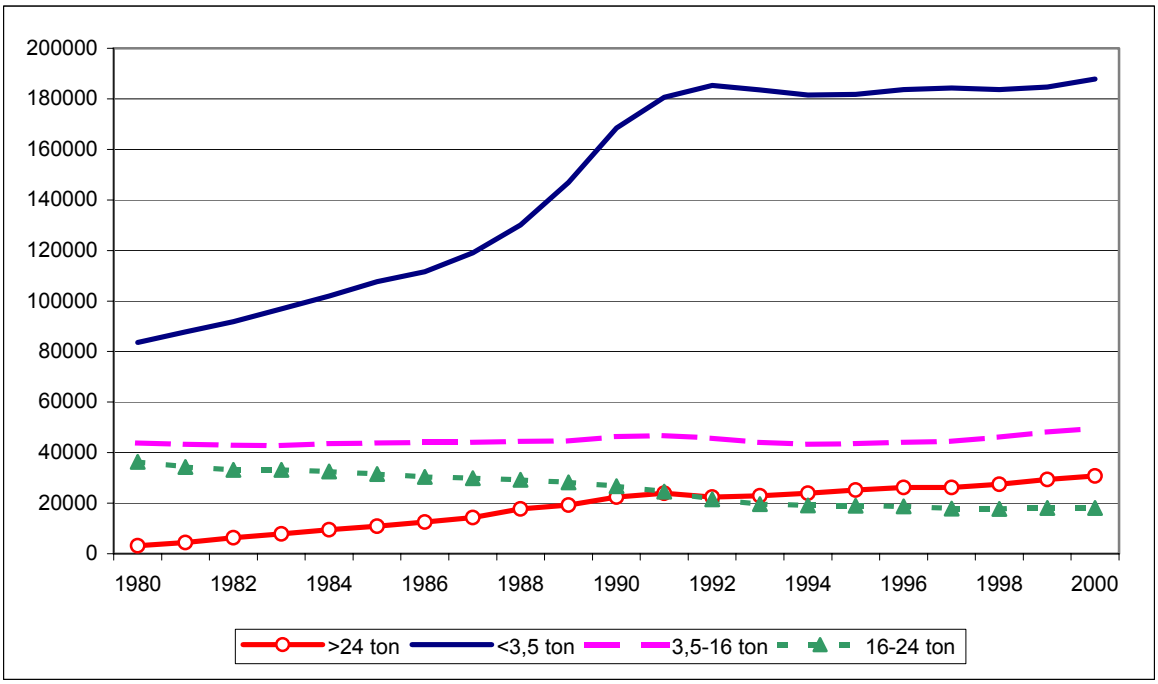

Figure 8. Number of registered trucks distributed on vehicle carrying capacity.
Source: SCB

The REDEFINE project published statistics on logistical indicators over the time period from 1985 to 1995 for a number of European countries. The indicators of greatest interest for this study were empty running, handling factor, load factor, and vehicle carrying capacity. In Table 2, the results from a selection of the indicators presented in the REDEFINE project are shown.

Table 2 Selection of logistical indicators for Sweden between 1985 and 1995 according to the REDEFINE project

Logistical indicators	**Changes in % for Sweden 1985 to 1995**
Handling factor	-20%
Vehicle carrying capacity	+28%
Load factor	-4%
Average pay load	+22%

Source: REDEFINE (1999)

Empty running in Sweden decreased with 7% between 1985 and 1995. The empty running in Sweden has continued to decrease from 28% in 1993 to 24% in 2001 (SIKA 2003b). Empty running differs a lot from different commodity groups where "mixed goods" has an empty running of 7% and logging had 46% (nothing to take back) (ibid, pp81)

The handling factor measures the number of separate freight journeys that a consignment makes in moving from raw material to sales market. The handling factor is derived as a crude measurement by dividing tonnes lifted by tonnes transported. The REDEFINE project calculated handling factors for a numbers of European

countries and the conclusion was that the handling factor in EU showed no consistent trend from 1985 to 1995. In Sweden is was reported to have decreased by 20% during this time period, that is 20% fewer separate journeys for the average transported good (REDEFINE 1999).

Vehicle carrying capacity increased across Europe with a trend towards bigger trucks. In Sweden, vehicle carrying capacity increased with 28 % between 1985 and 1995 (REDEFINE 1999). The use of heavier vehicles has resulted in an increase in payload with 22% for the same time period while the load factor (how much of the carrying capacity that is utilised) decreased with 4%

2.2 Brief conclusions for freight transport activity

- The growth of transport activity can be explained with the increase in length of haul, where commodity groups generally considered to have a higher value (food, machines, mixed goods) dominate the growth trend for trucks

- Road freight transport grows (in tonne-km) whereas sea and rail transport remains constant.

- The traditional bulk goods remain fairly constant or is even decreasing in tonnes lifted

- The logistical indicators show an increasing efficiency off-setting some of the growth in demand the last years.

3. THE SWEDISH ECONOMY

3.1 Economic development

The statistics of economic growth measured in GDP is presented, together with industrial GDP distributed into sectors. A brief overview of the export versus import of the Swedish economy is given and a discussion of the possible long-term structural changes in Sweden with special focus on a transition from manufacturing towards services.

3.1.1 Economic growth and economic sectors

The Swedish economy has grown according to Figure 9. The only downturn since 1980 in the Swedish economy was between 1990 -1992. After 1993, an export-lead growth occurred[5] until the year 2000. The economy then faced new difficulties as the world economy slow down.

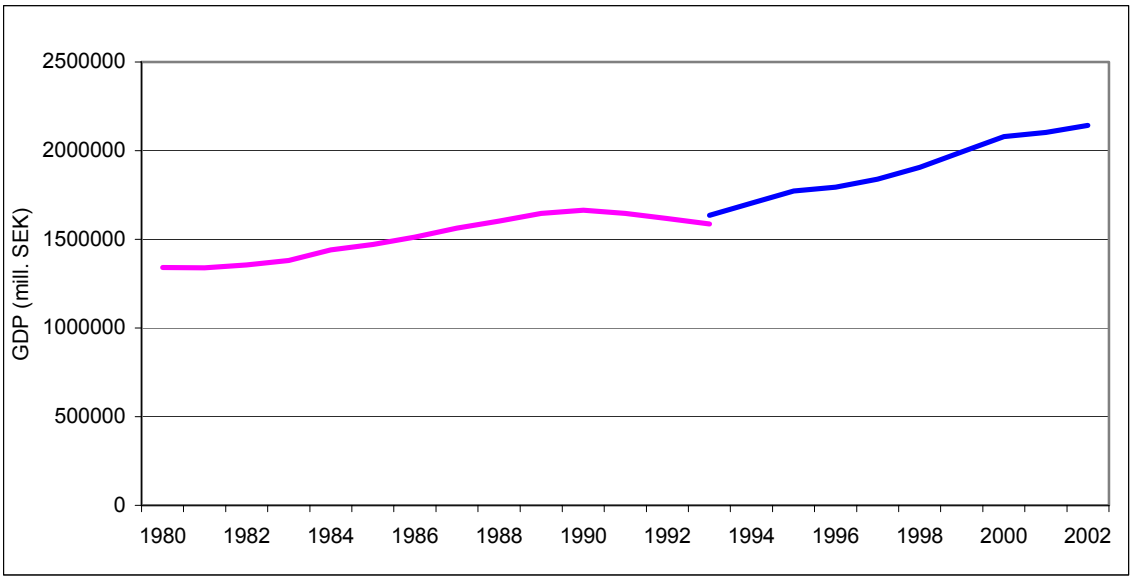

Figure 9. Economic growth measured in GDP in Sweden at 1995 prices.
Source: SCB. Note: The numbers given here are according to the SNA 93/ENS95 standard. Prior to 1999 GDP was calculated according to SNA 68 and then the standard was changed to SNA 93/ENS 95. The calculations on GDP according to SNA93 standrd are made "backwards" until 1993. Further back in time these calculations has been estimated on aggregated numbers. The major difference between SNA68 and SNA93 is that VAT is included on services within the public sector.

In Figure 10, the industrial economy distributed into sectors is shown. The numbers in Figure 10 show that the manufacturing sector (SNI 15-37) was fairly constant from 1980 to 1992 but has grown with 62% the since 1993. The private service sector has grown substantially with 80% since 1980. Mining, agricultural, forestry and construction have all been relatively constant sectors.

[5] The Swedish crown was depreciated with 25 % the years after 1992.

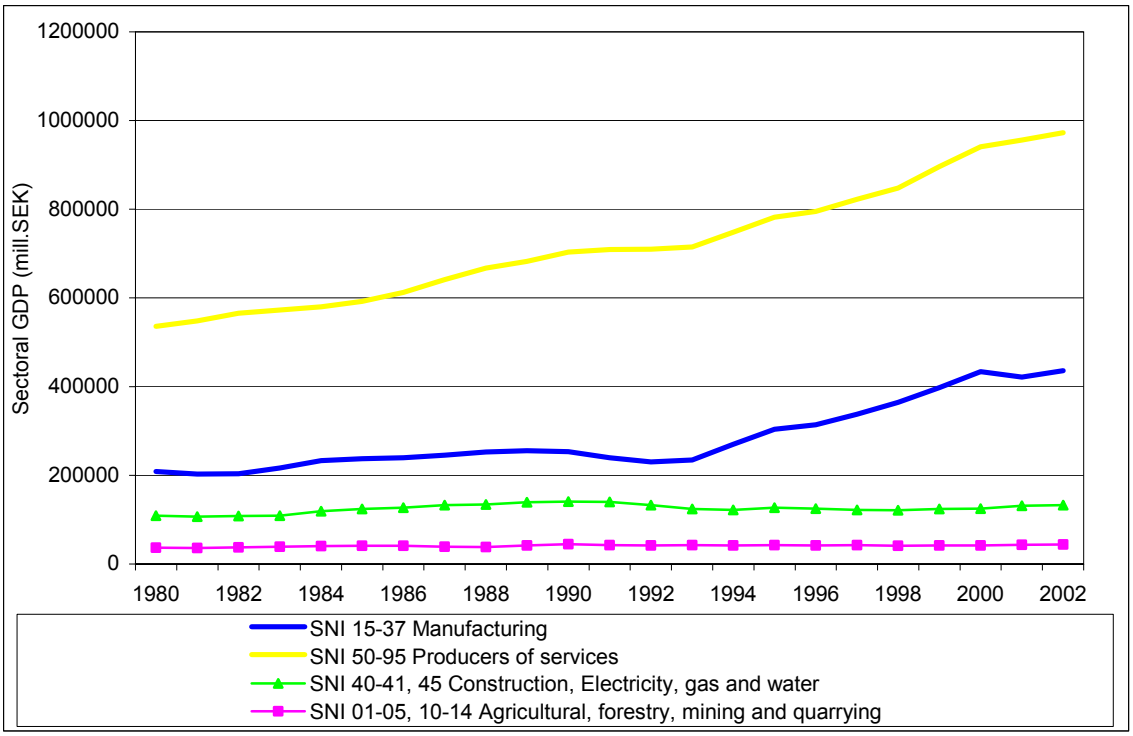

Figure 10. Economic growth and Sectors in Sweden in year 2000 prices.
Source: SCB Note: In 1992 also the division into economic sectors where changed from SNI69 standard to SNI 92. The numbers prior to 1992 have been recalculated by the author to fit the SNI 92 nomenclature.

3.1.2 The internationalisation of the Swedish economy

In Figure 11, the value of export for Sweden is given. The share of export has increased, both in real terms and in relatively to the total GDP.

As stated previously, the growth of the economy since the depreciation of the Swedish Crown in 1992 has to a large extent been export lead. This, together with the Swedish membership in the European Union and the increasing internationalisation of the world economy ("globalisation"), has contributed to the development illustrated by Figure 11.

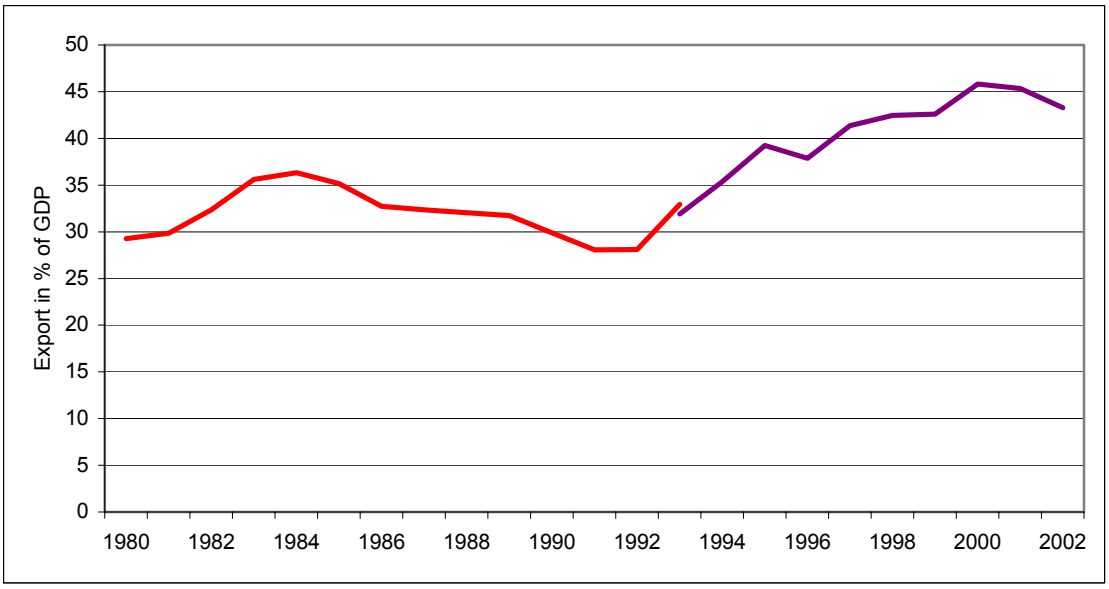

Figure11. The share of export of the Swedish GDP
Source: SCB

Most tonnes exported are still raw materials but the commodity groups currently growing are manufactured goods. Most tonnes imported are mineral fuels followed by raw materials. The import show a similar trend as the export i.e. manufactured goods is growing. Raw materials and mineral fuels are to a greater extent transported by either trains or ship whereas manufactured goods mostly go by truck.

A further indication of the internalisation of the Swedish economy is the share of Swedes employed in foreign owned companies and the numbers of employees abroad in Swedish owned companies (ITPS 2003a and b).

3.1.3 Long-term structural changes

The long-term structural changes in the economy could have a great significance on the freight transport volumes. Here, the structural change of interest is the shift away from an economy based on manufacturing towards an economy based on services. An economy more dependent on seemingly less transport intensive sectors, such as services, could allow economic growth with less transport activity. Schön (2000) defines this structural change as follows:

1) The strongest definition is that the volume of services increases more than the volume of industrial products. The indicator should thus be that the service sector's share of the total economy in volumes (given as the share of GDP in fixed prices) should increase.
2) A second definition looks at the number of people of employed in the service sector contra in the industrial goods production. This is measured in the share of people of employed.
3) A third definition is that the service sector is the "dynamic force" in the economy through innovations. The innovative capacity would shift from the industrial sectors to the service sectors.

In Figure 12, the distribution between industrial goods production (SNI 1-45), industrial services (SNI 50-95) and public expenditure on services is given. A small increase in the share of GDP for the service sector can be seen since 1980, but this

fact should be interpreted with care due to the relatively short time frame and uncertainty in numbers. The statistics in the service sectors have been boosted as a result of out-sourcing and privatisation.

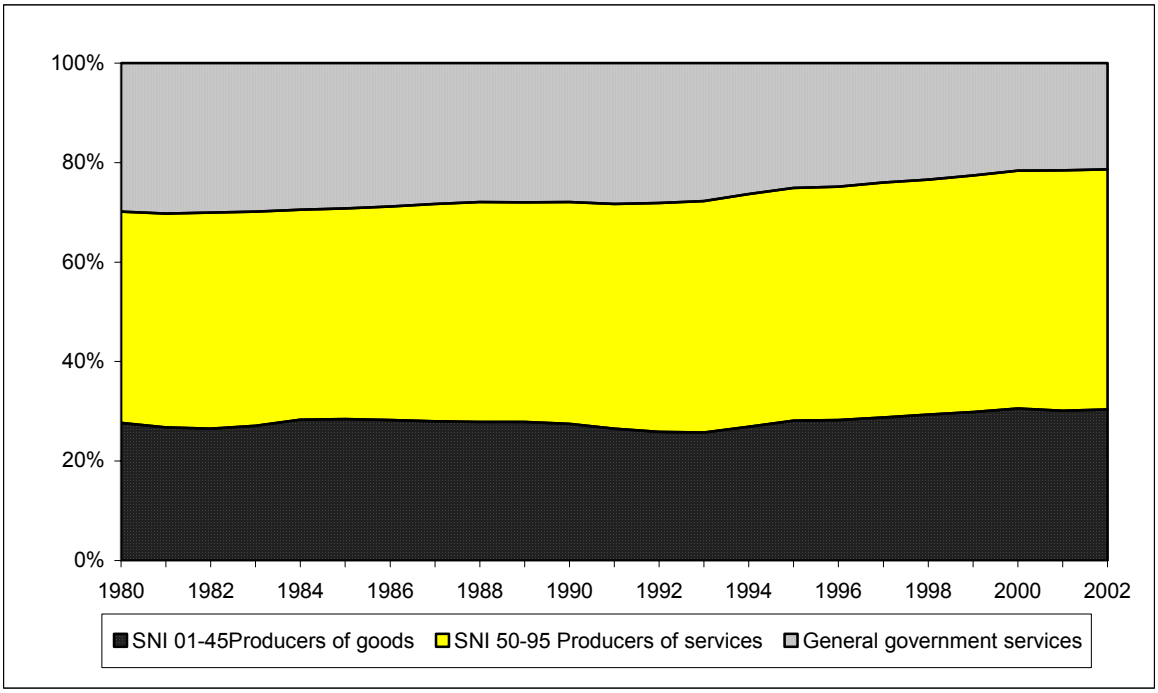

Figure 12. GDP distributed on producers of goods and producers of services in year 2000 prices.
Source: SCB.

Figure 12 does not support the idea that Sweden is moving towards a ”service economy” the last 22 years. Also, over a much longer time (since 1800), it is difficult to see any signs that the “service economy” has gained any significant share of the total GDP in Sweden according to the first definition[6] (Schön 2000).

Looking at the second definition, the number of people employed, there has certainly been a shift towards more service-oriented employments the last decade (ibid). From the third definition of structural change, the innovative capacity largely related to the service sectors, it is also difficult to draw any clear conclusions at this stage. According to the ITPS[7] the innovations in the service related sectors have mostly been related to industrial sectors as well. The dynamic force of the service sectors has grown but not at the expense of the industrial sectors (ITPS, 2001).

However, future freight transport demand is derived from the volume of goods produced and consumed in the economy, neither the share of people employed or the dynamic force of the economy can be expected to influence freight demand to any greater extent.

[6] However, the share of service related GDP has fluctuated substantially since 1800 (Schön, 2000). The time frame in Figure 12 is perhaps too short for drawing any clear conclusions on this subject.
[7] ITPS; Swedish Institute for Growth Policy Studies (Institutet för tillväxt politiska studer),

3.2 Brief conclusions for economy

- The economy in Sweden has been steadily growing since 1980 with some minor disruptions

- The economy is becoming increasingly international as the share of exports and imports of the GDP is growing

- Strong development of manufacturing industry the last 10 years partly due to the depreciation of the Swedish crown in 1992.

- No signs that the service related sectors´share of the GDP is increasing or decreasing in the long run.

4. LINKING ECONOMY AND FREIGHT TRANSPORT

4.1 Transport intensities as indicators

Transport intensities are used as indicators reflecting some sort of "efficiency" linking the economy to transport activity. Examples of transport intensities are CO_2-emissions/GDP, vehicle-km/GDP, tonnes/GDP or tonne-km/GDP. The concept of "decoupling" is referred to as changing a historically constant intensity. The intensities above allow for different possibilities to break the link.

The perhaps most fundamental measurement of transport freight activity is tonne-km measuring the length of haul for every trip and the weight of the goods transported. The measure tonne-km intuitively relates to both the derived demand from the economy and to the externalities such as CO_2-emissions, congestion, and road "wear and tear". A decrease of the indicator tonne-km/GDP means thus less "demand" for freight transport services, e.g. a combination of less tonnes transported and-or goods transported shorter trips.

The demand for freight transport measured in tonne-km could increase at the same time as the vehicle-km driven decreases due to increasing logistic efficiency by increasing the average payload and less empty running. Complementing the indicator tonne-km/GDP with vehicle-km/GDP is thus useful for studying logistic efficiency.

The indicator tonnes/GDP measure the material intensity of the economy but reveals nothing of the distances that goods are transported.

CO_2-emissions/GDP is the indicator directly related to two currently vividly debated externalities, energy security and climate change. This indicator does not relate directly to the demand for freight transport and the CO_2-emissions could, to some extent, be decoupled from GDP growth through technical measures such as increased motor efficiency, shifting fuels and shifting transport mode.

As can be seen from the discussion above there are a number of ways to measure transport intensity and each measure focus on different factors, such as modal shift, vehicle efficiency or demand efficiency. The different strategies presented in the introduction can all relate to one or more of these indicators.

4.2 Trends in freight intensity for Sweden

The main focus of this report is to look at the demand for freight transport and the link to the economy. The focus is thus on the indicator tonne-km/GDP that best relates to the derived demand for freight. However, all other indicators mentioned above are also presented, and needed, in order to get a more complete understanding of freight development in Sweden.

In Figure 13, the freight intensity measured in tonne-km/GDP is shown. The total freight intensity here includes all freight modes (rail, road, and sea) in Sweden.

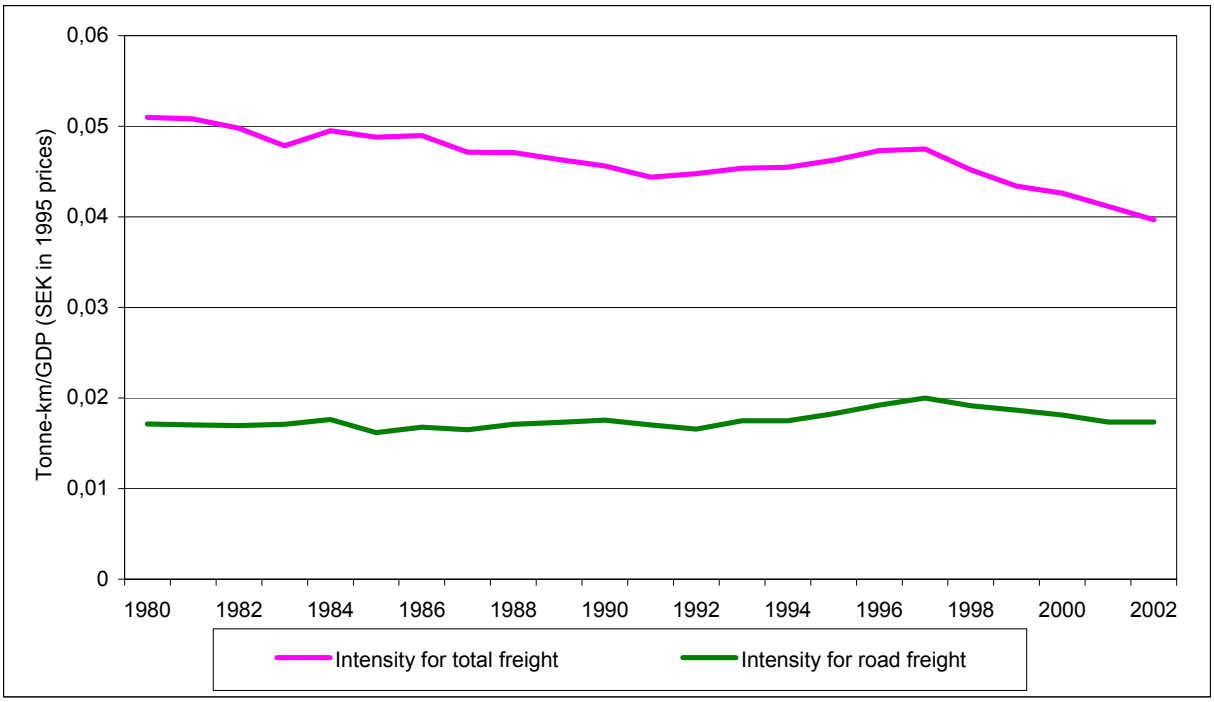

Figure 13. Transport intensity of the economy (tonne-km/ GDP).
Source: Calculated from previous Figures. Road freight activity, in both series, also includes estimates on foreign and small trucks according to Wajsman/SIKA, see Figure A1 in Appendix A1.

The *total freight intensity* has slowly declined for the Swedish economy since 1980. Between 1991 and 1997 the slow decoupling effect seems to be reversed with growing transport intensity for a couple of years. This is the period with first a slow economy (1991-93) and then an export lead economy and followed by a European integration process. After 1997, the transport intensity seems to be declining at approximately the same rate as before. However, it should be noted that with regard to the statistical uncertainties the slow decoupling effect is by no means certain.

The *road freight intensity* does not show on the same development as the total freight intensity. At first, there is a small increase between 1980 and 1996 and thereafter a small decrease. Generally, the road freight activity intensity seems much more constant and the shifts are too small to talk about a decoupling or a growing road freight dependency.

In Figures 14,15 and 16 the freight intensities measured in tonnes/GDP, vehicle-km/GDP and CO_2-emissions/GDP are shown. In Figure 14, both the total freight activity and road freight intensity is shown whereas in Figures 15 and 16 only the road freight intensity is given.

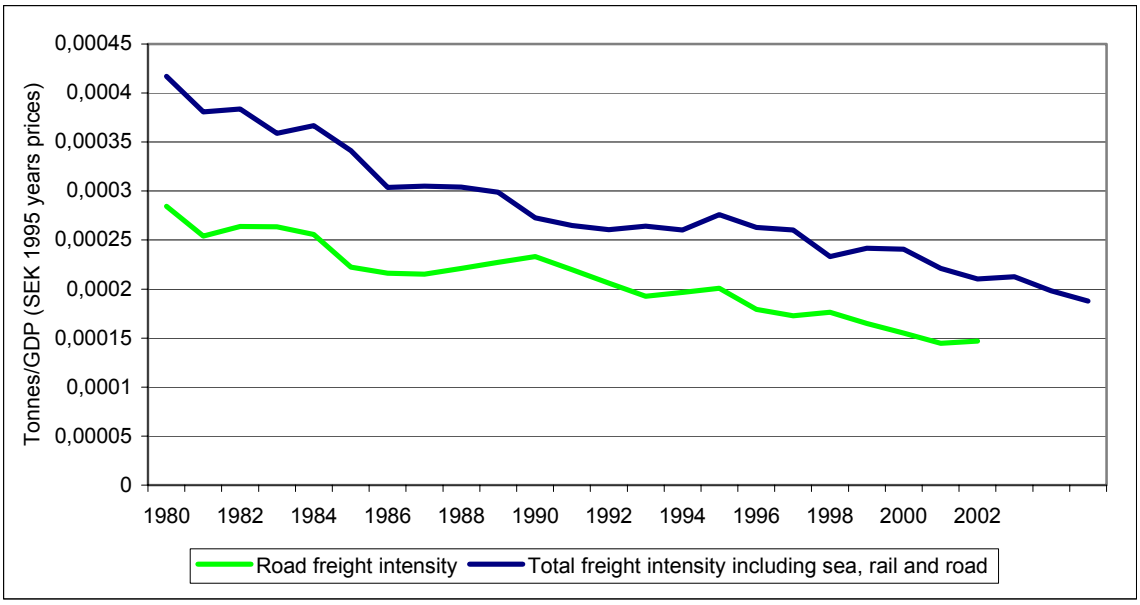

Figure 14. Freight intensity measured in tonnes/GDP.
Source: Calculated from previous Figures

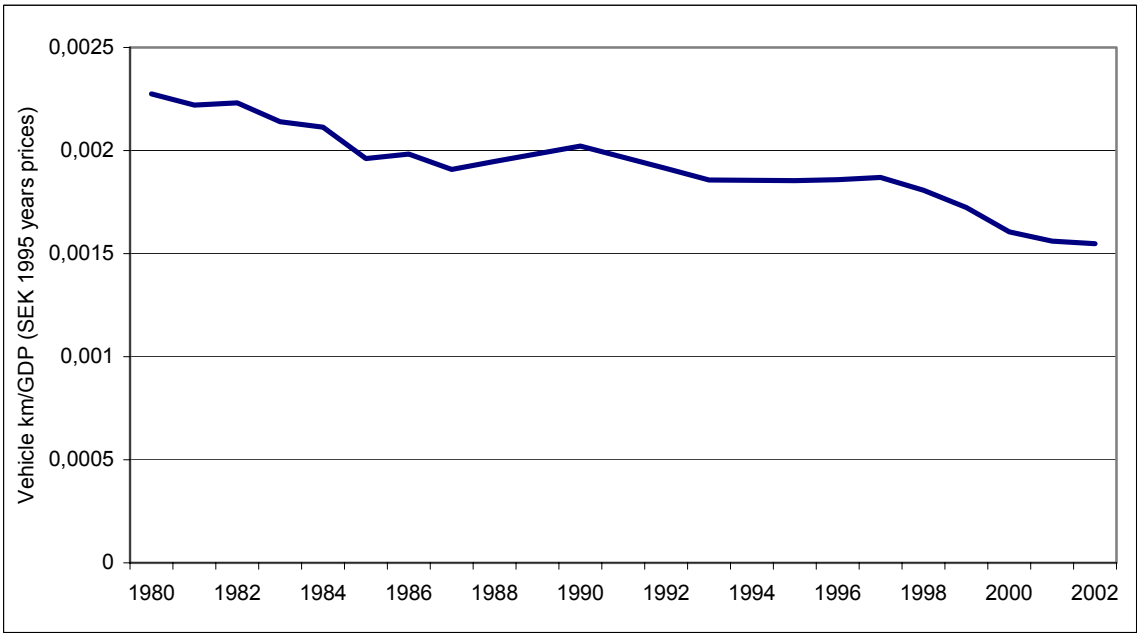

Figure 15. Road freight intensity measured in vehicle-km/GDP.
Source: Calculated from previous Figures. Numbers on vehicle-km from SCB calculated according to Edwards et al (1999 p.54). Includes Swedish truck activity in Sweden and foreign trucks activity in Sweden. Numbers on activity also incl. activity ”not in duty”.

Both the freight intensity measured in vehicle-km/GDP and tonnes/GDP show a much more pronounced decoupling since 1980 than tonne-km/GDP. In these two cases, the trend is very clear and cannot be a statistical error.

The sharper decline in vehicle-km/GDP than in tonne-km/GDP can be attributed to the use of larger trucks with an increasing average load as a result, see Figure 8 and Table 2. The decline in tonnes/GDP can be explained by the decreasing building sector in Sweden and less growth in the energy sector (oil) after the oil crises. These both sectors demand heavy but short-range transports of goods. The decline in tonnes

has not resulted in a decline in tonne-km as the average length of haul has increased, see Figure 7.

Finally, in Figure 16 the road freight intensity is shown measured in CO_2-emissions per GDP. From 1981 to 1988 there is a "dip" in intensity that is difficult to explain. A closer look at the actual numbers reveals that the CO_2 emissions have been fairly constant at the same time as GDP has grown. Why the CO_2 emissions have not grown between 1981 and 1988 is not known.

However, from 1993 and onwards there seems to be an increasing relationship between CO_2 emission from freight and GDP. The relationship between CO_2 emissions from road freight transport and tonne-km has been fairly constant (see Figure A5 in appendix) with a slight increase the last years. In reality, increasing CO_2-emissions/tonne-km means less efficient trucks as all other indicators (empty running, vehicle-km/GDP e.t.c) show a decreasing relationship compared to GDP. However, that trucks would have become less energy efficient seems unlikely from a motor efficient point of view. This need to be further analysed in order to determine whether the statistics are flawed or a reasonable explanation exist.

The numbers below are the estimated CO_2 emission by road freight made by the Swedish Road Administrations´ and these numbers are rough estimates primarily based on diesel imports to Sweden that are distributed among different modes of transport. Figure 16 should be interpreted with great care as the numbers on CO_2 emissions from freight transport are very uncertain[8].

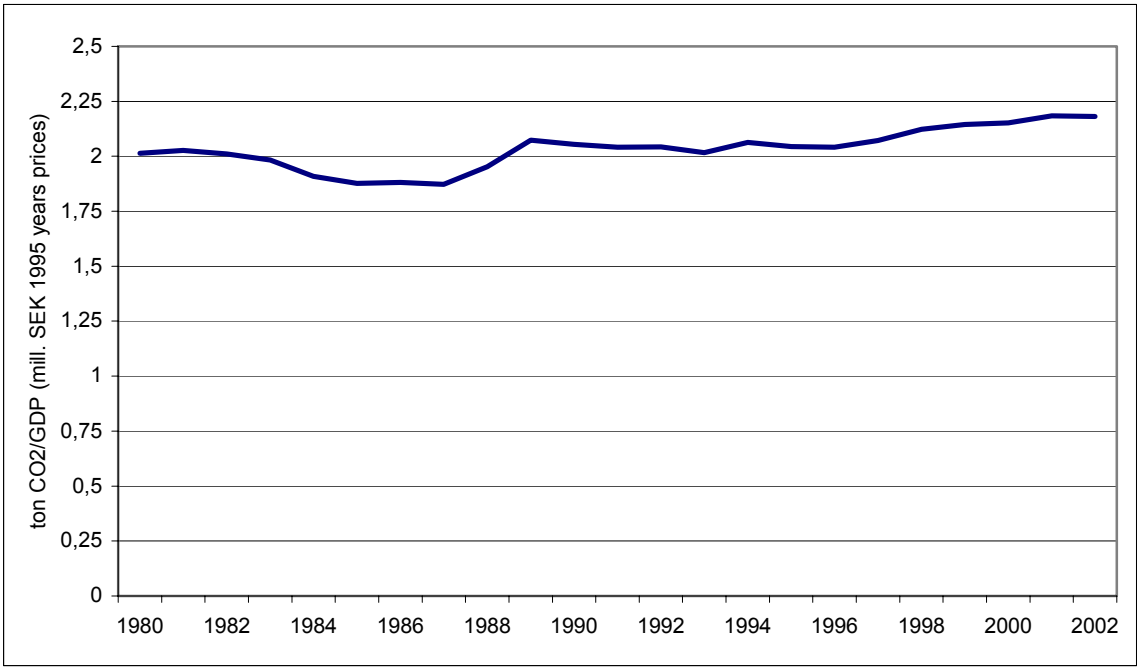

Figure 16. CO_2 emissions for road freight/GDP.
Source: Calculated from previous Figures and numbers on CO2 emissions from road freight from the Road Administration (Vägverket). The CO_2 emissions are crude estimates by the Swedish Road Administration (Vägverket) based on statistics on the total amount of diesel used in Sweden.

As a comparison, the total freight intensities for eight industrial countries are shown in Figure 17. Transport intensities are influenced by a number of factors but the

[8] Currently the road administration, SIKA and the Swedish Environmental Protection Agency is trying to develop better statistics.

absolute numbers is country specific. Schipper and Marie-Lilliu (1999) found freight intensities to be much higher in the US and in Australia than in the EU, see Figure 17. The US and Australia have the highest freight intensities. It is, however, also worth noting that a much larger share of US freight transport is made by rail (~35 % as compared to ~22% in Sweden). The difference between these countries is, according to Schipper and Lilliu (1999), largely due to geographic differences.

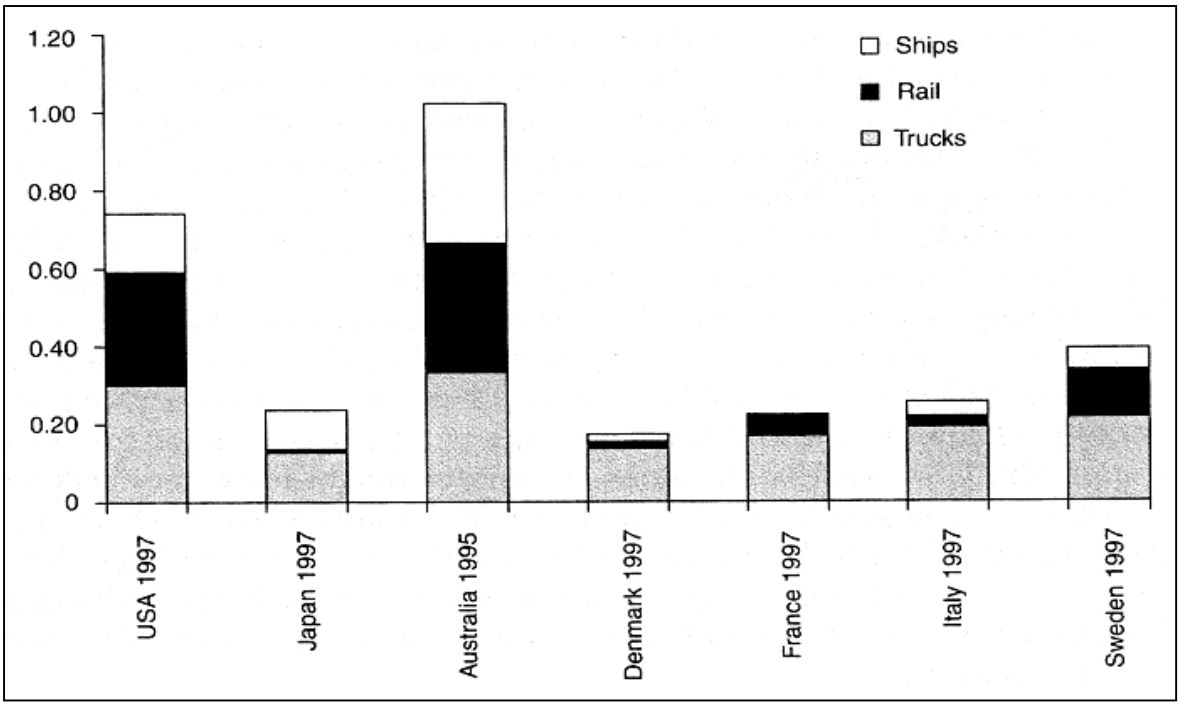

Figure 17. Freight intensities in tonne-km/GDP (1990 US$ Purchasing Power Parity per 1000 tonnes) for different countries
Source: Adopted from Schipper and Fulton (2004). Original source: LBNL and IEA databases developed by Schipper and colleagues.

4.3 Road freight intensities based on sections or product groups

Freight intensities are usually presented as the total freight activity related to the total economy. Narrowing down the analysis and constructing *sectional freight intensities,* either based on sectors of the economy or for a specific category of products, is relevant for a deeper understanding of transport growth.

4.3.1 Sectional freight intensities in Sweden

Sectors of the economy and the transported commodity groups do not easily correlate. An economic sector is not the same as a commodity group since a sector usually produces products belonging to several different commodity groups. In order to link the statistics available on commodity groups to the statistics available on economic sectors you need a “key” distributing activity within a sector to different commodity groups.

Starting from an assumed sectional economic growth according to the governmental long-range planning commission (Långtidsutredningen), the freight model in Sweden, SAMGODS, links the assumed economic growth, with the help from “keys”, to a derived demand for transported goods distributed into commodity groups. This calculated demand for freight transport is later distributed over the road

network in the model and forms the basis for strategic infrastructure planning in Sweden.

From the "keys" linking economic sectors to commodity groups it would be possible to construct a time series with freight intensity measured in tonne-km per sectional GDP. This sectional freight intensity would, however, probably be of a poor quality as the link is not certain and the statistics itself (as time series) of transport activity distributed into commodity groups is also uncertain[9].

4.3.2 Freight intensities for groups of products

A study done by the DIW (Deutsches Institute für Wirtschaftsforschung) in Germany is the so far only published freight intensities for different commodity groups in a times series (DIW, 1996), see Figure 18.

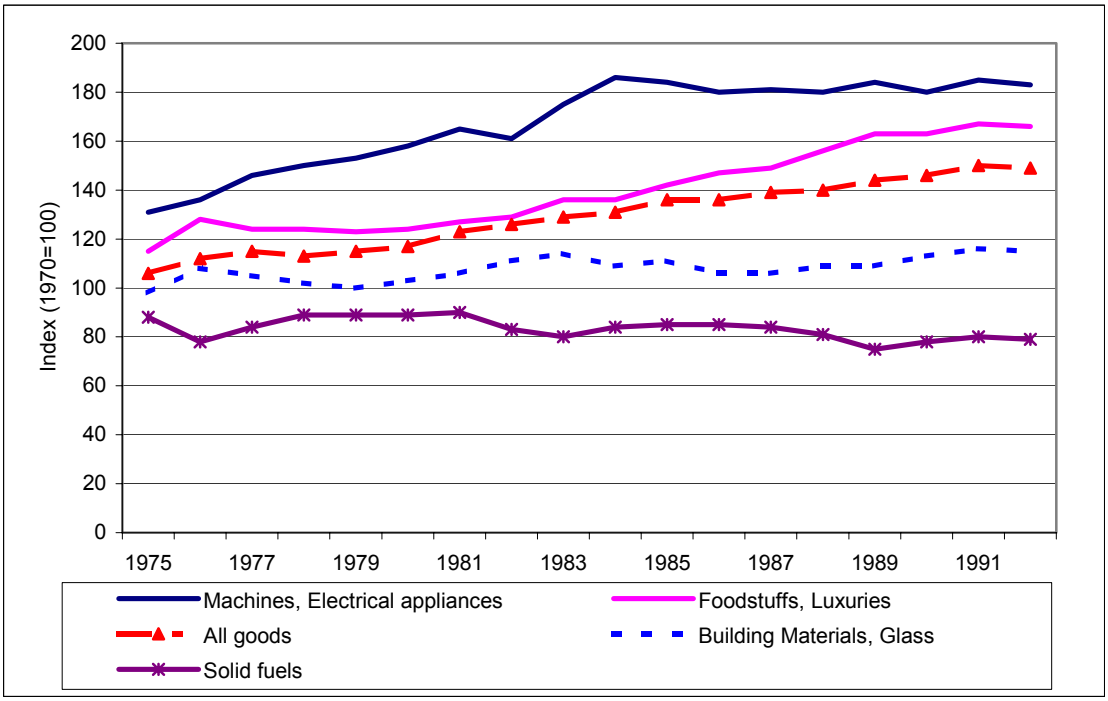

Figure 18. Freight intensities measured in tonne-km per volume of products of major product groups from 1975 to1992 in Germany.
Source: DIW 1996

In Figure 18, the freight intensity is measured in tonne-km per volume of product. An increasing intensity here means that the transport activity required to manufacture and sell each product would have increased. Figure 18 indicates a general increase in tonne-km required per volume of product. It is interesting to note that machines, electrical appliances and foodstuffs and luxuries have increased in transport intensity whereas building materials and solid fuels remains the same. However, as the methodology for the DIW study is unclear the results should be interpreted with care.

It is currently not possible from the statistics available to see the freight activity generated by single products on the consumer market. There is no possibility to follow single products like the well-cited Yoghurt beaker study by Böge (1995).

[9] Another sectional transport intensity that is currently being developed in Sweden by the Environmental Strategies Research Group (FMS) is an analysis based on official vehicle-km data from the annual car inspection and allocated onto consumer products using an input-output model. The results are due to the autumn 2004.

4.4 Are there any signs of decoupling in Sweden?

In Figure 19, the total freight activity, the road freight activity, the Swedish economy and the CO_2-emission from road freight are summarised.

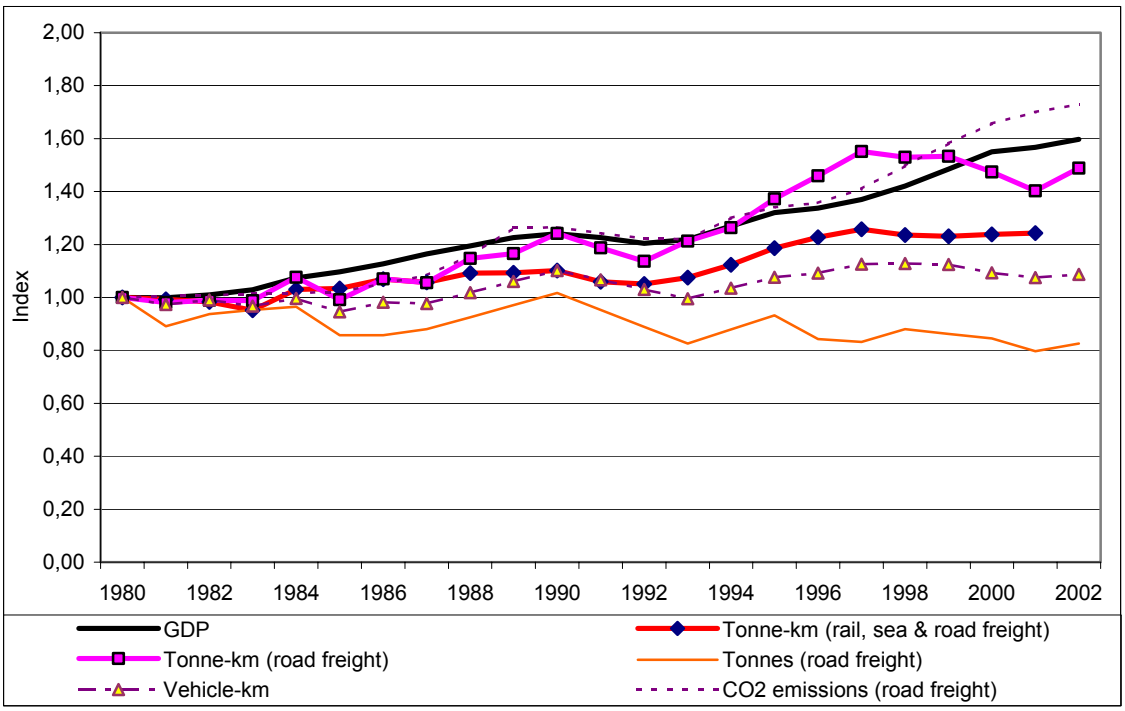

Figure 19. Development of freight activity, economy and CO_2-emissions from road freight in Sweden.
Source: Derived from previous figures.

The total freight activity in tonne-km has increased less than the GDP-growth, thus the minor decoupling trend of decreasing *total* freight intensity in Figure 13. The *road* freight intensity has, however, been constant and not shown any real signs of decoupling. Only since 1996 could a very small decrease in the road freight intensity be noticed. In absolute numbers, road freight measured in tonne-km has continually grown whereas the other modes, rail and shipping, has remained at fairly the same volume. The freight intensity measured in CO_2-emission/GDP has followed the development of tonne-km/GDP and has thus not been decoupled, see Figure 16.

Both the road freight intensity measured in tonnes/GDP and vehicle-km/GDP has been partly decoupled from GDP-growth, see Figure 14 and 15. The transported volume in tonnes by road has actually been slowly decreasing, see Figure 19. This is mostly due to the decrease in heavy but short haulage transport, such as construction materials. The road freight activity measured in vehicle-km has increased much less than GDP. The explanation is that the logistic systems have become much more efficient using larger trucks and decreasing empty running.

In conclusion, the road freight intensity measured in tonnes/GDP and vehicle-km/GDP has been partly decoupled whereas the road freight intensities most interesting from an environmental point of view, tonne-km/GDP and CO_2-emission/GDP, has not been decoupled.

5. EXPLAINING THE GROWTH OF ROAD FREIGHT TRANSPORT

In Sweden, approximately the same amount of goods in tonnes (or even less) have been transported the last 20 years, thus there has been a decoupling between transported tonnes and the growth of the economy. However, transport activity measured in tonne-km continues to grow. What causes the growth of tonne-km seems to be the fact that goods are transported longer trips from raw material to the final customer.

This study investigates three different sets of assumptions, (i) *the expanding economic geography,* (ii) *friction of space / costs of transport and* (iii) *logistical changes,* as explanatory variables for the continuing freight growth. However, neither of these assumptions are independent from each other but should be seen as three different views on the same problem, i.e. that we transport the goods longer distances from raw material to final consumption. The brief analysis here rests on Swedish statistics but international statistics are used for comparison or to illustrate when national statistics are lacking.

5.1 Expanding economic geography

An expanding economic geography means that the process from raw material to finished product needs more transport due to fewer component manufacturers located over a wider area and centralised storages. Not only the production system is becoming increasingly global but also the markets for these products. The goods are exported further away to the final customer as trade has become more international and we consume more products manufactured far away (e.g. Germans drinking Mexican beer and Swedes drinking water from France).

The measure for geographically expanding production systems and far away final markets would be transport intensity/volume of product. The numbers, however uncertain, on transport intensity for German products presented by the DIW in Figure 18 is an indication on how products have become more transport intensive over time.

The harmonisation of regulations and decreasing customs have enabled European companies to exploit the economic efficiency gains to be made by moving production to countries with lower factor costs and centralisation of production systems to fewer locations. Also, as an effect of an increasing number of mergers creating bigger and more internationally owned companies, the production is further specialised and concentrated on fewer locations resulting in more transport. The production structure has geographically spread in Europe since the completion of the European single market (Amiti 1998, Brülhart 1998).

The transport intensity (tonne-km/GDP) within the EU is increasing whereas the transport intensity in the US is decreasing, but from a much higher level (Gilbert and Nadeau 2002). Vickerman (2002) claims though that the increase of transport intensity within the EU should be seen as an adjustment process to a new wider geographic reality (the single market), and not as a new relation to economic growth.

5.2 Friction of space / costs of transport

The classical explanation for linking freight transport needs to economic growth is the reduction in "space friction" enabling access to raw materials and larger markets and thus enabling economic growth. This reduction of friction is both related to the cost, the technical ability of transport systems, and to the legal and cultural context like trade regulations and languages.

Cost

It is often claimed that prices for truck transport have declined over time. Looking at very long time frames this is certainly true, see e.g. (Kander 2002). No numbers exist of actual prices for freight in Sweden but a study from the Netherlands could be seen as an indicator of decreasing transport prices, see Figure 20.

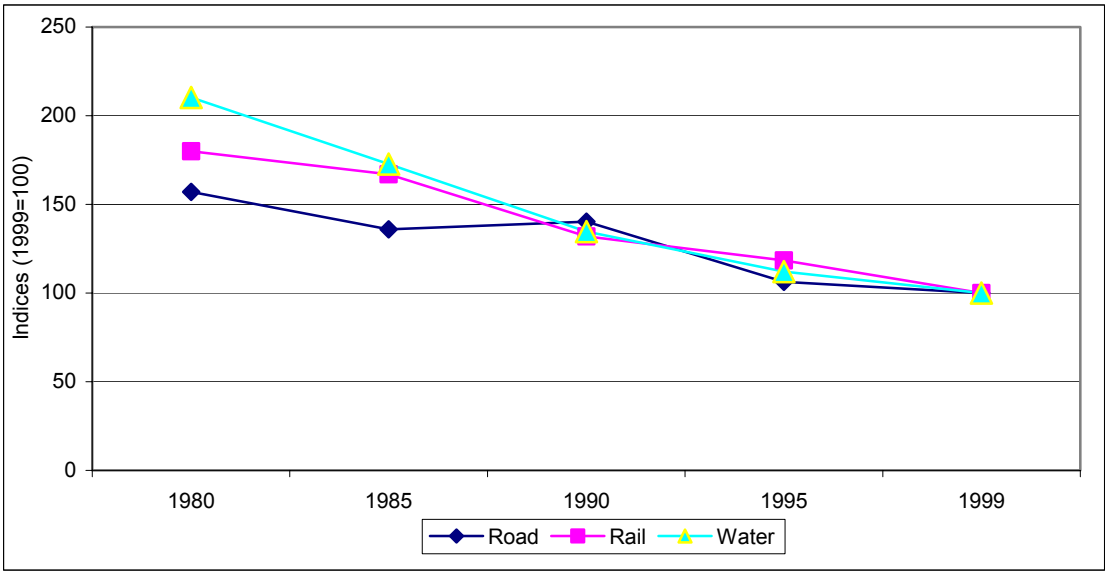

Figure 20. Price development of international freight transports in The Netherlands
Source: European Environment Agency (2003)

The transport cost is low compared to the total sales revenues; numbers around 1,6 % to 4,7% has been forwarded by Touche Ross in McKinnon (2002), Strutinsky (1995) and (McKinnon and Woodburn, 1996). In Figure 20, the costs for hired transport in Sweden are shown as shares of sales revenues for a selected number of industries. Figure 21 represents a selection of industries. For most of the industries, the costs of hired transport services[10] amounts to somewhere between 2% to 4% of sales revenues. There are however some remarkable exceptions as mining (7%), mineral extraction industry (12%), wood (5,5%) and coal and peat industry (7%, not shown in Figure) and recycling industry (7% not shown in Figure). However, these are all raw material based industries and for the general manufacturing industry the cost of transport seems to be around 3-4% of sales revenues.

[10] 11% of truck activity (ton-km) is made "in house" (SIKA rapport 2003:6) This figure has been almost halved the last 25 years. (ibib).

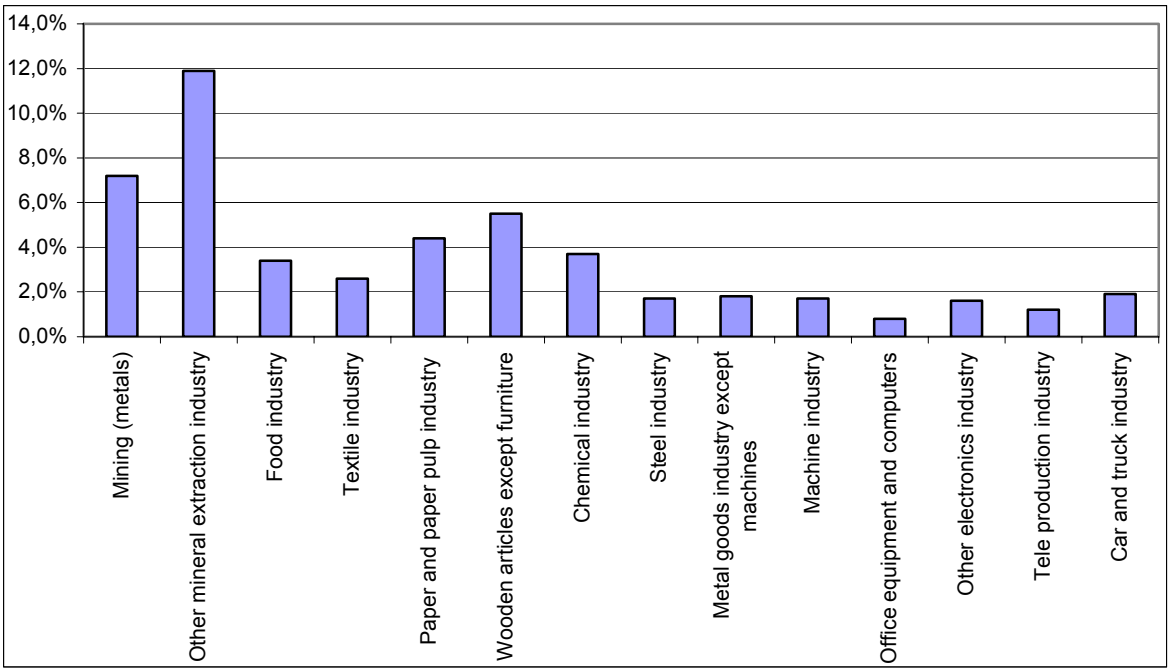

Figure 21. Share of costs of sales revenues. Costs are the cost for hired transports.
Source: SCB, a selection of industries

The relative low cost of transport compared to the sales revenues challenges the idea that higher transport prices through e.g. petrol taxes, will have any significant effect on demand. The difference in factor prices (wages e.t.c) between possible distant location sites can motivate very long transport distances, especially for the fastest growing industries (electronic, manufacturing). Schipper et al (1997) comes to the conclusion in an investigation of freight development between 1973 to 1993 for different OECD countries that fuel prices changes has had very little effect on choice of mode of transport.

Trade regulations

International trade has increased continually since the end of WWII. Free trade has long been on the international policy agenda and was last manifested with the formation of the World Trade Organisation (WTO) in the mid 1990s. Within the EU, integration and the removal of trade barriers has actively been pursued since the single European act in 1987. The internal European transport market has been liberalised since 1993. The restrictions of the amount of traffic between member states has been abandoned and formalities and controls at internal borders have been eliminated with the introduction of the single customs territory. International traffic is authorised by the EU for any member state transport company with a license for international transport. The EU integration has thus lowered the cost of road transport and reduced trade barriers that lead to efficiency gains in the economy. Unfortunately, the deregulation trend has not been equally successful when it comes to railways where a number of hurdles and state monopolies still remain. The road transport system has thus been favoured the last years as an effect of EU policy (EU White Paper 2001).

5.3 Logistical changes

Improving logistic systems has been a major issue for the industry the last 20 years. The demand for faster and smaller deliveries "just-in-time" could introduce a big inefficiency in the transport system with a large number of trucks running empty or with little cargo. However, there are no figures that support the idea the Just-In-Time (JIT) systems have created an inefficient transport system. On the contrary, more focus on logistics seems to have increased the efficiency the last 15 years. Table 2 and Figure 8 give some examples of indicators showing an increased efficiency in the logistic systems, for example, empty running has decreased, average pay-load have increased, and vehicle carrying capacity gas increased.

The use of smaller trucks for special deliveries have increased but according to the statistics, the transport activity measured in tonne-km constitutes a very minor part of the total amount of activity (<2%), see Appendix A1. The numbers of smaller trucks have certainly increased but smaller trucks seem to a large extent not being used for transporting freight.

However, one effect of JIT systems might be that competitive transport markets have increased the efficiency and thus lowered the cost of transport for manufacturing companies. Another effect of JIT systems could be the large growth of mixed goods. More freight being transported by third parties which pack the goods together with numerous other articles and thus brands the whole trucks as " mixed goods" instead of specifying the goods.

5.4 Brief conclusions for freight growth.

- The increasing "globalisation" creates a structural demand for more freight transport by increasing the economic geography.

- Prices for transport can be assumed to have relatively declined, even though very few actual numbers are available. However, the cost for transport services seems no longer to have a crucial role in determining transport activity. Other reasons for "space friction" such as tolls and regulations seem to matter more.

- The emergence of JIT systems and an increasing focus on logistic systems have not increased the demand for transport services but instead increased the efficiency of the transport system.

6. EXPLORING THE OPPORTUNITIES FOR DECOUPLING

The previous chapters have shown that the long-term growth of freight transport activity could be explained by a spatially expanding economic system. This trend has been enhanced the last years with the formation of free trade agreements and the single European market act. Below, we briefly analyse (i) what affect business decisions on location, with a special focus on the influence of fuel prices, (ii) the effects of long-term of government policy and planning, (iii) the possibilities for a spontaneous decoupling, and (iv) the opportunities for creating a more transport demand efficient economy.

6.1 Deciding on location

The location of factories and the distances to markets, the *structural demand*, is the key to understanding freight transport growth. In the dawn of industrialisation, the physical geography decided the geographic structure of production together with the ability and cost of transport. Today, transport costs have a limited influence on strategic location decisions and access to raw materials has been replaced with access to knowledge, creative environments or low labour costs, all human created attributes. Decisions on location of factories is influenced by strategic thinking about access to current markets, beliefs about future markets, differences in wages, government intervention such as location support, and for historic reasons**,** see Baum and Sorenson (2003) for a good overview.

McKinnon and Woodburn (1996) present a 4 level structure of how different decisions at the business level affect freight growth. The long-term structural growth of freight can be explained by decisions taken at the two top levels.

- 1. *Structure of the logistical system.* This relates to strategic decisions relating to numbers of factories, locations, warehouses, shops and terminals.

- 2. *Pattern of sourcing and distribution*. This relates to commercial decisions on products sourcing, sub-contracting of production process and distribution of finished products. These establish the pattern of trading links between a company and its suppliers, distributors and customers.

- 3. *Scheduling of product flow*. This relates to operational decisions on scheduling of production and distribution that translate the trading links into discrete freight flows, are made.

- 4. *Management of transport resources.* This relates to tactical decisions relating the management of transport resources. Within the framework defined by decisions at the previous three levels, transport managers still have discretion over the choice, routing and loading of vehicles.

6.1.1 Internalising external costs and the effects on long-term demand

Raising the costs of freight transport will create incentives towards a more efficient transport system in the short and medium term. The long-term effect on the structural demand (level 1 decision above) is analysed below.

The external costs of transport are not paid by the transport sector itself resulting in an overuse according to standard economic theory. Correcting the prices to include

the costs of external effects would create the theoretical opportunities for attaining a socio-economic efficient transport system. This strategy has been on the EU agenda for several years (EU White paper, 2001), but is still not fully implemented in any EU member country. In Sweden, SIKA has been responsible for estimating the effects of internalising the external costs of transport.

Two kinds of effects can be anticipated when implementing policy instruments for reducing transport; first, *efficiency* gains in choice of routes, mode and logistical systems (level 3 and 4 above); second, effects which are more long-term and influence the *demand* for moving goods (level 1 and 2 above).

In the SAMGODS model, the internalisation of external costs is modelled only to cause a shift in mode and route, not to alter the total demand for freight transport (level 3 and 4). This is a realistic assumption for the time frame (10-15 years) studied in the SAMGODS model. The results from the SAMGODS model is that road traffic would decrease by 3% and sea transport would increase with 5% and railways would decreases with 4% (SIKA 2003b).

The external costs, including infrastructure "wear and tear", emissions to air, accidents and noise, are listed in Table A4 in the appendix. For CO_2 emissions the true external costs have not been used. Instead the value of CO_2 emission has been estimated as the price needed in order to attain the current short-term emissions target for 2008-2012 of keeping CO_2 emissions at the same level as in 1990. Here, it should be noted that Swedish government has also set a long-term target that the total Swedish emissions of CO_2 should not exceed 4,5 tonnes CO_2/year in 2050 (roughly 50% of current emissions) and thereafter further decrease (Government, 2001). When estimating CO_2 emissions from transport SIKA, via VTI, estimates an elasticity of -0.8 for passenger transport and -0.2 for all other transport including freight. This means that an increase in fuel prices of 1% would result in a decrease in freight fuel use 0,2%. According to SIKA, a tax of 2,70 SEK/kg CO_2 (0,3 Euro/kg CO_2) (SIKA 2003b) would be needed to attain the current CO_2 targets for 2008-2012. A major decrease in CO_2 of 50% and in the time frame of 2050 is not within the scope of current methods of estimating costs.

6.1.2 Long-term demand

The results of internalising the external costs according to the SAMGODS model are an increasing efficiency of the transport system, e.g. less traffic for basically the same amount of required mobility. These relatively modest changes in the transport system should be compared to the estimates by McKinnon and Strutinsky of the needed increased of fuel prices in order to influence the long-term demand caused by the strategic decisions on location of storage, manufacturing sites e.t.c (level 1). McKinnon (2002) estimates that an increase in excess of 100% and Strutynski (1995) thinks that a 5-fold increase in fuel prices would be needed. These estimates are of course very rough and imprecise but give an indication of what would be needed in order to curb freight growth in the longer run when the potential efficiency gains have already been harvested.

With the relatively low transport cost for commodity goods relative the total production cost, higher fuel prices will most likely have a serious effect on haulers, but not on the structural demand for more transport.

The anticipated low effect of higher fuel prices on the structural demand does not mean, however, that the price mechanism should not be used as a policy instrument. On the contrary, higher fuel prices are needed in order to avoid any rebound effects from more efficient trucks, better logistical systems e.t.c The argument here is that the

price mechanism should not be relied on as the sole instrument but needs to be combined with other policies aimed at enabling a low transport economy, such as physical planning.

6.2 Effects of government planning

Government transport policy in Sweden decides the standard of physical infrastructure, including roads, railways, harbours, and air ports. Infrastructure has long been regarded as a public good financed by the government and the main objective has been to avoid bottlenecks in the infrastructure and to accommodate the expected growth in an efficient manor, a "predict and provide" approach.

The models used currently in the Swedish infrastructure planning leads to a "predict and provide planning" where current trends in economic activity are extended in the future (including structural shifts in the economy) and from this the future transport volumes are calculated, see the SAMGODS model (SAMPLAN 2001). The infrastructure that is built will last for at least 50 years and becomes a part of a spatial structure that will influence transport demand during this time. The risk of "locking in" the development into a spatially dispersed non-sustainable transport system is evident.

The "predict and provide" model of traffic planning has been put into serious questioning as traffic volumes has reached levels that are no longer possible to "provide for", especially in England (Goodwin 1996, Owens 1995). Not providing any new road space, e.g. freezing the infrastructure at current level, can be the result of future land-use conflicts but has also been forwarded as an instrument to limit growth. However, a 50% increase in road traffic would be manageable in current road networks in Europe according to modelling by Eberhard (in McKinnon 2002). The effect of such policy would thus be to move freight traffic to hinterland roads and to nighttime transport instead. This strategy would thus cause congestion on smaller roads, noise pollution and would not curb traffic growth.

6.2.1 Planning further ahead?

The current planning tools and planning paradigm of avoiding bottle-necks and thus maintaining the transport system efficient from a traffic flow view cannot be abandoned but needs to be complemented with a structured way of planning for the long-term towards a transport system that could be become ecological sustainable. New planning instruments are needed that take into account the long-term goals of transport policy (beyond 15 years).

Planning further than 10 to 15 years involves assuming that current relationships between freight traffic and economic development could be changed. Scenario building and back-casting are two, usually intertwined, methodologies that address the problems involved in long-range planning, see Steen et al (1997), POSSUM (1998) and Brokking et al (1997). These methodologies explore possible pathways for attaining a predefined "scenario". However, a closer link between policies targeting short and medium term needs to the long-term needs of curbing traffic growth is missing. The practical implications and how to integrate "scenario approaches" into day-to-day infrastructure and land-use planning is difficult and has not been tried yet.

6.3 Spontaneous change of the economic structure

A spontaneous decoupling would mean that the relation between freight transport and economic activity would change as a natural consequence of economic development. One possible example could be an industrial restructuring resulting from the growth of the service sectors making the economy less dependent on transport intensive sectors. A "spontaneous" decoupling occurred for example of the energy use relation to GDP growth after the two oil crises. Increased industrial energy efficiency and industrial restructuring were the main explanations for this decoupling.

A spontaneous decoupling can occur if a shift towards a more service based economy with a greater share of low transport intensive sectors of the total GDP is developing. For the purpose of this study, the definition of structural change should be based on volume of production (the first definition by Schön). It is the volume produced that causes transport demand and thus links to our understanding of freight growth. As seen in chapter 3.1.3, there is no support that Sweden's economy is currently moving in this direction. The relationship between service based economy and industrial manufacturing have been remarkably constant seen as the share of GDP.

The current growth trend of steadily increasing transport distances cannot be sustained forever, a natural level of saturation will eventually occur. Currently, no such break can however be seen and the scope for continued growth seems large. If a spontaneous decoupling does not occur, or does not occur fast enough, society may have to consider a forced decoupling, that is implementing policy instruments that target a reduction of transport activity.

6.4 Transport demand efficiency

There are alternative development paths to the current trend of increasing centralisation and globalisation of the production systems that could offer lower transport intensity. Production systems with small and locally based companies organised in regional networks have shown an alternative to the centrally managed "Economies of Scale" by offering greater flexibility and innovative capacity. Here, product development and diversity are more important than large scale manufacturing facilities ("Economies of Scope"). High flexibility and high innovative capacity that comes form the close relations between small companies organised in networks are the characteristics of this development. Examples of this development concept are the industrial developments in "Third Italy" in the Florence-Bologna region and the Mondragón co-operative in northern Spain (Bennet and Estall, 1991). The effect on transport demand is that, at least in the production phase, the demand is low due to the geographical concentration. Furthermore, the drivers for moving manufacturing to low-cost countries and to centralise production is contrary to the comparative advantages of this development concept. However, the goods produced are still being exported on a global market.

Another related approach is the theoretic emergence of a "glocal" production system, see e.g. Åkerman (2000) and POSSUM (1998). The idea of glocal production states that companies will design and advertise products at a central location, but that the production will be dispersed and based locally close to the market. Glocal production would decrease the need for transporting materials long-distances. Jonsson et al (2000) claims that IKEA, Lucent and Hewlett-Packard have a production philosophy that resembles glocal production with strategically placed "merge centres"

for final assembly close to market. However, the opportunities and true impacts offered by glocal production systems need to be explored further.

There are also possibilities to improve the current centralised production systems and to make them more "demand" efficient. Strutinsky (1995) suggest that a new organisation of production flows and structure might save huge amounts of transport activity. Strutinsky shows how a 60% reduction of transport activity can be attained only by changing the supply pattern by supporting regional networks of production. The idea is to produce larger volumes of the product regionally before transporting the goods further, see Figure 22.

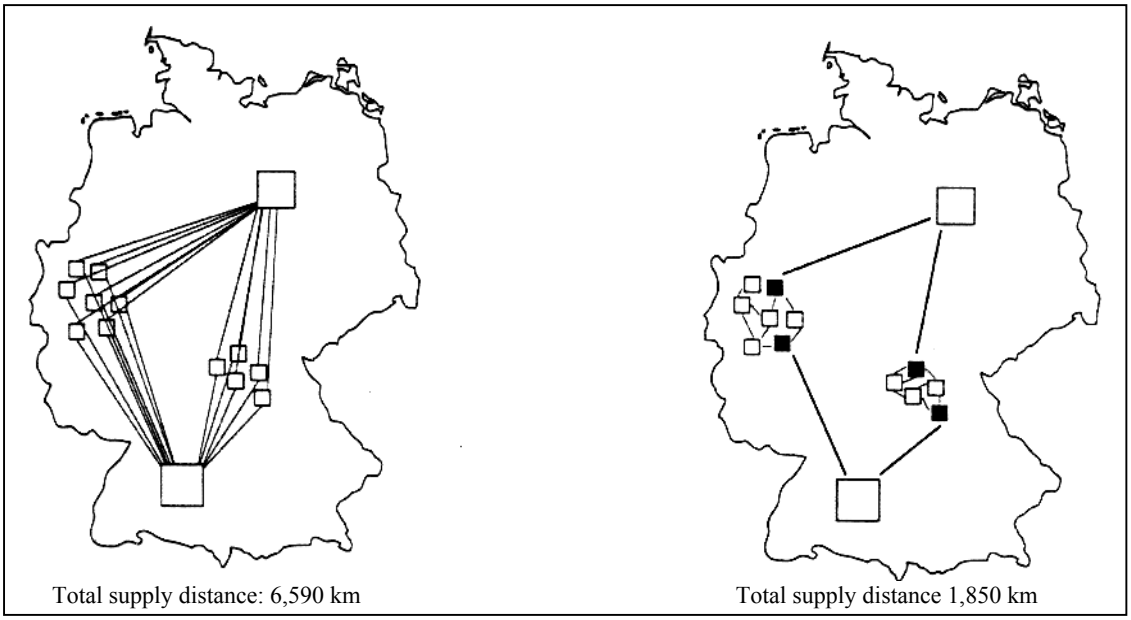

Figure 22. Difference in transport need between a centralised logistic system and a regional logistic system.
Source: Adopted from Strutinsky (1995)

6.4.1 Visibility of transport

One problem previously mentioned is the fact that data on how much transport each product contains is not available. The official statistics are not organised in this way. This makes the "transport problem" invisible both for consumers and for producers. The possibility for consumers to choose a "low transport product" is today almost impossible as no information is available. This also holds for true for many producers were the total transport content, including also the parts bought from other manufacturers during the manufacturing process, becomes invisible.

One part of the solution is to properly price transport services and thus include *all* the external costs. Then the transport content would become visible in the price of the product. However, the true external costs are not easy to determine. Apart from the difficulty of reducing all transport related problems, such as the degradation of cultural landscapes and accidents, to one variable (cost), there are also great difficulties on deciding the actual cost when the effects are not very well known. Especially the costs of using fossil fuels have been heavily debated the last years. It would be worthwhile to investigate other options, less politically difficult than increasing fuel prices, to visualise the transport content in products. Reporting the transport need (as tonne-km) of each product (or product group) in the scheme of environmental reporting would be a first step of making the transport problem visible.

7. CONCLUSIONS

A minor trend of decoupling freight activity measured in tonne-km from GDP-growth could be seen in Sweden if we focus on the *total* freight activity including sea, rail and road freight. However, looking only at *road* freight activity the growth of tonne-km follows the GDP-growth fairly well. Road freight activity measured in tonne-km has thus not been decoupled from GDP-growth.

Road freight activity measured both in vehicle-km and in tonnes has, however, been decoupled from GDP-growth. Increasing efficiency in the road freight system with larger trucks and less empty running has decreased the road freight intensity measured in vehicle-km/GDP whereas the actual weight of tonnes transported by road has been decreasing mostly due to a decreasing construction sector.

The main *factor* currently contributing to the growth of tonne-km is the fact that goods are transported longer. The *driving forces* currently pushing towards more freight tonne-km on road are the increasingly dispersed production systems and the global markets for end-use products. The current economic development with an increasing globalisation of both markets and production systems demand thus longer transports but not necessarily more tonnes lifted.

Moving towards sustainability requires first that we "level the playing field" in terms of costs. Internalising the external costs and making the polluter pay is important. Taxation levels need, however, to be very high in order to influence the long-term structural demand. Higher taxation, better logistics management, and more competitive alternative modes (rail and sea) will increase the efficiency of the transport system but will not be enough to curb the current growth trend. Currently, no "natural" level of saturation can be seen for this trend of steadily increasing tonne-km. However, this does not mean that no such level exist nor does it mean that any such "natural" saturation level would be compatible with what society currently regards as sustainable.

More bottom-up studies are needed. The statistics analysed in this paper are all on a very aggregated level. For understanding the opportunities for decoupling, we need more detailed studies on the transport content in single products or commodity groups. The visibility of transport content in products would also be useful for exploring a "low transport society". It is currently not possible to estimate the transport content in single products, or even in groups of products, without dedicated research.

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APPENDIX

Appendix A1

1 Statistic on transport activity

This appendix presents the available statistic on Swedish freight transport activity, both official and from other sources of statistics, and the limitations of the statistics from the perspectives of this report

1.1 Official statistics

Since 1972, SCB (Statistics Sweden) has produced statistics on Swedish road freight activity within the country (TK30). SCB measures the flow of goods in tonnes and tonnes-km and the statistics are also available distributed on length of haul and into commodity groups. The statistics are based on sample surveys by mail. SIKA[11] has the responsibility for the statistics since 1994. SCB still, however, produces the statistics. Since 1995 the statistics were complemented with the activity of Swedish trucks *outside* the country (TK56). After 2000, both the statistic on Swedish trucks abroad and within Sweden is presented in one publication.[12]

SIKA has also produced a commodity flow survey (CFS) in 2001. The CFS measures the flow of goods in tonnes within Sweden distributed in sectors, commodity groups, origin and final destination and also measures the value of the goods.

The annual statistics produced by SCB does not include foreign trucks with final destination in Sweden, cabotage or tonne-km by light trucks and have only recently included Swedish road freight activity abroad.

Cabotage and foreign trucks

Since the first of July in 1998 cabotage[13] is allowed in Sweden for trucks from other EU-countries. SCB statistics do not capture road freight activity done in Sweden by foreign truckers, neither as cabotage or foreign trucks with final destination in Sweden. Within the EU, each country is mandated to keep track on their domestic haulers (including their activity abroad) and to report to Eurostat.

The statistics from Eurostat shows that cabotage in Sweden represents 0,7% of total transport activity (tonne-km) (Statistics in Focus, 2003a,b). Road freight activity by foreign haulers with final destination in Sweden amounted in 2001 to 3681 million tonne-km, which is roughly 12% of total tonne-km on road (ibid). This share has seen a slight increase the last 10 years.

Swedish trucks abroad

Since 1995, due to the EU requirements mentioned above, there are official statistics of Swedish road freight activity abroad (TK56). The numbers were 3057

[11] First the DPU (Delegationen för Prognos och Utredningsverksamhet inom transportsektorn) which was later transformed into SIKA

[12] This has theoretically lead to an increase in truck activity defined as international and to a decrease in truck activity defined as domestic. This is due to the fact that the activity performed from the Swedish destination to the border was previously regarded as domestic but is now regarded as international as the final destination is abroad. Also the definition of what is a "shipment" or not has changed, see TK33(2000) for more details.

[13] Goods transported with starting point and destination in the same country with a foreign hauler.

million tonne-km in 1995 and 2684 million tonne-km in 1999 and represents thus approximately 7-8 % of the total road freight activity in Sweden.

Light trucks

The number of light trucks has increased the last 10 years but most statistics available on activity are given in km driven and not in tonne-km. According to the statistics on vehicle-km, a 1/3 of the distances driven included building materials and only 13% of the distances driven are for delivering goods to shops in 1999.

In 1991, the only survey since 1972 that has measured tonne-km by light trucks (T57) estimated the transport activity by light trucks to 257 million tonne-km for the second half of 1991 amounting to less than 2% of the total freight truck activity. Light trucks can thus be assumed to represent only a very small part of the total truck activity measured in tonne-km

Table A1. Statistical map over official statistic in Sweden

Publications and year published	**Tonnes**	**Km**	**Tonne-km**
Swedish trucks in Sweden	TK30[a] 1972-1999, TK33 since 2000	TK30 1972-1999, TK33 since 2000	TK30 1972-1999, TK33 since 2000
Swedish trucks abroad	TK56 1995-1999, TK33 since 2000	TK56 1995-1999, TK33 since 2000	TK56 1995-1999, TK33 since 2000
Foreign trucks in Sweden	Eurostat since 1999	TK54 1987 and 1991, Eurostat since 1999	Eurostat since 1999
Cabotage	-	-	Eurostat, since 1999
Light trucks	T57 1991	T57 intermittent	T57 1991

[a]The series T and TK are published by SCB or SIKA

1.2 Other sources of freight statistics in Sweden

The Swedish transport council (Transportrådet) has produced statistics on Swedish transport activity back in time from 1880 to 1980. The historic numbers were calculated in the 1980s using historical data on fuel use, vehicle ownership, industrial production and trade statistics.

An employee at Banverket, Jakob Wajsman, has during a number of years, including his earlier work carried out at Transportrådet, estimated the goods traffic in Sweden by complementing the official statistics of SCB/SIKA with the activity of foreign trucks, cabotage and light trucks, see (Wajsman 2003). Wajsman furthermore divides the transport activity into sectors and commodity groups. Unfortunately, no detailed description on his methodology is currently publicly available. This is the most comprehensive statistics available on the total freight transport activity within Sweden including long time-series.

In Figure A1, the official statistics from SCB and Eurostat are compared with the numbers of the road freight activity by Wajsman (2003) including light (<3.5 tonnes) and foreign trucks. The official numbers and the numbers calculated by Wajsman correlate well up to 1998. After 1998, the share of road freight activity of foreign and small trucks is estimated by Wajsman to have grown. This could partly be due to the liberalisation of the trucking market thus allowing cabotage and a trend towards more light trucks (< than 3.5 tonnes) delivering more goods. However, the statistics available from Eurostat (Statistics in Focus 2003a,b) claims that only 216 milj tonne-km was cabotage in Sweden in 2001. This suggest that Wajsman (2003) has

overestimated the effect of cabotage and foreign trucks with final destination in Sweden.

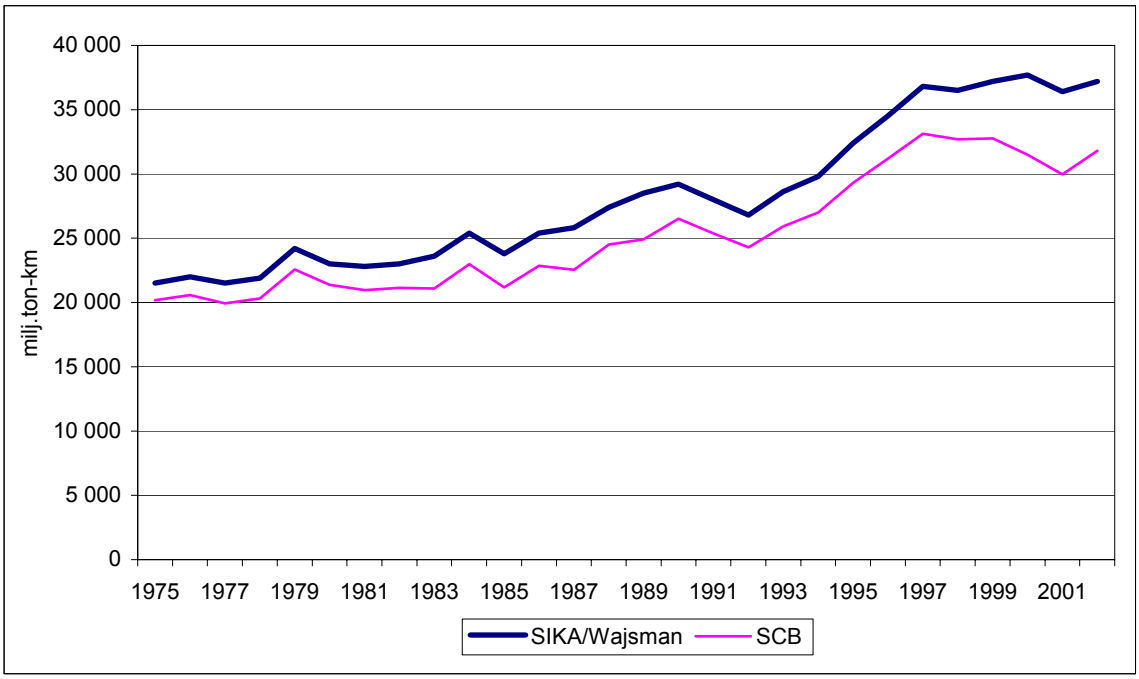

Figure A1. The difference between Wajsman/SIKA and SCB numbers.
Source: SCB, Wajsman (2003) and SIKA (2002).

The VTI (Vägtransport institutet) has estimated the vehicle kilometres by trucks and cars on Swedish roads dating back to 1950. These estimates are based on petrol and diesel consumption, registered vehicles, and interviews with drivers (Edwards et al 1999). The historic statistic for heavy road freight traffic on road is regarded uncertain due to lack of coordination of methods (Edwards et al 1999). From 1999, a survey estimating the km driven by Swedish vehicles is produced by gathering information from the annual and compulsory "vehicle tests".

Lee Schipper and his colleagues at the Lawrence Berkley and IEA have also over a number of years compiled data on road freight activity in a number of OECD countries including Sweden. A number of publications including Swedish road freight activity from Schipper et al are based on LBNL and IEA data bases (Schipper and Marie-Lilliu 1999, Schipper et al 1997).

Logistical indicators

Statistics on the changes in the logistical systems the last years are of importance for understanding freight development. Logistical indicators here include empty running, vehicle carrying capacity, average pay-load, load factor and handling factor. SCB statistics includes numbers on empty running and vehicle carrying capacity. Handling factor, load factor and average pay-load can be calculated from other sources of aggregated statistics. Statistics on logistical indicators used in this report is compiled and calculated by the REDEFINE project (between 1985 and 1995).

1.3 Needs for better statistics

The statistics are designed for looking at road capacity needs measuring the activity on the Swedish roads. The purpose of this study is however to analyse the *freight activity generated by the Swedish economy*. For better comparison with other countries we should ideally look at what the Swedish consumption of goods generates

in terms of freight activity. As an example, this would exclude national freight generated for export but include international freight generated from imports of goods. This is a broader concept and the statistics are not ideal for this purpose. We would need to follow the "transport content" in the consumed products. The transport statistics available on a yearly basis and in time series measure flows of goods and cannot identify single products, only groups of products distributed into 24 commodity groups (the NST/R standard) where the major group (and fastest growing) in terms of activity is termed "miscellaneous".

New standards for reporting freight activity, based on a new commodity group nomenclature (the CPA), is currently being developed internationally in order to facilitate analyses of specific commodity groups and to be able to link them to economic activity.

2 Statistics on economic activity

Statistics of GDP have systematically been measured in Sweden since after the WWII, but numbers estimated back to 1861 are available. The numbers are available distributed in sectors according to the statistical standard SNI 92. This standard includes industrial activity and not government services. In this standard, SNI 1- 45 is regarded industrial goods production and SNI 50-95 is regarded as private (not government) services. A description of the SNI nomenclature is found in appendix A3.

Appendix A2

Table A2

NST/R Commodity groups:

1. Cereals
2. Potatoes, other vegetables, fresh or frozen, fresh fruit
3. Live animals , sugar beet
4. Wood and Cork
5. Textiles, textile articles and man made fibres, other raw animal and vegetable materials
6. Foodstuff and animal fodder
7. Oil seeds and oleaginous fruits and fats
8. Solid mineral fuels
9. Crude petroleum
10. Petroleum products
11. Iron ore, iron ad steel waste and blast furnace dust
12. Non-ferrous ores and waste
13. Metal products
14. Cement, lime, manufactured minerals
15. Crude and manufactured minerals
16. Natural and chemical fertilizers
17. Coal chemical, tar
18. Chemical other than coal chemicals and tar
19. Paper pulp and waste paper
20. Transport equipment, machinery, apparatus, engines, whether or not assembled, and parts there of
21. Manufactures of metal
22. Glass, glassware, ceramic products
23. Leather, textile, clothing, other manufactured articles
24. Miscellaneous articles

Appendix A3

Table A3 SNI nomenclature

SNI92	
01-05	Jordbruk, skogsbruk, fiske
10-14	Utvinning av mineral
15-37	Tillverkningsindustri
40-41	El-, gas-, värme- o vattenförsörjn
45	Byggverksamhet
50-52	Parti- o detaljhandel
55	Hotell- o restaurangverksamhet
60-64	Transport, magasinering o kommunikationer
65-67	Finansiell verksamhet
70-74	Fastigheter o företagstjänster
75	Off. förvaltning o försvar, obl. soc.försäkr.
80	Utbildning
85	Hälso- o sjukvård, socialtjänst, veterinärverksamhet
90-95	Renhålln., kultur, sport, förvärvsarb. i hushåll

Appendix A4

Table A4 External costs for trucks SEK/litre petrol/diesel (SIKA 2003:1)

External costs	*Wear And Tear*	*Emissions to air excl. CO2*	*Noise*	*Accidents*	**Total**
Rural areas					
Truck 3,5-16 tonnes	0,09-0,18	1,52	0,29	1,62	3,52-3,61
Truck >16 tonnes	0,12-0,28	1,60	0,33-0,72	0,82	2,86-3,41
City areas					
Truck 3,5-16 tonnes	0,10-0,20	5,46	2,79	4,04	11,39-11,49
Truck >16 tonnes	0,10-0,24	3,34	2,59-5,66	1,23	7,26-10,47

Appendix A5

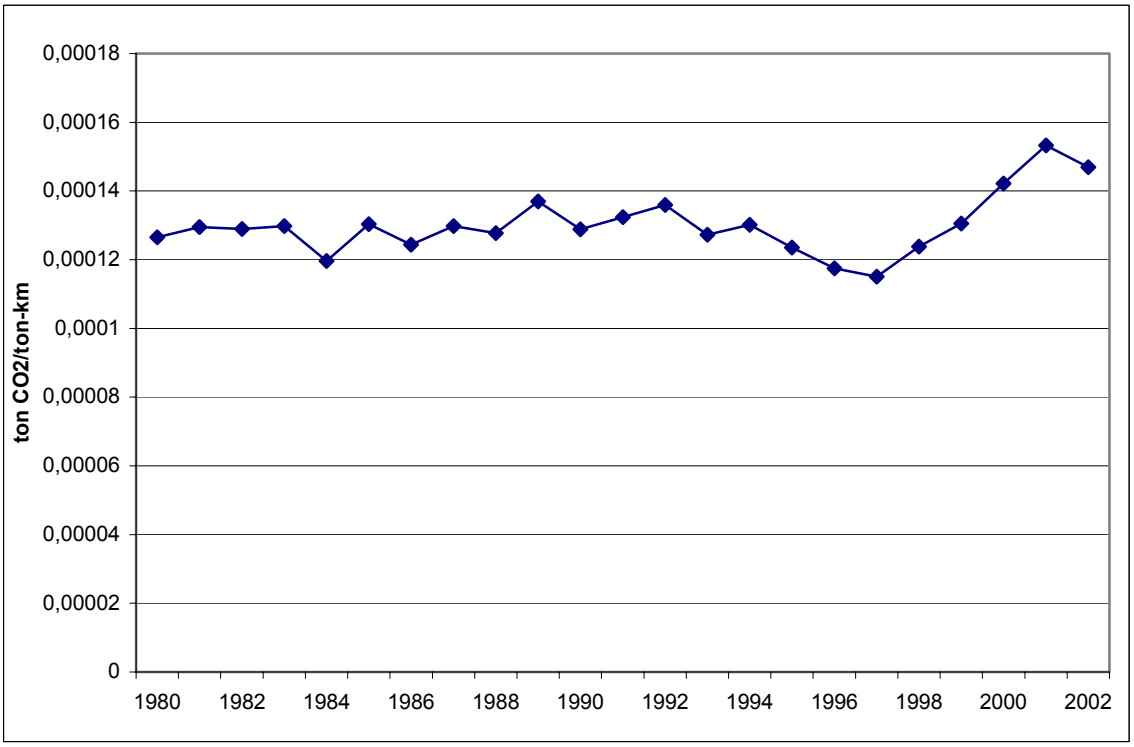

Figure A5. CO_2 emission per tonne-km for trucks
Source: Calculated from Figure 13 and 16

Report 5370

A Closer Look at Road Freight Transport and Economic Growth in Sweden

Are There Any Opportunities for Decoupling?

The growth of road freight transport has historically been closely related to economic growth. In order to attain a long-term sustainable transport system, road freight development must be decoupled from economic development. This report takes a closer look at what actually has been happening in the road freight system in Sweden the last 20 to 25 years and explains, on an aggregated level, the relationships between freight transport and economic development. The future opportunities for decoupling road freight growth from GDP-growth are also explored.

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