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Road freight transport in Sweden

– Are there any signs of a decoupling?

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Keywords

Decoupling, Freight transport, Transport efficiency, Transport development, Transport growth

Abstract

Decoupling freight transport growth from the economic development is necessary for shaping a sustainable transport system.

This paper takes a closer look on the development of the road freight system in Sweden and explains, on an aggregated level, the relationship between freight transport demand, logistic efficiency and economic development. Future opportunities for decoupling road freight growth from GDP-growth are also assessed.

The weight (*tonnes*) of goods transported has levelled out despite a continuous growth in economy the last 25 years, a “strong” decoupling. A “weaker” decoupling trend can be seen looking at *vehicle-km* resulting from increased logistic efficiency (less empty running and increased average payload). However, as a result of goods being transported longer distances and freight lorries carrying greater loads, the freight activity measured as *tonne-km* and the *CO₂-emissions* have been growing steadily showing no signs of decoupling from economic development.

The continued growth of road freight demand in Sweden, measured as *tonne-km*, can be explained by increasingly geographically dispersed manufacturing systems resulting from a general trend of reduced trade barriers and increased economic integration. There is thus a clear conflict of interest between increased European economic integration, resulting in greater economic efficiency, and the wishes to decouple freight transport from economic development. In-

ternalising the external costs by higher taxes on fuel or road pricing, the currently favoured solution, will not be enough to curb growth as transport cost does not, to any major extent, influence business location decisions

Introduction

Freight transport growth, measured in *tonne-km* or *vehicle-km*, has historically been closely related to economic growth. The main explanation to this link has been that more transport enables a greater division of labour and industrial specialisation. This leads to a higher economic efficiency and enables thus a greater economic activity.

However, the growth of freight transport produces problems as well. The transport system uses a large share of the world's finite fossil energy resources and, with limited availability of low cost renewable energy, continued growth will inevitably lead to conflict over how to best use available resources. In several urban areas congestion currently decreases the efficiency of the transport system but the need for improved and extended infrastructure leads to increasing land use conflicts. The emission to air of *CO₂*, 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 solved with new technologies, such as fuel cell vehicles, or with policy instruments aimed at increasing user efficiency, such as road pricing. However, a continued growth of transport will make a future shift towards a sustainable transport system more and more unlikely despite new promising technologies.

"Decoupling" refers to breaking the historical link between freight transport (or one or all of the externalities it causes) and economic development. This link could either be weakened (weak decoupling) or totally decoupled (strong decoupling). The current decoupling debate is primarily motivated by the emissions of CO₂, see e.g. EU White paper (2001). The decoupling of CO₂-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 etc.)
- Shifting to less transport intensive economic growth (via changes in the economic structure and/or through different localisation of production)

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 when estimating future demand. However, the major problems facing the transport system are on the longer term (20-50 years ahead). Changing large-scale infrasystems like the transport system is a slow process usually spanning over decades (Grübler and Nakicenovic 1991). Given the high inertia of built infrastructure, planning decisions taken today will have an impact on the long term. There is a need to take a strategic look at the future and to explore the future beyond what is currently the trend.

The aim of this report is to review the statistics available and to analyse the link between freight transport 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, indicators focussing on increasing the efficiency of the transport system are also presented and discussed. Road freight transport represent 35% of the total freight in Sweden (measured as tonne-km) and is, together with air transport¹, the only transport mode that is growing in absolute terms. Rail and sea transport has not grown the last 25 years. In this study we have thus chosen to look at freight transported on road. However, total freight activity (road, sea and rail transport) is included when necessary for the analysis.

Development of road freight transport in Sweden

ROAD FREIGHT DEVELOPMENT; TOTAL ACTIVITY AND DISTRIBUTED ON LENGTH OF HAUL

In Figure 1, road freight activity measured in *tonne-km* between 1975 and 2002 is shown². The total road freight activity has increased steadily since 1975 with the main growth coming from goods being transported further than 99 km.

In Figure 2, road freight activity measured in *tonnes* between 1975 and 2002 is shown. The weight of goods has decreased over time. Goods moved less than 99 km dominate the weight of transported goods. However, note that goods moved more than 100 km have increased whereas as the goods moved less has decreased since the 1970s.

The increase in freight transport, measured as tonne-km, is not the result of more goods (in tonnes) but is the result of goods being transported longer distances. The average length of haul (calculated from previous Figures) has increased from 45 km in 1975 to 100 km in 2002. From Figure 2 and 3 it can also be concluded that it is the growth of trans-

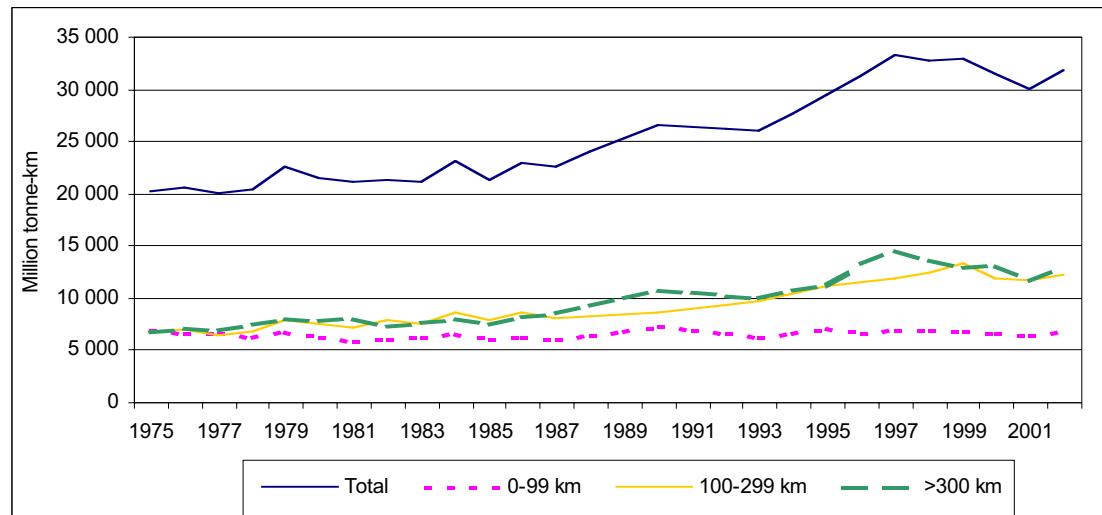


Figure 1. Road freight activity measured in tonne-km; total and distributed on length of haul. Source: SCB (2004)

1. Air transport is growing fast but still only represents a very small share of total freight.

2. All statistics in Figure 1 to 5 includes activity done by Swedish trucks within Sweden (thus also including transports that either started or had final destination abroad). Foreign trucks driving in Sweden is not included but typically represent 10 to 12% of the total tonne-km driven on Swedish roads, see appendix in (Åhman 2004) for further details.

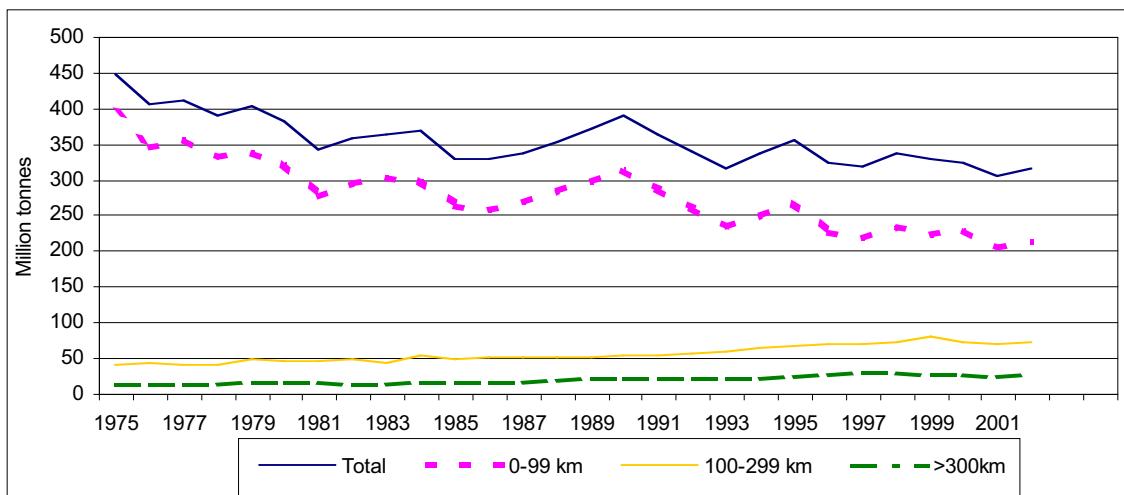


Figure 2. Road freight activity measured tonnes; total and distributed in length of haul. Source: SCB (2004)

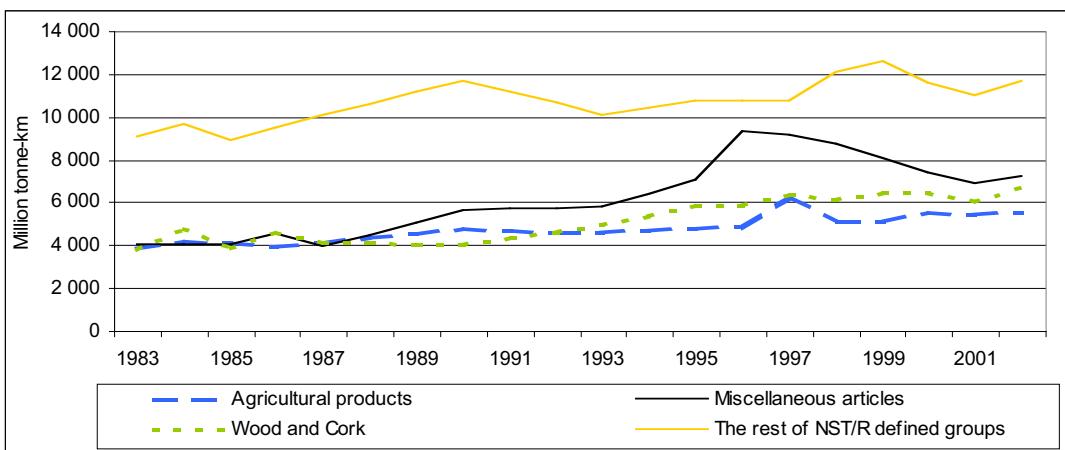


Figure 3. Road freight activity measured in tonne-km distributed on commodity groups. Source: SCB (2004)

ports with a length of haul beyond 100 km that has driven transport activity growth in Sweden the last 25 years.

ROAD FREIGHT DEVELOPMENT DISTRIBUTED ON COMMODITY GROUPS

The growth of freight is not evenly distributed over different commodity groups, see Figure 3 and 4³. The three groups of goods that have grown the most are shown together with the rest. The commodity group "Miscellaneous"⁴, "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 activity measured in tonne-km, see Figure 3. The group "Miscellaneous" contains mostly mixed goods and "Agricultural products" is dominated by food products.

In Figure 4, road freight measured in tonnes distributed on commodity groups is given. Wood & cork and Miscellaneous increase whereas the group Agricultural products shows a

fairly constant development. The rest of the commodity groups are actually decreasing in weight but this is mainly due to a decrease in crude and manufactured minerals (included in "the rest") used mostly for construction such as gravel, rock etc.

The conclusions that can be drawn from Figures 3 and 4 are that mixed goods and food products have increased in tonne-km by increasing the average length of haul and thus followed the general trend of fewer tonnes travelling longer trips from raw material to final customer. The increase of goods being classified as "Miscellaneous" can be related both to a greater trade with semi-finished products stemming from more spatially diverse production systems and the development of logistic systems, see chapters further ahead. Wood products have grown both in tonnes transported and in the length of haul (from 79 km to 97). The increase of wood products is a typical Swedish phenomenon

3. The division of commodity groups is based on NST/R groups. For more details on this, see Åhman (2004).

4. There is a peak of tonne-km activity for "Miscellaneous" around 1997 in Figure 3. 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 this peak and it is thus most likely due to flawed statistics.

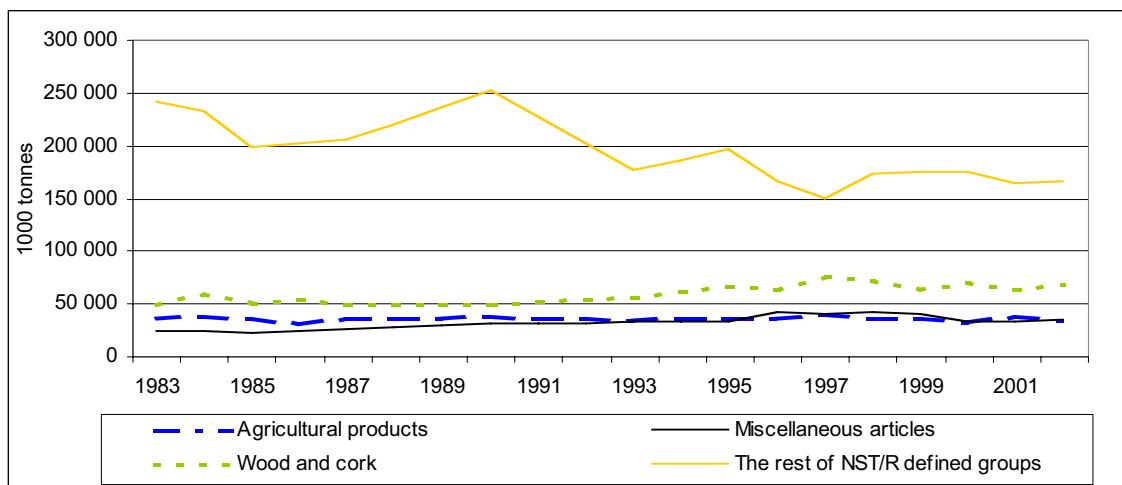


Figure 4. Road freight activity measured in tonnes distributed on commodity groups. Source: SCB (2004).

Table 1. 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)

that comes after 1992 when Sweden had an export led economic growth.

DEVELOPMENT OF SOME LOGISTIC INDICATORS FOR ROAD FREIGHT

The EU-sponsored REDEFINE project published statistics on logistical indicators over the time period from 1985 to 1995 for a number of European countries. These numbers are complemented with Swedish statistics from 1995 to 2000 below. The indicators of greatest interest for this study were empty running, handling factor, load factor, vehicle carrying capacity and the “resulting” vehicle-km driven. In Table 1, the results from a selection of the indicators presented in the REDEFINE project are shown.

The *handling factor* measures the number of separate freight journeys that a consignment makes from raw material to sales market and is derived by dividing tonnes lifted by tonnes transported. In Sweden, the handling factor decreased by 20% during this time period, that is 20% fewer separate journeys for the average transported good. On a EU-level no consistent trend could be seen (REDEFINE 1999).

A trend towards bigger trucks across Europe has increased the *Vehicle carrying capacity*. 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% (*ibid*). Swedish statistics from 1980 to 2002 show that the numbers of trucks carrying over

24 tonnes has increased and replaced lighter trucks in the range 16 to 24 tonnes. A brief calculation based on registered truck weight reveals that the carrying capacity has increased with at least 40% for the Swedish fleet of heavy trucks (over 3,5 tonnes) since 1980.

Empty running in Sweden decreased with 7% between 1985 and 1995 according to REDEFINE and has continued to decrease from 28% in 1993 to 24% of shipments running empty in 2001 (SIKA 2003). However, 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*).

As a result of changes in the logistic system and the underlying tonne-km growth, the *vehicle-km driven* for trucks is given in Figure 5. The Vehicle-km driven has only increased with 8% since 1980, which should be compared to the 49% increase of tonne-km and the 18% decrease of tonnes during the same time period. This development is the result of increasing the average payload (as a consequence of increased carrying capacity) and of decreasing empty running.

The economic development in Sweden

ECONOMIC GROWTH AND ECONOMIC SECTORS

The Swedish economy has grown steadily with 2% to 3% per year since 1980, see Figure 6. The only downturn was between 1990 and 1992. After 1993, an export-lead growth occurred⁵ that lasted until the year 2000. Industrial production of goods (SNI 01-45) and services (SNI 50-95) has

5. The exchange rate of the Swedish crown was allowed to float after 1992, which resulted in a depreciated with 25% the years after.

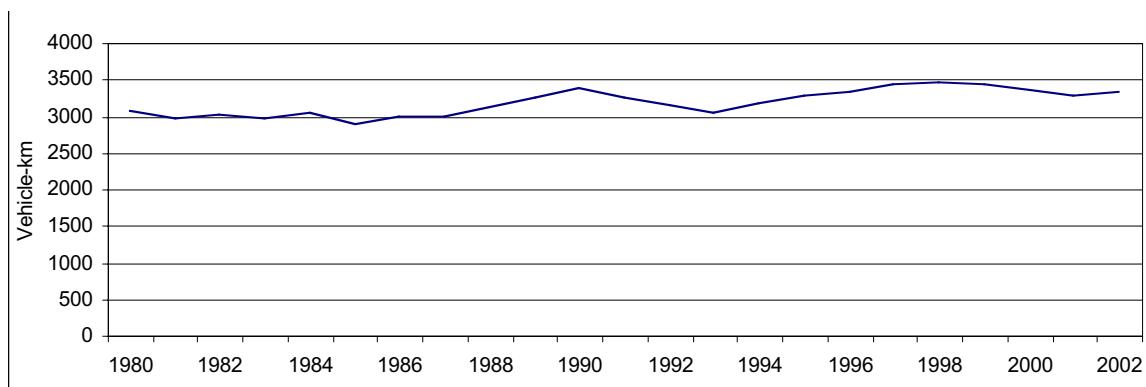


Figure 5. Vehicle-km for heavy trucks (>3,5 tonnes). Source: Numbers from SCB calculated according to Edwards et al (1999). Includes Swedish and foreign trucks when driving in Sweden. Numbers also incl. activity "not in duty".

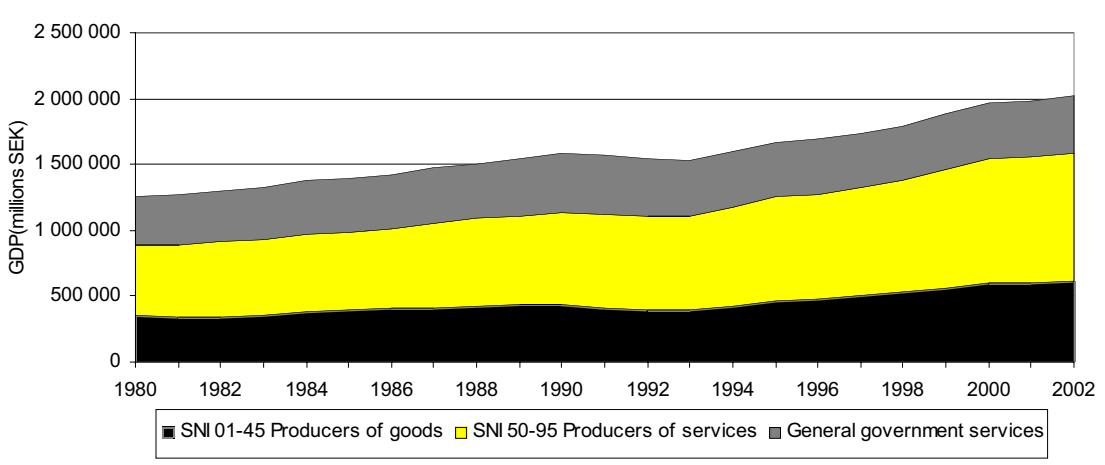


Figure 6. GDP distributed on producers of goods and producers of services in year 2000 prices. Source: SCB(2004)

grown steadily whereas the share of government services has declined. The private service sector (SNI 50-95) has however grown substantially with 80% since 1980. Within the industrial production of goods, the manufacturing sector (SNI 15-37) has shown a fairly constant development from 1980 to 1992. Since 1993, this sector has however grown with over 60%. Other industrial sectors such as mining, agricultural, forestry and construction have all been relatively constant sectors. Behind the steady economic growth in Sweden there is thus a shift in the industrial economy towards more industrial manufacturing, less public expenditure and less traditional raw material based sectors.

The share of export/import has always been relatively high in Sweden. With the membership in the European Union (1995) and the overall increasing internationalisation of the world economy, this share has increased even more from around 30% in 1992 to 45% in 2002 of the total GDP. Most tonnes exported and imported are still raw materials and mineral fuels but the commodity groups currently growing are manufactured goods⁶.

LONG-TERM STRUCTURAL CHANGES

Long-term structural changes in the economy can have a great significance on the demand for freight transport. 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, can allow an economic growth with less transport activity. A structural change towards a "service economy" can be defined as follows according to Schön (2000):

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 employed in the service sector contra in the industrial goods production sector.
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.

For investigating the first definition of structural change above, the distribution between industrial goods production (SNI 1-45), industrial services (SNI 50-95) and public ex-

6. Raw materials and mineral fuels are to a greater extent transported by either trains or ship whereas manufactured goods mostly go by truck.

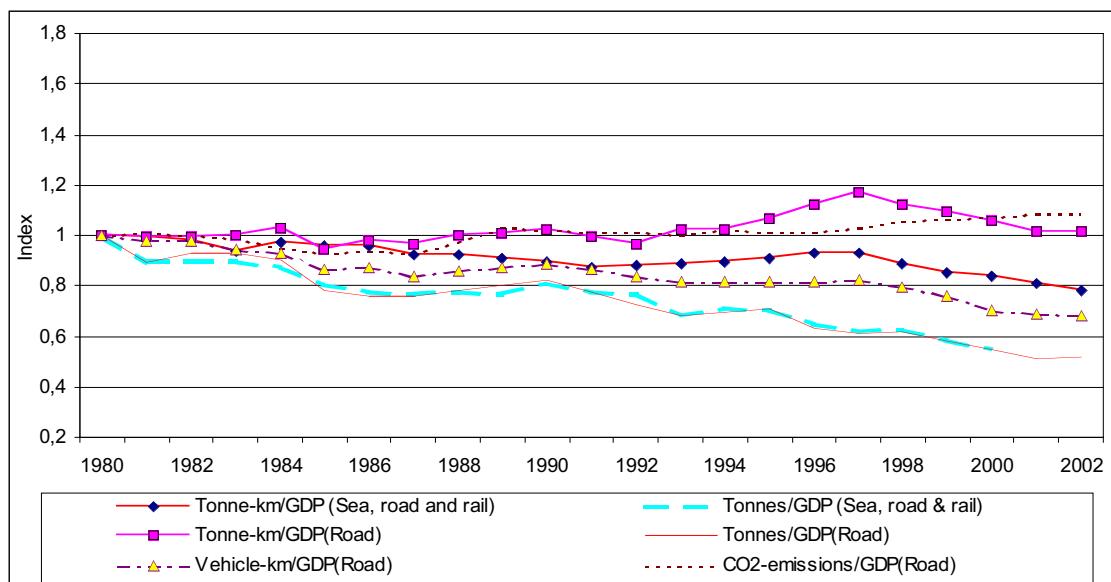


Figure 7. Transport intensities for the Swedish freight sector. Calculated from previous figures. Numbers on CO₂-emissions from Vägverket (2004).

penditure on services can be derived from Figure 6. A decrease in public expenditure from 29% to 21% can be seen as both the share of production of goods (from 27% to 30%) and private services (from 42% to 48%) has increased⁷. However, the total share of services (public and private services) has not grown (from 71% to 69%) and accounts for approximately 1,5 times the volume of the manufacturing sector. Schön (2000) shows, with reconstructed historical statistics over national GDP in Sweden, that the share of services and manufacturing in the economy has been remarkably stable even if we are looking at a very long time frame since 1800. There is thus no support to the idea that Sweden is moving towards a "service economy" according to the first definition.

Looking at the second definition, the number of people employed, there has certainly been a shift towards more service-oriented employments the last decade according to Schön (2000) and available statistics.

The third definition of structural change, that the innovative capacity should largely be related to the service sectors, has certainly raised hopes of a "new economy" the last years. No good statistics exist but according to the ITPS⁸ the innovations in the service 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).

Future freight transport demand is derived from the physical goods consumed in the economy (definition I), neither the share of people employed (def.II) nor the dynamic force of the economy (def.III) can be expected to influence freight demand to any greater extent. There is thus little statistical support to the idea that the ongoing structural change will mean less future transport.

Linking economy and freight transport

TRANSPORT INTENSITIES AS INDICATORS

Transport intensities, the ratio between transport activity and economic activity, are used as indicators reflecting some sort of "transport efficiency" in the economy. There are different ways to measure transport intensity and each measure focus on different factors, such as modal shift, vehicle efficiency or demand efficiency. Examples of transport intensities are CO₂-emissions/GDP, vehicle-km/GDP, tonnes/GDP or tonne-km/GDP. The different strategies presented in the introduction can all relate to one or more of these indicators. The concept of "decoupling" is referred to as changing a historically constant intensity.

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 and to externalities such as CO₂-emissions, congestion, and road "wear and tear". A decrease transport intensity measured as tonne-km/GDP would mean a combination of less tonnes transported and/or goods transported shorter trips. The indicator tonnes/GDP measure the material intensity of the economy but reveals nothing of the distances that the average goods are transported.

Complementing tonne-km/GDP with vehicle-km/GDP is useful for studying logistic efficiency. 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.

CO₂-emissions/GDP is the indicator directly related to two currently debated externalities, energy security and cli-

7. The statistics in the private service sector have been boosted as a result of out-sourcing and privatisation moving shares from public expenditure to the private services sector in the statistics.

8. ITPS; Swedish Institute for Growth Policy Studies (Institutet för tillväxtpolitiska studier),

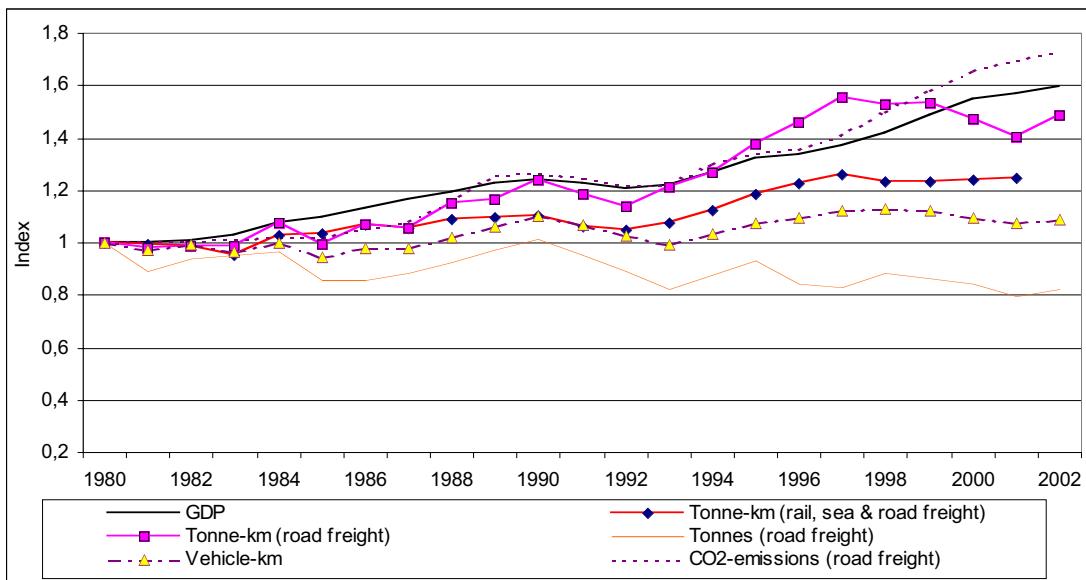


Figure 8. Development of freight activity, economy and CO₂-emissions from road freight in Sweden. Source: SCB (2004) and Vägverket (2004).

mate change. This indicator does not relate directly to the demand for freight transport and the CO₂-emissions could, to some extent, be decoupled from GDP growth by technical measures such as increased motor efficiency, shifting fuels, or shifting transport mode.

TRENDS IN FREIGHT INTENSITY FOR SWEDEN

In Figure 7, road freight intensities for Sweden are presented together with the total freight intensity. The focus in this paper is on the indicator tonne-km/GDP that best relates to the derived demand for freight. However, all other indicators mentioned above are needed in order to get a more complete understanding of freight development in Sweden.

The *total freight intensity* (tonne-km/GDP) has slowly declined since 1980. However, between 1991 and 1997 the slow decoupling effect seems to be reversed. This is the period with first a slow economy (1991 to 1993) and then an export lead economic growth and followed by a European integration process with the Swedish membership in 1995. After 1997, the transport intensity seems to be declining at approximately the same rate as before.

The *road freight intensity* (tonne-km/GDP) does not show the same development as the total freight intensity. At first, there is a small increase between 1992 and 1996 and thereafter a small decrease. Whether the break in intensity around 1997 is due to real effects or due to flawed statistics is too early to say. It should be noted that the peak of intensity around 1997 coincides with the introduction of new reporting procedures for road freight statistics in Sweden (see also note on Figure 3). Nothing has come up, in discussions with freight companies and their organisations, that can explain this peak in intensity. With this uncertainty in mind, road freight intensity seems relatively constant and the shifts are yet too small to talk about decoupling.

However, both the freight intensity measured in *vehicle-km/GDP* and *tonnes/GDP* show a pronounced decoupling since 1980. In these two cases, the trend is very clear and cannot be a statistical error. The decline in tonnes/GDP re-

flects a decreasing material intensity in the economy and can, in detail, be explained by a decreasing building and energy sector (less oil transport after the oil crises). These both sectors demand heavy but short-range transports of goods. 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 previous chapter.

Finally, the *CO₂-emissions/GDP* for road freight shows a minor increase over the long-term. In reality, increasing CO₂-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, the numbers on CO₂-emissions from road freight are very uncertain. The numbers are rough estimates by the Swedish Road Administration (Vägverket 2004) based on diesel imports to Sweden that are allocated to the different modes of transport. That trucks would have become less energy efficient, as suggested by the statistics, seems unlikely. This need to be further analysed in order to determine whether the statistics are flawed or a reasonable explanation exist.

Are decreasing intensities enough?

Slowly decreasing intensities is a sign of a weak decoupling of freight from the economy and thus positive for the environment. However, what in the end matters for the environment are the absolute numbers. In Figure 8, the total freight activity, the road freight activity, the Swedish GDP, and the CO₂-emissions from road freight are given in absolute numbers.

As can be seen from Figure 8, most of the indicators are still increasing in absolute terms, including the CO₂-emissions from road freight. However, there are positive signs as the transported volume in tonnes by road has actually been decreasing (a strong decoupling!).

In conclusion, the road freight intensity measured in tonnes/GDP and vehicle-km/GDP has been decoupled from economic growth (a relatively strong decoupling) whereas the road freight intensities most interesting from an

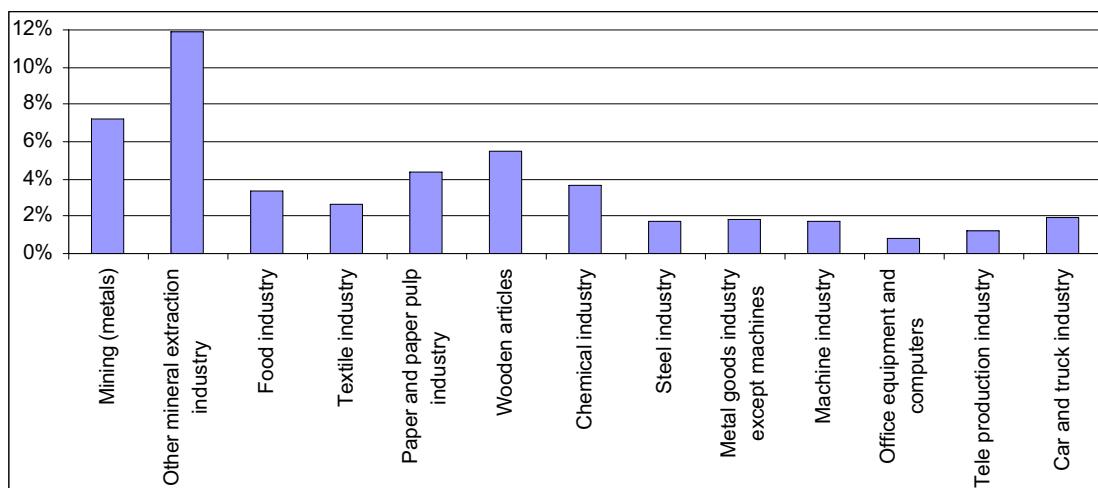


Figure 9. Share of transport costs of sales revenues. The costs are for hired transports. Source: SCB (2004), a selection of industries.

environmental point of view, tonne-km/GDP and CO₂-emission/GDP, has not been decoupled at all. In fact, the absolute numbers on tonne-km and CO₂- emissions are still increasing without any real sign of flattening out.

Explaining the growth of road freight transport

The last 20 years, less goods in tonnes have been transported at the same time as the average length of haul has increased causing tonne-km to continue to grow. 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.

EXPANDING ECONOMIC GEOGRAPHY

An expanding economic geography means that fewer component manufacturers are located over a wider area and that the manufactured products are sold on markets further away from the original manufacturing place (or places!). This process of a spatially dispersing economy includes both the production system (from raw material to manufacturer) and the market system (from manufacturer to customer). The increasing "globalisation" creates a structural demand for more freight transport by expanding the economic geography.

The harmonisation of regulations and decreasing customs have enabled European companies to exploit the gains to be made from moving production to countries with lower factor costs (notably employment) and by centralising production systems to fewer locations. The production structure has been measured in Europe and confirms geographically spreading of production systems since the completion of the European single market (Amiti 1998, Brülhart 1998).

The market for products has also grown spatially as our consumption patterns have become more global. An increased taste for variety and/or low cost products has result-

ed in that we today import a large number of products that is also produced domestically (e.g. Germans drinking Mexican beer and Swedes drinking water from France).

FRICITION OF SPACE / COSTS OF TRANSPORT

Growth of freight transport can be seen as a continued reduction of "space friction". The reduction of space friction is both related to the cost, the technical ability of transport systems, and to the legal and cultural context such as trade regulations and languages.

Cost

The cost for transport has declined over time to levels where the cost for transport services seems no longer to have a crucial role in determining transport activity (at least for manufactured goods). Looking at very long time frames this is certainly true. In Figure 9, the costs for hired transport in Sweden are shown as shares of sales revenues for a selection of industries. This excludes "in house" transport but according to SIKA (2003) this only represents 11% of truck activity (ton-km), a figure that has been almost halved the last 25 years (*ibid*). For the general manufacturing industry, using predominately road transport, the cost of transport seems to be around 2% to 4% of sales revenues. There are however some exceptions (e.g. mineral extraction) with higher shares of transport cost but these industries usually use rail or sea transport.

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 etc.) between possible distant location sites can motivate very long transport distances, especially for the fastest growing industries (electronic, manufacturing).

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 ac-

tively 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 reduced barriers and lowered the cost of road transport. Unfortunately, the deregulation trend has not been equally successful when it comes to the railway sector 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 a not fully implemented EU-policy.

LOGISTICAL CHANGES

Improving logistic systems has been a major issue for industry the last 20 years. However, the demand for faster and smaller deliveries that arrive "just-in-time" to the manufacturer can potentially introduce inefficiencies in the transport system such as trucks running empty or with little cargo. However, the statistics available do not support the idea that 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 1 and Figure 5 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 has increased. The use of light trucks for special deliveries have increased but the transport activity for light trucks measured in tonne-km constitutes a very minor part of the total amount of activity (<2%).

In conclusions, 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. However, one effect of JIT systems might be that increasing efficiency lowers the cost of transport for manufacturing companies and thus induces more transport. Another effect of JIT systems could be the large growth of mixed goods, see Figure 3 and 4. More freight is being transported by third parties who pack the goods together with numerous other articles and thus brands the whole trucks as "mixed goods" instead of specifying the goods.

Exploring the opportunities for decoupling

Current growth trends cannot be sustained forever. Whether a natural saturation of freight demand will occur at a sustainable level or policies restricting freight growth will be needed is unclear. With a strong definition of sustainability, some sort of restrictions will be necessary. Below, we briefly discuss (i) how business decisions on location affects transport demand, (ii) the effects on transport demand of internalising external costs, (iii) the effects of long-term of government policy and planning, and (iv) the possibilities for a spontaneous decoupling.

DECIDING ON LOCATION

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. The two lower levels, scheduling and management, has more to do with the operational logistic efficiency.

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.

The location of factories and the distance to markets, the *structural demand* (level 1), is the key to understanding freight transport growth. In the dawn of industrialisation, the physical geography together with the ability and cost of transport decided the location of factories. Today, decisions on where to locate factories does not depend on the physical geography but is more influenced by strategic thinking about access to 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. However, within this "strategic framework", the current location paradigm is that of taking full advantage of the differences in factor costs (notably costs for employment) and low transport costs.

There are, at least theoretically, alternative development paths to the current trend of increasing centralisation and globalisation that could offer production systems with lower transport intensity. Production systems with small and locally based companies organised in regional networks are an alternative to the centrally managed "Economies of Scale". Here, product development and diversity are more important than large scale manufacturing facilities ("Economies of Scope"). High flexibility and high innovative capacity that comes from 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). Transport demand is, at least in the production phase, 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 et al (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) claim 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, there is so far no strong empirical evidence that suggest neither that these production philosophies gain in importance nor that they are as transport efficient as theoretically claimed.

INTERNALISING EXTERNAL COSTS AND THE EFFECTS ON LONG-TERM DEMAND

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 economic incentives for a socio-economic efficient transport system. This strategy has been on the EU agenda for several years, but is still not fully implemented in any EU member country (EU White paper, 2001).

In Sweden, SIKA⁹ has been responsible for estimating the effects of internalising the external costs of transport. *When estimating the effects of higher fuel costs on future CO₂ emissions*, SIKA calculates with an elasticity of -0.2 for freight. This means that an increase in fuel prices of 1% would result in a decrease in freight fuel use 0,2%. The Swedish Government has the ambition to stabilize the CO₂-emissions from the transport sector at the 1990 level in the years 2008 to 2012. According to SIKA calculations, this would require an extra fuel tax of 2,70 SEK/kg CO₂ (0,3 Euro/kg CO₂) (SIKA 2003). Internalising the external costs would, according to SIKA calculations, increase the efficiency of the transport system, not alter the original demand¹⁰.

The Swedish government has also set a long-term target that the total Swedish emissions of CO₂ should not exceed 4,5 tonnes CO₂/capita in 2050 (roughly 55% of current per capita emissions in Sweden) and thereafter further decrease (Government, 2001). Such a drastic cut in emissions is not within the scope of SIKAs methods of estimating costs and effects. There is, however, a debate in Sweden whether the transport sector should have a less ambitious long-term target for reducing CO₂-emissions due to the relatively high cost of mitigation in the transport sector compared to e.g the housing or electricity sectors.

The relatively modest fuel price increases suggested by SIKA should be compared to the fuel prices needed to influence the strategic decisions on location of storage, manufac-

turing sites etc. (level 1). With transport costs amounting to around 3% to 4% of the sales value for manufactured goods (the share of the fuel cost is thus even less), the fuel taxes need to be unrealistic high in order to influence location decisions. 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.

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 etc. 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.

EFFECTS OF GOVERNMENT PLANNING

The main objective of government infrastructure policy has been to avoid bottlenecks in the infrastructure and to accommodate the expected growth in an efficient manor, a "predict and provide" approach. The tools used for government planning typically extend the current trends in economic activity into the future (including structural shifts in the economy) and calculates the future transport demand assuming the link between freight and economy to be constant, see the SAMGODS model (SAMPLAN 2001). However, 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, see e.g. Goodwin (1996), and Owens (1995). Another fact is that the built infrastructure 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 current planning tools cannot be abandoned but needs to be complemented with a structured way of planning for a long-term ecological sustainable transport system. Planning further than 10 to 15 years ahead must assume that current relationships between freight traffic and economic development can be changed. Scenario building and back-casting are two, usually intertwined, methodologies that address the problems involved in long-range planning, see POSSUM (1998), Brokking et al (1997) and Åkerman et al (2000). These methodologies explore possible pathways for attaining a predefined "scenario". 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. As an illustration, in Åkerman et al (2000), an image of a future sustainable Swedish transport system (the year 2050) is outlined and one of the conclusions is that with a future *sustainable* level of transport activity no

9. SIKA; Statens institut för kommunikationsanalys (Government institute for communication analysis)

10. 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 (levels 3 and 4). This is a realistic assumption for the time frame (10-15 years) studied in the model. The result is that road traffic would decrease by 3% and sea transport would increase with 5% and railways would decreases with 4% (SIKA 2003).

further arterial road capacity is needed in Stockholm. This is in stark contrast to the traffic needs of Stockholm today. The difference in the scenario by Åkerman et al (2000) and the current situation in Stockholm is that the scenario also includes huge shifts in economic structure and life-styles.

Not providing any new road space, i.e. freezing the infrastructure at the current level, can be the result of future land-use conflicts but has also been forwarded as an instrument to limit traffic 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.

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. 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 where energy intensive industries lost in economic importance 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 economic volume of goods produced that causes transport demand and thus links GDP to freight growth. As can be seen in previous chapters, 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. However, 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.

Conclusions

The weight (tonnes) of goods transported has levelled out despite a continuous growth in economy the last 25 years, a strong decoupling. A weaker decoupling trend can be seen looking at vehicle-km resulting from increased logistic efficiency (less empty running and increased average pay-load). However, as a result of goods being transported longer distances and freight lorries carrying greater loads, both the transport activity measured as tonne-km and the CO₂- emissions from freight have been growing steadily and showed no signs of decoupling from economic development.

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 long-

er transports but not necessarily more tonnes lifted. There is thus a clear conflict of interest between increased European economic integration, resulting in increased economic efficiency, and the wishes to decouple freight transport from economic development.

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 and currently the favoured solution. Higher taxation could induce better logistics management, and making alternative modes (rail and sea) more competitive which will increase the efficiency of the transport system. However, this will not be enough to curb this growth as transport cost does not, to any major extent, influence business location decisions. 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.

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