TRENDS IN LOGISTICS AND THE MAIN COMPONENTS—THE SWEDISH CASE IN POST-WAR YEARS

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Abstract

Production, logistics and goods transport are closely interrelated. This paper examines how Sweden has moved from material to service production. The effect of changing logistical management principles on transport is studied. The paper examines saturation in goods transport and concludes that environmental standards set by the government can be fulfilled.

TRENDS IN SWEDISH ECONOMY AND PRODUCTION

For both logistical and transport planning it is important to ascertain likely future production patterns. In this paper the concept Gross Domestic Product (GDP) by sector at producers' values and constant prices has been used as the approximation for production.

Table 1 shows the result of the calculations for selected years and production activities between 1950 and 1990. As the total GDP of the nation is normally calculated inclusive of indirect taxes and exclusive of subsidies the table includes correction for indirect taxes (net) when comparing with GDP by sector.

Table 1 Gross Domestic Product by industry in million Kronor and percentage distribution: producers' values at 1980 prices, 1950, 1960, 1970, 1980 and 1990

	Million Swedish Kronor					In Percent				
	1950	1960	1970	1980	1990	1950	1960	1970	1980	1990
Primary production	16635	17719	20201	19278	23078	8.2	6.3	4.7	3.7	3.6
Manufacturing	36580	53369	98776	111018	132862	18.0	18.9	22.8	21.1	20.9
Manufacture of fabricated metal products, machinery and equipment	10054	19071	39678	48153	62752	5.0	6.8	9.2	9.2	9.9
Electricity, gas and water	1913	3641	7249	13093	21760	0.9	1.3	1.7	2.5	3.4
Construction	17869	22141	35638	38675	46951	8.8	7.8	8.2	7.4	7.4
Trade, restaurants and hotels	23366	32494	48382	58297	71299	11.5	11.5	11.2	11.1	11.2
Transport, storage and communication	8901	13197	20204	31727	46490	4.4	4.7	4.7	6.0	7.3
Transport and storage	5190	7850	12388	21944	29627	2.6	2.8	2.9	4.2	4.7
Other services	82690	113722	152235	197232	233242	40.8	40.3	35.2	37.6	36.6
Corrections for indirect taxes (net)	17293	30114	49962	55779	64350	8.5	10.6	11.5	10.6	10.1
Discrepancy	-2254	-3815	0	0	-2776	-1.1	-1.4	0.0	0.0	0.5
Gross Domestic Product	202993	282582	432647	525099	637256	100.0	100.0	100.0	100.0	100.0

Table 1 shows that the relative importance of primary production (agriculture, hunting, forestry, fishing, mining and quarrying) has declined from period to period. Manufacturing increased in relative importance from 1950 to 1970. Afterwards a decline has set in. Manufacturing and construction might be grouped together and called secondary production, but even for such material production the picture is similar. Over the years the importance of fabricated metal products, machinery and equipment has steadily increased.

When all service producing activities (including electricity, gas and water) are grouped together, a pronounced decline can be found between 1950 and 1970, but an even more pronounced increase between 1970 and 1990. In the literature one can find the name tertiary activity attached to service producing sectors. The era of tertiary activities has seemingly begun to unfold since the seventies. According to Table 1 the various service activities show very different development patterns over time. The relative importance of two sectors—electricity, gas and water, and transport, storage and

communication—has steadily improved while the relative importance of trade, restaurants and hotels has been very stable.

Table 1 illustrates one aspect of development, Table 2 another. Economic growth was very high in the years between 1950 and 1970 but has fallen markedly since. Dramatic changes seem to have taken place in the growth pattern of the various production sectors and these changes have been captured by dividing the change in sector production by the overall growth in GDP. The ratio of the two elasticities has in this paper been denoted *Elasticity of direction.* The term does not imply cause and effect, but has been considered a meaningful concept for measuring relative sectoral changes. In such terms all service sectors, and particularly electricity, gas and water, transport, storage and communication and other services have become more important. When production of all service activities is summed up, this aggregate tertiary production also discloses an increasing elasticity of direction from 0.90 in the period 1950-1970 to 1.25 in the period 1970-1990. Table 2 supports the hypothesis that Sweden has been shifting its production base from material production to service production.

Table 2 Gross Domestic Product by industry: annual average growth in per cent at constant prices (1950-1990)

	1950-1970		1970-1990	
	In per cent	Elasticity of direction	In per cent	Elasticity of direction
Primary production	1.0	0.3	0.7	0.3
Manufacturing	5.1	1.3	1.5	0.7
Manufacture of fabricated metal products, machinery and equipment	7.1	1.8	2.3	1.2
Electricity, gas and water	6.9	1.8	5.7	2.9
Construction	3.5	0.9	1.4	0.7
Trade, restaurants and hotels	3.7	0.9	2.0	1.0
Transport, storage and communication	4.2	1.1	4.3	2.2
Transport and storage	4.4	1.1	4.5	2.3
Other services	3.1	0.8	2.2	1.1
Gross Domestic Product	3.9	1.0	2.0	1.0

The composition of industrial activities is an important explanation for the level of transport volumes. For a country such as Sweden with pronounced dependence on its foreign trade, the development of exports and imports is also important when explaining transport volumes. In post-war years both the annual average growth of foreign trade in per cent at constant prices and the elasticities of foreign trade with respect to GDP have been high. The elasticity of exports appears to increase while the elasticity of imports appears to decrease. Both elasticities have been in the area 1.5-2.0.

The elasticity between tonne-km and GDP illustrates a characteristic pattern: A growth for many years with culmination in the sixties with value close to 1.5, a moderate decline in the seventies followed by a steep decline in the eighties to below 0.5.

Figure 1 illustrates the long-term development of GDP at constant prices and domestic goods transport (tonne-km). The levelling out of growth in tonne-km is evident. If the overall level of GDP had been the only explaining factor, such a trend would have been very difficult to explain. However, a shift from material production (primary and secondary production) to service production so visible from the seventies might lend an important partial explanation to the observation of transport saturation.

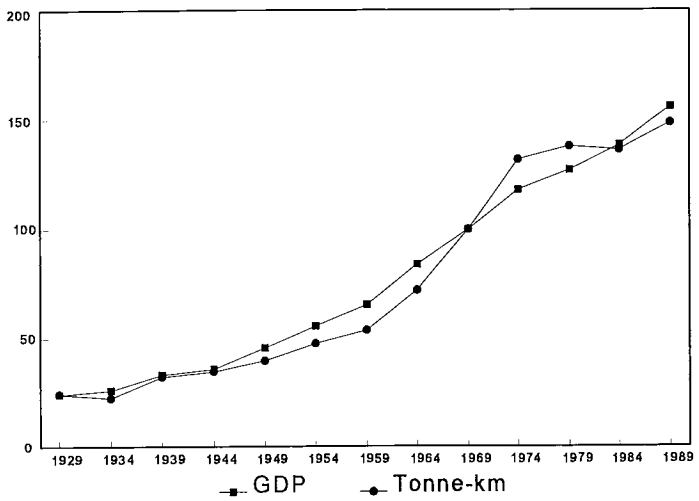

Figure 1 **Domestic Goods Transport (tonne-km) and Gross Domestic Product (GDP) at constant prices 1929-1989 (1969=100)**

MEGA TRENDS IN LOGISTICS

This section draws heavily on a European wide Delphi analysis called *Logistics Futures in Europe* in which The Technical University of Linköping was the Swedish organiser. The study was carried out in 1992 with 1991 as base year and 2001 as horizon. In addition to answers from this Delphi analysis this section draws on publications from the study of Scandinavian Links in the eighties.

According to the Scandinavian Links study trends in logistical efficiency in transport infrastructure improvement and in transport performance have several consequences. Nordic manufacturing firms can adapt much more flexibly to their markets, they are expanding their markets and their market shares, the number of customers is increasing and distribution networks growing. Production capacity is better exploited, production volumes are greatly increasing and the size of each production series greatly decreasing. The use of components and the adaptation of production to assembly are becoming more widespread. Average shipment size and lead time are greatly decreasing while regularity, shipment frequency and stock turnover are greatly increasing. The number of suppliers is going down as well as the extension of the supply net. Quality of service and access to information are improving.

According to *Logistics Futures in Europe* production in the European Economic Area (EEA) might on average increase by about 2 per cent per year in the nineties. Both in Sweden and in the EEA area the number of production sites for manufacturing industry and the number of suppliers of input components, sub-assemblies and raw materials for the usage by manufacturing industry will go down, more in Sweden than in the rest of the EEA area. The number of inventory holding sites will also be reduced in the nineties. The turnover of inventories of finished products as well as of raw materials, components and sub-assemblies will increase in manufacturing industry. The average shipment size for both finished goods and for raw materials, components and sub-assemblies will be reduced. The picture drawn by the Delphi panel implies a concentration of material production in fewer locations with increasing production. Such a concentration is also anticipated in retailing.

Lead times will be significantly reduced in both manufacturing industry and retail trade in Sweden as well as in the rest of the EEA area. By the turn of the century there will be very few missing items in orders delivered and punctuality or timeliness will be high. The Swedish experts have higher expectations of performance in Sweden than the European experts have for the whole EEA area. The experts expect the ratio of inventory holding to GDP to be further reduced in future.

New management techniques based upon just-in-time (JIT) production put tension on transport firms. One consequence is the reduction of inventory to very low levels, so as to expose the weaknesses and inefficiencies in the production chain. Not only is less money tied up in part by finished products and supplies, faulty items are more quickly identified and JIT is an aid to innovation because production runs are tuned to final assembly and thence to demand.

The transport sector gets a large share of extra burden created by these changes. JIT requires much higher performance in the areas of timeliness and reliability, which is harder to achieve in the more centralised warehousing and distribution structure which is emerging. At the same time, JIT is associated with smaller more frequent deliveries. Once again it is the transport sector which has to meet these demands. There has also been a trend towards outsourcing of many production processes. Sub-contracted firms undertake many functions which would have been done in-house in the past. This puts a lot more goods on the road, which would in the past have merely been shunted around a factory site.

Future logistical efficiency will depend heavily on the diffusion of electronic data interchange (EDI). By the turn of the century the expert panel expects that about half of the suppliers of input components, sub-assemblies and raw materials to manufacturing industry will be EDI-linked. An even higher percentage is expected for goods suppliers to retailers. On average more than half of all orders, transport documents and invoices are expected to be transmitted via EDI-networks in Sweden by 2001. The expected average share is much lower for the whole EEA area. Even in the retail trade transmitting documents via EDI networks is expected to be frequent by the turn of the century.

High percentages for the use of bar codes and electronic tags are expected on consignments with Swedish experts having much higher expectation for Sweden than the whole group of experts for the EEA area. Automatic handling and retrieval systems will be common in pallet-load warehouses, and orders will be carried out automatically by machine in several warehouses. By the turn of the century it is expected that manufacturers and retailers will be required to recycle or reuse most packaging and life-expired products.

In the current restructuring of European manufacturing industry the importance of the different logistics channels will change. The expert panel expects that the usage of European distribution centres will increase in relative importance, as will the combined use of European and regional distribution centres. The use of national distribution centres in combination with regional distribution centres is expected to be reduced in relative importance. The logistics performance of major industrial sectors is expected to improve in the nineties. In retailing the importance of hypermarkets/malls, supermarkets, cash and carry and teleshopping are all expected to become relatively more important.

Future trends in logistics continue past trends and presume high efficiency in the transport industry. The volume of vehicle kilometres might increase significantly unless the transport industry succeeds in coordinating transport production. Successful route and transport planning and coordinating might reduce the pressure on vehicle kilometres, but this might very well increase the volume of tonne-km. Transport costs might come under pressure, the magnitude of increase will depend on such factors as technological development and competition in the transport industry. If efficient logistics will boost transport volumes and transport costs, this is the price to be paid for increased overall logistical efficiency.

TRANSPORT COSTS AND TRANSPORT EFFICIENCY

Initially the definition of transport costs in relation to logistics has to be settled.

Logistics is in this paper related to industrial activities in Sweden. This implies that transport for domestic purposes as well as for Swedish foreign trade has to be included in any calculation. The actual transport distance (tonne-km) to be included from foreign trade depends on the prevailing terms of trade. If Sweden had been dominant in foreign trade relations, it might have bought and sold cif (all costs, insurance and freight). If this had been the case Swedish exporters and importers would control trading terms and could reap all potential trading benefits themselves. In reality Sweden is only one country among many trading in the world market. The normal procedure in public statistics of defining export values fob (free on board) and import values cif has been adhered to here. Tonne-km and costs will then go as far as port activities in relation to exports, while tonne-km and costs related to imports will begin when the goods leave a foreign port or some other terminal abroad.

As is usually done, production costs are defined as the evaluation in monetary terms of resources used up in the production process whether such resources are services supplied or resources physically used up such as raw materials, semi-processed goods, components and modules.

In a well-functioning market economy prices of commodities and services exist, making it possible to assess relevant costs. Then the price demanded and achieved by the seller is at the same time the cost incurred by the buyer. So whether price achieved or cost incurred is the basis of measurement, the two approaches will give equal results. In such a case a relevant cost survey can be designed so as to minimise time and effort to attain the necessary statistical information. In practice various market distortions exist making it more or less difficult to assess relevant prices and costs. In such instances indirect approaches to information compilation have to be used. Basically transport costs in the logistical chain have been calculated as production values in relevant transport activities. Some typical instances can illustrate the procedures.

Port and shipping activities are competitive transport activities which in the long run must cover their total costs including some normal profit on own capital. Production values from these transport activities have been included as cost elements in the production values of those activities which are in need of transport. Measuring transport costs as production values in port and shipping activities seems fairly straight forward.

In goods transport by rail not all infrastructure costs are included in the price paid by customers. An imputed value of capital costs not included in the transport price paid by the railway customers might be added. Considering the relatively small correction implied, this has not been done in this paper.

In transport policy issues it is argued that some transport users should pay more and some less than the full transport infrastructure costs they incur. In particular road users have been in political focus for years. The allegation has been that lorries do not pay the total social costs incurred by their transport. This paper does for practical reasons not correct for the so-called external effects or social costs. However, there is the more modest issue of whether lorries pay for the transport infrastructure costs involved. The road transport industry is fairly competitive and one would expect that road infrastructure costs, in so far as they are charged to the transport users, are included in the prices charged by the hauliers.

In this paper transport costs have been measured as producers' values. This is the value the producer gets in the end after subtracting indirect taxes levied and adding subsidies received. The charge for road transport infrastructure costs is in Sweden considered an indirect tax which, therefore, has to be added to get an estimate of the total transport costs incurred by road transport. The kilometre tax on lorries aimed in principle at recovering variable infrastructure costs incurred by such vehicles. Taxes paid on diesel fuel should be added to the kilometre tax. In addition an

annual vehicle tax was levied to recover the difference between total costs and the variable element and should also be included in the calculations.

When there are no market values available and the researcher needs to estimate the value of some activity supplied in transport, theory prescribes the second best alternative. But what would be the remuneration of the activity in the best alternative usage? Admittedly such a calculation might also be difficult in practice.

The borderline between transport and other productive activities might in some cases be difficult to draw. The question is mainly related to internal transport in which case the activity might be classified as terminal or warehouse activity or it might belong to the realm of material production. The transport of fish by a fishing boat to a processing plant, the transport of crops to barn, the transport of timber to some location where it will be collected by a haulier are all examples of transport activities belonging to the realm of material production. This is also the case with products on a conveyor belt or products handled by a forklift in a factory as part of material production. In practice public statistics draw a border line between the various productive activities sketched above.

In this paper transport and forwarding costs in the logistical chain have been calculated for the following activities:

- Railway goods transport
- Road goods transport (for hire, on own account, road infrastructure taxes)
- Air freight
- Coastal shipping and inland waterways
- Timber floating
- Ocean water transport
- Supporting services to water transport
- Supporting services to land transport and services allied to transport

There are other transport activities than the ones included in the list. Transport by pipelines might be mentioned as an example. In the context of this paper it has not been possible to estimate such costs. In any case they are insignificant compared with the items included.

The calculations go as far back as to 1950. For the more recent years it is possible to draw heavily on public statistics necessitating only minor adaptations. A great many approximations have to be made when the researcher wants to go back more than 10-20 years in transport history. Most time series drawn from public statistics simply stop at some point of time necessitating the use of indicators.

The most consistent long-term time series in public Swedish statistics cover the period 1970-1987 and has been calculated in 1980 prices. More recent data have been calculated in 1985 prices and data prior to 1970 have been calculated in prices prevailing in selected years in the fifties and the sixties. In Table 3 the detailed data are presented in 1980 prices. The total is also presented in 1985 prices.

Transport costs increased in both absolute and relative terms (per cent of GDP) for many years. After 1980 the relative share fell, but in absolute terms the value continued to increase. The growth in outlays has been highest in road transport and air freight. These transport modes have been the most successful ones to supply effective logistical services.

The implied growth in the sum of all outlays for road transport has been 4.4 per cent per year between 1950 and 1990. The annual growth in tonne-km has been as high as 6.3 per cent per year between 1950 and 1990. There is evidence that efficiency gains in road transport have been reflected in prices charged and income received.

Table 3 **Gross output at producers' values in freight and forwarding 1950-1990 (Million Swedish Kronor)**

1980 prices	1950	1955	1959	1960	1965	1969	1970	1975	1979	1980	1985	1989	1990
Railways	1843	2270	2145	2373	2787	2945	3080	2965	3170	3064	3401	3537	3527
Road transport: For hire	2212	3232	4128	4565	6613	7930	8131	12331	14438	15235	15142	16618	16504
Own account	929	1244	1470	1598	2081	2320	2332	3193	2989	3400	2782	2566	2521
Infrastructure taxes	506	573	703	722	1032	1130	1130	1427	1659	1606	1442	1535	1541
Air freight	5	5	5	5	33	82	101	128	157	140	155	164	167
Ocean water transport	1189	1328	2056	2348	3060	4258	4595	3878	3889	4150	5018	5295	5188
Coastal and inland water transport	267	254	273	287	299	347	324	382	453	497	452	406	441
Timber floating	254	313	246	268	238	149	91	34	34	23			
Supporting services to water transport	282	322	395	458	599	765	842	1067	1493	1477	1425	1690	1745
Supporting services to land transport and services allied to transport	650	754	839	910	1182	1460	1524	2363	3790	3899	4361	5796	5801
TOTAL	8137	10295	12260	13534	17924	21386	22150	27768	32072	33491	34178	37607	37435
1985 prices (1)	12428	15724	18725	20670	27375	32663	33830	42410	48984	51151	52200	57437	57174
GDP	297254	349979	399512	414110	532986	612105	651731	740455	778019	790999	865788	952881	959952
In per cent of GDP	4.2	4.5	4.7	5.0	5.1	5.3	5.2	5.7	6.3	6.5	6.0	6.0	6.0

1) 1985-1980 (1980=100) 152.73

From Lumsden (1989) it can be inferred that efficiency gains in cargo handling have been significant. On the assumption of about a forty year adaptation time for palletising and mechanising cargo handling the annual gain in efficiency can be estimated at 3 per cent per year.

COSTS AND EFFICIENCY IN LOGISTICS

In this section logistical costs are estimated on a national scale for 1950, 1960, 1970, 1980 and 1990 and for the following cost elements:

- Freight and forwarding costs, see preceding section
- Stocks carried
- Warehousing
- Packages, containers, boxes etc.
- Capital costs of goods in transport
- Insurance of goods in transport

There are other logistical costs which might be likely candidates for calculation. One such item is documentary costs, which might amount to as much as 4 per cent of all logistical costs according to a Norwegian study. However, for this paper it is not possible to calculate such costs. Another cost item outside the scope of calculation, is the cost of failing to deliver the demanded quantity or quality.

Swedish national accounts have published data on the overall change in stocks carried year by year since 1950 in 1985 prices (Statistics Sweden N 10 SM 9201). The supposition has been made that there were very little stocks when the Second World War ended and that the nation started to build up its stockpiles from 1950. The volume of stocks increased until 1976. From then on a significant drop set in, a drop which might still go on for several more years.

Calculation of capital costs of stocks carried has to be based on some relevant interest rate. In practice this rate probably varies from industry to industry. In this paper the average interest rate relevant for borrowing funds for carrying stocks has been used. Ågren (1980) has made a very comprehensive study of the logistical situation in the seventies. His interest rate for 1980 was 12.5 per cent. According to the statistical yearbooks of Sweden this interest rate does not seem to have changed significantly by 1985, which has been chosen for base year. To this rate has been added 2.5 per cent to account for depreciation of stocks carried. This is admittedly a speculative assumption, but it would be wrong not to include something in the nature of depreciation in the

calculations. So 15.0 per cent has been used for all calculations in 1985 prices. The following survey shows the results relating to stocks carried.

	Stocks carried 1950-1990				
	1950	1960	1970	1980	1990
Billion Swedish Kronor at 1985 prices					
Stocks carried	0	28.6	104.4	173.6	123.9
Capital costs (15 per cent)	0	4.3	15.7	26.0	18.6

Warehousing costs consist of capital costs of buildings, equipment, trucks, manpower costs related to people working in and with warehousing, electricity and other costs related to warehousing. Average figures have been used based on a national approach and assumptions about the volume of goods passing warehouse during the year and the relevant terminal costs per tonne of goods warehoused.

The total volume of goods in domestic transport and in Swedish foreign trade is well documented. In this paper this volume has been reduced for ores, coal, coke and petroleum which have not been considered relevant for the calculations.

In Lumsden (1989) there are examples of terminal costs for various sorts of terminals. For rail/road land terminals costs are given at 45-75 Swedish Kronor per tonne handled. The book was published in 1989, so the information might be considered relevant for the year 1985. An average of 60 Swedish Kronor per tonne has been used, but calculation has also been done on the presumption of 45 Swedish Kronor per tonne handled.

Over the years significant efficiency gains have occurred in terminal handling. Unitization is probably the most significant example to give. In Lumsden (1989: 270) a figure is presented from Unit Load Council in 1972 showing that there is a gain of about 70 per cent to go from the traditional manual based cargo handling to palletised and mechanised cargo handling. If the mechanisation process has taken some 40 years to run, the efficiency gain might be about 3 per cent per year. This rate has been used to derive the development of terminal unit costs over time.

	Warehousing 1950-1990				
	1950	1960	1970	1980	1990
Million tonnes transported in all	265	413	652	593	640
Less iron ores, coal, coke, petroleum and petroleum products	25	40	61	50	45
Million tonnes warehoused	240	373	591	543	595
	Unit warehousing costs per tonne (Swedish Kronor at 1985 prices)				
Alternative 1	169	126	93	70	52
Alternative 2	127	94	70	52	39
	Warehousing costs in billion Swedish Kronor at 1985 prices				
Alternative 1	40.6	47.0	55.0	38.0	30.9
Alternative 2	30.5	35.1	41.4	28.2	23.2

Sweden has played a pioneering role in the mechanisation process of cargo handling. This process was visible already in the fifties. A pallet pool was organised in 1955 to achieve effective usage and circulation of pallets. By 1959 containers were used to transport pressed steel. The first genuine roll on-roll off vessel in the world was put in service in 1967 by the Swedish Transatlantic Shipping Company. Sweden was one of the first countries in the world to use demountable bodies

for trucks. Sweden produces some of the world's best container handling equipment, trucks, railway engines and wagons.

Previously it would have been very difficult to estimate the logistical costs related to protecting and encompassing commodities. Due to the conscientious social efforts to reuse old material there are official estimates on how many tonnes total levels might amount to. A summary of such estimates can be found in Engström et al. (1993). In addition there is relevant information to be found in production statistics from Statistics Sweden in the yearbooks. This information has lead to the following estimate for 1985:

Costs for packages, containers, boxes etc. Million Swedish Kronor 1985	
Pulp and paper	3,800
Plastics	1,500
Glass	1,400
Aluminium	800
Wood	500
Total	8,000

The 1985 estimate has been projected according to the development of private final consumption expenditure at 1985 prices. The time series is presented in Table 4.

Table 4 Logistical costs 1950-1990 (Million Swedish Kronor, 1985 Prices)

	1950	1960	1970	1980	1990
Freight and forwarding	12.4	20.7	33.8	51.2	57.2
Stocks carried	0.0	4.3	15.7	26.0	18.6
Warehousing: Alternative 1	40.6	47.0	55.0	38.0	30.9
Alternative 2	30.5	35.1	41.4	28.2	23.2
Packages, containers, boxes etc	3.6	4.6	6.7	7.8	9.1
Capital costs of goods in transport	1.0	1.6	2.5	2.3	2.5
Insurance of goods in transport	1.0	1.1	1.2	1.4	1.1
TOTAL Alternative 1	58.6	79.3	114.9	126.7	119.4
TOTAL Alternative 2	48.5	67.4	101.3	116.9	111.7
In per cent of GDP, Alternative 1	19.7	19.2	17.6	16.0	12.4
In per cent of GDP, Alternative 2	16.3	16.3	15.5	14.5	11.6

The calculation capital costs and insurance for goods under transport is based on the volume of goods transported for domestic purposes and in foreign trade. An average unit value of 4 700 Swedish Kronor per tonne for goods in foreign trade in 1985 has been used together with an interest rate of 12.5 per cent per annum. Transport volume has been estimated at 525 million tonnes in 1985.

The most difficult part to estimate is the number of days an average consignment is transported. The average transport distance for domestic transport was 127 kilometres in 1985. Including time for loading and unloading transport time has been estimated to be one day. According to an analysis of Norwegian foreign trade it took in all 9 days to ship from Norway to Germany which is the most important market for both Swedish and Norwegian foreign trade. A reduction of one day has been assumed in the Swedish case. The two journey times have been weighed together with transport volumes as weights giving two-three days as the average time consumption. Capital costs for 1985 have been estimated to be of the magnitude of 2 billion Swedish Kronor at 1985 prices. This estimate has been projected based on the transport volumes. The figures are shown in Table 4. In the statistical yearbooks from Statistics Sweden there is an item called transport insurance which has been taken at face value and deflated by the inflation rate for GDP.

The logistical costs increased up to 1980 but were lower in 1990 than in 1980. In percentage of GDP the logistical costs have gone down since 1950. One reasonable interpretation might be that

efficiency gains have been so significant as to have had a marked effect on the whole Swedish economy.

Up to 1980 the cost of stocks carried and warehousing outweighed freight and forwarding costs but by 1990 the latter costs were higher. Costs related to stocks carried went down from 1980 to 1990 and warehousing costs went down from 1970. It seems reasonable to conclude that transport efficiency has made reductions in costs possible, both to stocks carried and warehousing.

The other logistical cost items are small compared with freight and forwarding, stocks carried and warehousing. The largest of these items, costs of packages, containers, boxes etc have increased in all the selected years and amounted to about 8 per cent of all logistical costs by 1990.

SUSTAINABLE MOBILITY IN A LOGISTICAL CONTEXT

The European Union (EU) has coined the phrase *sustainable mobility* for the volume of traffic which might be considered in keeping with politically established environmental objectives and standards. By technological development and policy measures it seems possible for traffic in Swedish territory to comply with the standards set both by the EU as well as the more stringent standards set by the Swedes.

Austria is an important transit country for the other EU Member States. There exists a bilateral agreement on transit rights for road vehicles between the EU and Austria. The bilateral agreement has set the target at a 60 per cent reduction in pollution before 2003 with 1991 as the reference year. Since the volume of international road transport is increasing significantly each year, such a reduction in pollution can only be achieved by an increasing number of less polluting heavy vehicles and better utilisation of heavy vehicles. Transit licences are expressed in *ecopoints* which is a aggregate measure of the volume of pollution from selected components (CO, HC, NOx and particles). The transit agreement between Austria and the EU gives a good indication of the potential for air pollution reduction in relation to components such as volatile organic compounds, carbon monoxide, sulphur oxides and nitrogen oxides.

It is generally accepted that transport activities produce a large share of the emissions in Sweden responsible for local, regional and global environmental problems. High levels of local air pollutants such as nitrogen oxides, hydrocarbons, ozone, carbon monoxide, sulphur oxides and particulates can be harmful for human beings, animals and plants. Noise and physical encroachment are other local environmental problems for which the transportation sector is responsible. Emission of sulphur dioxide and nitrogen oxides lead to regional and environmental problems such as acidification and over fertilisation, while carbon dioxide is the most important contributor to the greenhouse effect.

Johansson (1993) has made a comprehensive study of future traffic emission levels in Sweden. The effect on total emissions of different choices of technology and fuel for different modes of transport is studied. Estimates of future specific energy use and emission factors for different vehicles, technologies and fuels have been used. When present environmental standards are expressed relative to 1989, the official goal prescribes no increase in carbon dioxide emissions, while nitrogen oxide emission should be reduced by some 30 per cent and sulphur dioxide emissions by some 20 per cent.

Johansson (1993) shows that emission of all the above gases except carbon dioxide can be reduced with technology which is commercially available today. Present policy objectives are reached for these gases using the best available technology. Alternative fuels in the transport sector would lead to a further decrease in nitrogen oxides and to decreased emissions of carbon dioxide. If methanol produced from bio-mass were to be used in all road vehicles, carbon dioxide emissions could be reduced by some 80 per cent.

Johansson (1993) has calculated that if the load factor for trucks is increased by 30 per cent, if one third of the goods transported more than 100 km by trucks is put on rail, and the assumed increase in traffic in aviation 1989-2015 is put on rail, emission of nitrogen oxides would be reduced by

25 per cent. This means according to the study that a reduction of nitrogen oxides by about 80 per cent compared to 1989 could be reached if methanol is used in all road vehicles.

Carbon dioxide is mainly the responsibility of the private car. Heavy vehicles normally constitute 10-15 per cent of vehicles in a traffic flow on the more important roads. All in all there should be good reason to maintain that social activities leading to the observed goods transport volume can in future be performed on the basis of current environmental standards set by the Swedish government.

This paper has substantiated the claim that Sweden is moving into an era of service production. This means less pressure from the economy on the goods transport system. The demand from industry for just-in-time deliveries and increased recycling of waste products might on the other hand inflate transport volumes. By better management the transport industry can at least partially compensate for this, since capacity utilisation is rather low in transport. The potential of rail and sea transport to carry more goods than they do today is clear and in future the two transport modes may offer much more competitive logistical supply than they do today. This will have a beneficial influence on the environment.

Reduction in stocks may not increase transport volumes as long as it is the so called security stock which is being reduced. This might still be the case in Sweden for some time to come. The following calculation indicates the line of reasoning. The average value of a tonne transported in Swedish foreign trade was 4700 Swedish Kronor in 1985. This unit value used to calculate the value of stocks gives the result that stocks amounted to 22 million tonnes in 1970, 37 million tonnes in 1980 and 26 million tonnes in 1990. As indicated in in this paper, the potential for further substantial reduction is still present. As an example that stocks might be further reduced by some 20 million tonnes, this amounts to 3 per cent of the total transport volume in 1990. Actually this factor might also provide some explanation for the observed transport trend in the post war years although so far it has received little attention. When stocks are being piled up as happened up to the end of the seventies, transport volumes are inflated. Afterwards when stocks are being reduced the need for transport will be reduced down to the critical level of security.

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