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Freight Transport Intensity of Production and Consumption

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FREIGHT TRANSPORT INTENSITY OF PRODUCTION AND CONSUMPTION

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Foreword

The European Union has decided a sustainable development strategy that includes as an important objective the ‘decoupling’ of transport growth from economic growth. This reflects grave concerns about the problems that would inevitably be associated with ever-increasing transport. For example, the transport sector is the fastest growing energy consumer in Europe and a main source of greenhouse gas emissions. At the same time the objective is very ambitious - some might even say unrealistic to achieve – as the link between transport growth and economic growth has proved to be very robust. There are hardly any signs of moving towards the desired decoupling, particularly in the case of freight transport. In recent years in the EU the growth rate of freight has even exceeded the growth in gross domestic product (GDP).

Taking up such a difficult challenge requires understanding very well the developments and the driving forces behind them. This is why this report presents an in-depth analysis of freight transport intensity and how it depends on evolving modes of production and consumption. Freight transport intensity is the indicator that allows to measure directly whether de-coupling happens in the area of freight. It is defined as the amount of transport activity (measured in tonne kilometres) in an economy per output (measured in GDP). The analysis starts from a detailed description of past trends, discerning different supply chains and using product and industry specific data as far as possible, and studies the reasons for these trends. Why is it that road freight intensity has been rising at around 1% per annum between 1970 and 2000 for the EU as a whole, while at the same time the manufacturing sectors and heavy industries have lost importance and advances in information technology and logistics management allowed to improve system efficiency? Then it turns to the future to explore the drivers that determine the perspectives for de-coupling in the years to come. Will changes in business models, manufacturing processes or in product design affect freight intensity trends? Finally, the report discusses how policy, both public and industrial, influences the relationship between transport and economic growth and the effectiveness of measures. Is there anything public policy can do to help developments that allow producing and consuming more while transporting less? Will real marginal cost pricing of transport make a difference? What can be done to ensure the signals get through to those in industry that make the relevant decisions?

Peter Eder, project manager at the IPTS

Contents   Page

FIGURES

TABLES

1. EXECUTIVE SUMMARY

1.1 The objective of the study is to review existing data and research into factors affecting freight transport intensity.

1.2 Freight transport intensity is defined as the measure of the amount of transport activity (measured in tonne kilometres) in an economy to the output (measured in GDP) of that economy. Increased economic output generally results in greater freight transport movement and freight intensity can be used to measure change in the relationship between economic activity and transport activity. Freight transport intensity is therefore a convenient measure to use for assessment of trends and appraisal of policy measures.

1.3 Road freight intensity has been rising at around 1% per annum between 1970 and 2000 for the EU as a whole. There are, however, differences between countries for the same time periods ranging from 2.4% annual growth for Italy to an annual reduction of 3.4% for Ireland.

1.4 Freight intensity for each mode of transport can be derived by its components. For road transport, components of intensity are the modal share of the road, the average length of haul, value density (measure of weight to value) and the supply chain structure that defines the number of times a product is handled from production through to consumption.

1.5 All changes in freight intensity must logically derive from changes in one or more of these components. Analysis of past trends can therefore use this framework and using individual components, assess their contribution to an increase or decrease in intensity. This implies that the percentage change in transport activity can effectively be approximated by the sum of percentage changes in GDP, modal share, average haul and structure. This framework can also be used for projecting changes in freight intensity into the future.

1.6 Examination of these components for a sample of five EU Member States (Germany, Spain, France, Italy and UK) show that the growth in average haul has tended to make an important positive contribution to the increase in road freight intensity (by about 2% per annum) and that factors grouped under the heading of supply chain structure and value density have tended to decrease road freight intensity (by about 2% per annum). Modal shift to road has by-and-large made a positive contribution to increase in road freight intensity (Table 1.1).

TABLE 1.1 CONTRIBUTION OF ROAD FREIGHT MOVED: AVERAGE GROWTH 1982 - 2001

	D *	E	F	I	UK
Road freight moved	4.7%	2.9%	4.4%	2.5%	3.8%
of which					
Modal Share	1.8%	0.6%	0.8%	0.3%	0.4%
Average haul	3.1%/1%	2.2%	1.7%	0.3%	2.6%
GDP	1.9%	3.0%	2.3%	2.0%	2.6%
remainder					
Supply Chain Structure Product Density	-2.1%/0%	-3.1%	-0.4%	-0.1%	-1.8%
Tonnes Lifted	1.5%/2.6%	0.6%	2.7%	2.2%	1.2%

* Consistent data on Germany is disrupted in the early 90s as a result of reunification. Average haul jumps implausibly by nearly 50% between 1993 and 1994. The second figure for Germany therefore refers to a growth in average haul which is the average for years up to 1993 and after 1994.

1.7 The main drivers influencing freight transport requirements over time can be summarised as follows:

- Mix of products and services
- Configuration and design of commodities
- Manufacturing processes
- Warehousing and handling technology
- Information technology
- Logistics management
- Technology of transport systems
- Regulation

1.8 The analysis has sought quantifiable evidence for the effects of these main drivers, however, little or no evidence is available on many of the drivers. Often the evidence, where it does exist, refers only to one type of supply chain in one country. Therefore, evidence on the direction of the drivers on the components of freight intensity is deduced from the nature of the driver itself. Table 1.2 provides a summary of the conclusions concerning the importance of the various drivers.

1.9 The overall conclusion is that the major driver leading to a reduction in intensity has been the change in average value density. A critical driver leading to an increase in road freight intensity has been the change in road freight's relative cost. This together with increasing economies of scale (leading to greater concentration of production), improvements in warehouse technology (leading to logistical restructuring) and the realisation of the single market have all contributed to the increase in road's modal share, increased average length of haul and growth in intensity. The decrease in rail's share of the freight market has increased road freight intensity partly because of the relative decline in rail's traditional product market and its deterioration in competitiveness compared to road.

1.10 In examining the role the drivers play in influencing the growth of intensity over the next thirty years, it is assumed that GDP will continue to grow steadily in the countries of Europe and that the driving force behind this (as in the past) is the emergence of new technology and its gradual dispersion throughout the industries of the countries. However, the future growth of knowledge (new technology, new management practices) cannot be predicted, and therefore predictions of the future tend to fall back on an assumption that past trends will continue uninterrupted. The approach adopted has been to examine the past trends of the drivers and to consider whether these will continue or whether there are reasons to expect them to change.

1.11 Table 1.3 provides a summary of the conclusions concerning future importance of the various drivers of intensity. A shaded box shows where a trend is predicted to change in the future compared to the past. These trends do not distinguish between sectors, countries or, indeed, periods in the future. Such refinements are too demanding but some impressions are included below.

1.12 The mix of products in the economies of Europe will continue to change towards services and products with longer average hauls. This trend may be stronger in Acceding Countries leading to a greater contribution to increasing freight intensity. This effect can be expected to reduce over time as the manufacturing sector's share in an economy falls.

1.13 Trends increasing product value density stemming from development of products and manufacturing processes will continue in most product areas. The effect will be to reduce intensity. The trend is likely to be strongest in sectors where the opportunities for technological innovation (which may increase value and reduce weight) are greatest. Experience from the past suggests that there will be a common development of products throughout Europe, and therefore any benefits from its impact on freight intensity will be experienced in all countries.

1.14 The most significant change arises from the prediction that road transport unit costs will increase in the future (due partly to a slowdown in technology improvements, deteriorating road speeds and policy initiatives). This will be experienced to a varying degree by all countries and all supply chains. Eventually it should lead to a halt in the relentless rise in average haul seen in the last 50 years. Its exact timing is impossible to judge as decision makers only react slowly concerning location of facilities or sourcing. The impact of falling freight costs is probably not yet fully exhausted. The effect should start to emerge within 10 years.

1.15 At the same time the increasing competitive advantage of road compared rail experienced in the last 40 years will not continue, and with assistance from policy it may actually be reversed. Precise estimates are impossible but there seems every prospect that this change will stabilise the share of rail in the freight market.

1.16 Taking all these considerations into account it seems highly likely that the gradual increase in road freight intensity experienced in EU15 as a whole will eventually change to a situation of relative stability in the index with the possibility of decline in the longer term. The balance of the arguments presented here suggest that road freight intensity will be significantly lower (perhaps 20%) in 2030 than now. There are uncertainties behind this of which the assumption that average haul will not experience the rapid growth of the past is crucial. Countries will not follow precisely the same paths and the future path of individual countries is likely to be erratic (partly due to the vagaries of the data collection process) and it will take some years for the long term trends to emerge.

1.17 The prospect for a reduction in freight intensity in the Acceding States is even stronger given the likelihood that they will move towards a larger share of services in their economies.

1.18 However, when the long-term indication is pointing towards a downward trend, why should policy bother about the future development of road freight transport intensity? The objective of decoupling economic growth and transport growth for a sustainable development should perhaps be better expressed in terms of other underlying components of freight transport intensity. Few, if any, policies have any great impact on tonnes lifted. The main concern with growth in road freight stems mainly from its social costs and its impact on the environment.

1.19 Damage (environmental and ecological) of trucks is the real output of interest for policy – not tonne kilometre *per se*. The limit on the volume that trucks can carry, not the weight, is likely to be a more common constraint in the long term, and subsequently, freight transport intensity, as a measure of environmental impact, will fail to register this need for more vehicle kilometre deriving from increased volume.

1.20 The impact of policy on road freight intensity is imperfectly understood. In particular knowledge about the elasticity of response (to price changes) is very limited. Where the impact falls is also uncertain. The main thrust of policy in recent years has been a tendency to increase charges to reflect real marginal cost pricing. Modal split will certainly be affected by many measures including higher prices. Of the other components to be affected average haul seems most important. The handling factor representing the number of times a product sold to the consumer has been lifted may change but is not likely to be very sensitive to changes in cost.

1.21 At the same time there appears to be little evidence that value-density changes in response to transport costs. A major reason for this is that product designers responsible for determining that ratio take little or no account of it or of its implications on transport. One possibility to counter this is to incorporate transport considerations (or its derivative – environmental considerations) into the "Life-Cycle Thinking" approach in product development in the way suggested by the EU Integrated Product Policy approach. Influencing all the different processes and procedures used in new product development will probably have to be achieved by persuasion rather than legislative requirement and the role of the industry and governments ought to be in developing appropriate Life-Cycle information and interpretative tools to assist SMEs in particular.

1.22 By looking closely at freight transport intensity and its components, the study came across incidences where consistency in the base data between different member states and through time series could be questioned. One of the potential areas for future work is the reassessment of the information from national sources and the way they are collected. A comparative study of the components of freight transport intensity between different Member States and Acceding Countries could also assist in understanding variations between different countries. For example, is average haul in Germany really half those in Italy, and if so, to examine the policy implications of factors that has led to this condition.

1.23 Regarding the suitability of tonne kilometres and freight transport intensity as indicators for sustainable development, the study concludes that including more suitably placed measures may be better indicators. For example, the measure of vehicle kilometres is one example of an indicator that is not only easier to estimate but can also better reflect volumetric attributes of product density as well as deal with environmental load on the road network.

TABLE 1.2 SUMMARY OF DRIVERS AND THEIR IMPACTS

Changes in	Product value density €/tonne	Key logistic impacts	Handling factor	Modal share road	Average haul	Intensity	Vehicle payload	Lading efficiency	Vehicle utilisation
Mix of products/services	↑			↑	↑↑	↑↑			
Configuration/design of commodities Packaging Variety/ customization Sophistication	↑	Smaller order size			↑	↓		↓	
Manufacturing processes Modularisation Materials Economies of scale	↑ ↑	Vertical disintegration of production Spatial concentration of production; either through reduction in plant numbers, or increased plant specialisation ('focused production')			↑	↑		↓	↓
Warehouse/handling technology Reduced costs		Spatial concentration of inventory Development of break-bulk / transhipment systems Centralisation of sorting operation in hub-satellite network	↑		↓	↑			
Information technology Increased use of ICT Increased use of e-commerce		More efficient transport operations						↑	↑↑
Logistics management Application of JIT principles, quick response and ECR in retail distribution Proliferation of booking-in / timed-delivery systems		Less efficient transport operations						↓	↓
Technology of transport systems Improvement in road's relative cost/performance *Management of transport systems*		Wider geographical sourcing of supplies Wider distribution of finished products Increased use of outside transport / distribution contractors		↑↑	↑↑	↑↑			
Government Regulation Changes in vehicle size regulations Taxation Recycling requirements Realisation of Single Market		More efficient transport operations More movement per product	↑		↑	↑	↑		

TABLE 1.3 SUMMARY OF FUTURE DRIVERS AND THEIR IMPACTS

Shaded cells represent change in future

Changes in	Product value density €/tonne	Key logistic impacts	Handling factor	Modal share road	Average haul	Intensity	Vehicle payload	Lading efficiency	Vehicle utilisation
Mix of products/services	↑			↑	↑				
Configuration/design of commodities Packaging Variety/ customization Sophistication	↑	Smaller order size			↑	↓		↓	
Manufacturing processes Modularisation Materials Economies of scale	↑ ↑	Vertical disintegration of production Spatial concentration of production; either through reduction in plant numbers, or focused production.			↑			↓	↓
Warehouse/handling technology Reduced costs		Spatial concentration of inventory Break-bulk / transhipment systems Centralisation of hub-satellite network	↑		↓	↑			
Information technology Increased use of ICT Increased use of e-commerce		More efficient transport operations						↑	↑
Logistics management Application of JIT principles, quick response and ECR in retail distribution Proliferation of booking-in / timed-delivery systems		Less efficient transport operations						↓	↓
Technology of transport systems Improvement in road's relative cost/performance *Management of transport systems*		Wider geographical sourcing of supplies Wider distribution of finished products Increased use of outside transport / distribution contractors			↑	↑			
Government Regulation Changes in vehicle size regulations Taxation Recycling requirements Realisation of Single Market		More efficient transport operations More movement per product	↑	↓	↑	↓			

2. INTRODUCTION

Overview

2.1 Steer Davies Gleave has been commissioned by the Institute for Prospective Technological Studies (IPTS) to conduct a study of the freight transport intensity of production and consumption.

2.2 This entails to analyse past and expected future trends of freight transport intensity of production and consumption by studying the underlying driving forces throughout the value chains of the most relevant products, as well as to explore expectations and trend change potentials for the future.

Structure of this Report

2.3 Following this introduction, Section 3 sets the definition of freight intensity and assembles the basic data that makes up its components. A comparative analysis is made between different countries and time periods to understand variations in the components of freight intensity. A more detailed analysis is carried out on a selected number of countries to assess the general patterns in these countries. The relationship between intensity and environmental cost of transport is also discussed at the end of this Section.

2.4 Section 4 identifies the drivers of intensity and reviews their impact in more detail. This is used to develop a framework for the assessment of freight transport intensity in relation to production and industrial activity.

2.5 Section 5 examines the role these drivers play in influencing its growth over the next 30 years.

2.6 Finally, Section 6 goes on to explore policy initiatives that can reduce road freight intensity.

2.7 Section 7 is the conclusion of the study, bringing together the main elements of the work in previous Sections.

2.8 A Bibliography of material referenced in the Report is given in Section 8.

3. ROAD FREIGHT INTENSITY

Overview

3.1 This Section sets the definition of freight intensity and assembles the basic data about past trends and current situation that make up its components. A comparative analysis is made between different countries and time periods to understand variations in the components of freight intensity. A more detailed analysis is carried out on a selected number of countries to assess the general patterns in these countries. The relationship between intensity and environmental cost of transport is also discussed at the end of this Section.

Definition

3.2 Road freight intensity can be defined as the ratio of freight moved (as measured in tonne kilometres) by road divided by the level of GDP in an economy. Similarly, rail freight intensity is measured by the ratio of rail freight tonne kilometres to GDP and likewise for other modes such as short sea shipping, air transport and inland waterways.

3.3 In recent years the concept of freight intensity has received increasing attention. The steady growth in GDP experienced by countries in Western Europe over the last 5 decades has brought with it an increase in the amount of freight moved by road through a combination of larger tonnages and longer distance of movement.

3.4 This relationship is not a simple one – there are many forces interacting in an economy as it grows and consequently the growth in tonne km moved by road may increase more or less slowly than GDP over a period of time. The examination of freight intensity naturally leads to an examination of the forces behind its relative level – between countries and between time periods in individual countries.

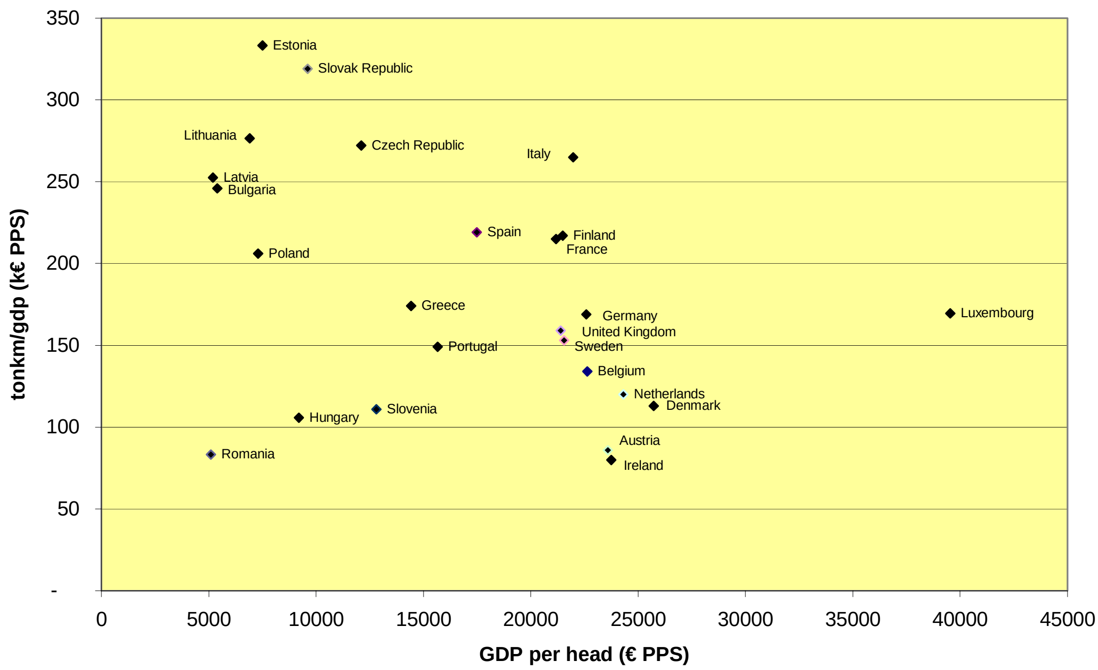
Basic Data

3.5 Basic data on road freight intensity can be constructed for a number of countries from data available on GDP, which is available on a consistent and regular basis, and on tonne km moved by road.

3.6 The data on freight is not always available for all European countries over an extended period on a consistent basis. Sometimes data has not been collected, different methods are used between countries and countries sometimes change the method that is used.

3.7 Figure 3.1 shows the estimates in most European countries plotted against an estimate of GDP per head. The figures for freight movement refer to both national and international traffic of a country measured in terms of tonne km of freight moved.

FIGURE 3.1 ROAD FREIGHT INTENSITY, 2000



3.8 The share of international traffic is 21% for the EU as a whole (Table 3.1) with variation between countries (Table 3.1 shows figures for 5 major countries). Cross trade and cabotage movements are not included in the measure of intensity. Their contribution to total freight movement in a country only occasionally exceeds 1%.

TABLE 3.1 SHARE OF TRAFFIC TYPE ROAD FREIGHT MOVEMENT (TKM) IN THE EU - 1999

	D	E	F	I	UK	EU15
National	0.81	0.73	0.78	0.88	0.90	0.76
International	0.16	0.26	0.21	0.12	0.09	0.21
Cross Trade	0.016	0.006	0.015	0.002	0.002	0.024
Cabotage	0.005	0.002	0.004	0.000	0.000	0.005

Source: Statistics in Focus 2/2002, Eurostat

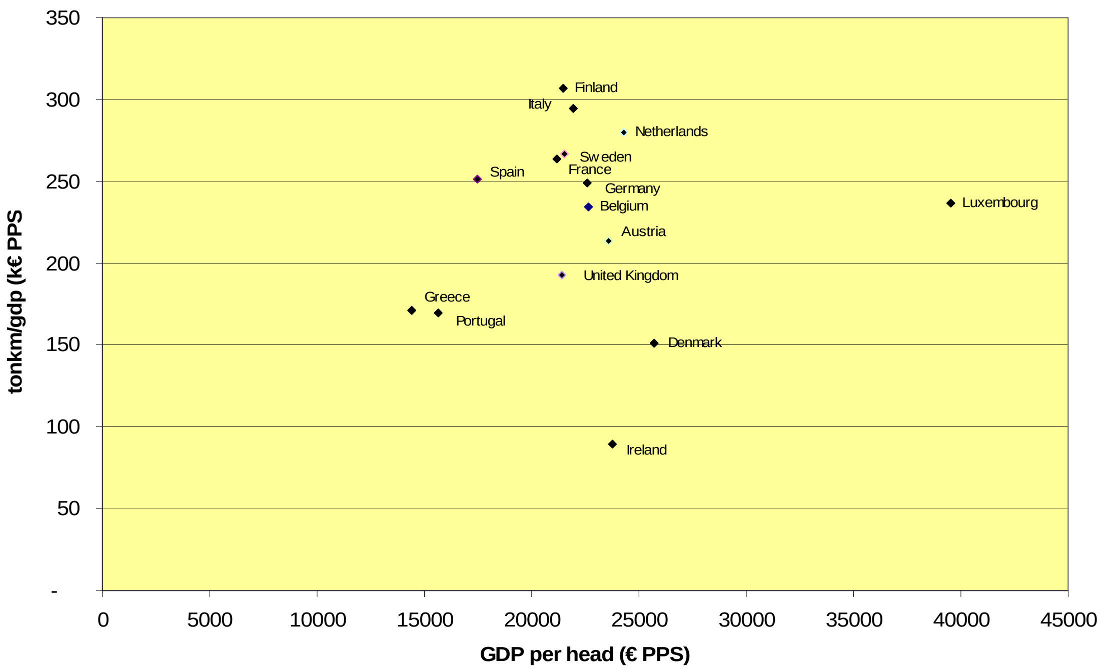
3.9 Estimates for GDP in the countries are measured in euro for the year 2000 but with an adjustment for purchasing power standards (PPS). GDP calculated by this method takes account of price variations within individual countries (as reflected in exchange rates) and adjusts the individual country estimates of GDP to a common price basis. The main effect of this adjustment is to increase significantly the GDP estimate of Acceding Countries (and consequently to reduce their freight intensity). Considerable variation is found amongst countries; some of this may be due to the different methods used to collect data.

3.10 The figures for road freight intensity show a wide dispersion between countries, with the three highest recorded for countries in Eastern Europe – Bulgaria, Estonia and the Czech Republic. Within the European Union there is also a wide dispersion. Italy records a figure over 250 tkm/GDP whereas Austria and Ireland are below 100 tkm/GDP.

3.11 The reasons for such a wide dispersion are unclear. Some of the variation is undoubtedly due to different methods of data collection and the errors inherent in this process. It is not possible to be precise about the scale of these effects but it could be as high as 50%. The error is likely to be particularly large where data on the total vehicle fleet is poor and hence the grossing factor for sample surveys is poorly estimated.

3.12 The figures refer specifically to road freight and hence differences in mode use lead to differences between countries. The Netherlands (42.7% share in 2000), Germany (13.1%) and Belgium (13.1%) make use of the inland waterways which should lead to a lower road freight intensity. Sweden (38.2% share in 2000), Austria (37.2%) and Finland (26.6%) have the largest share for rail. Extensive use of pipelines (Denmark 18.1% share in 2000 and Austria 17.3%) should also lead to a reduction in road freight intensity. A recalculation of intensity based on movement (tkm) by 4 modes still shows a wide dispersion with Ireland and Denmark having a low intensity compared with Italy and Finland with the highest figures.

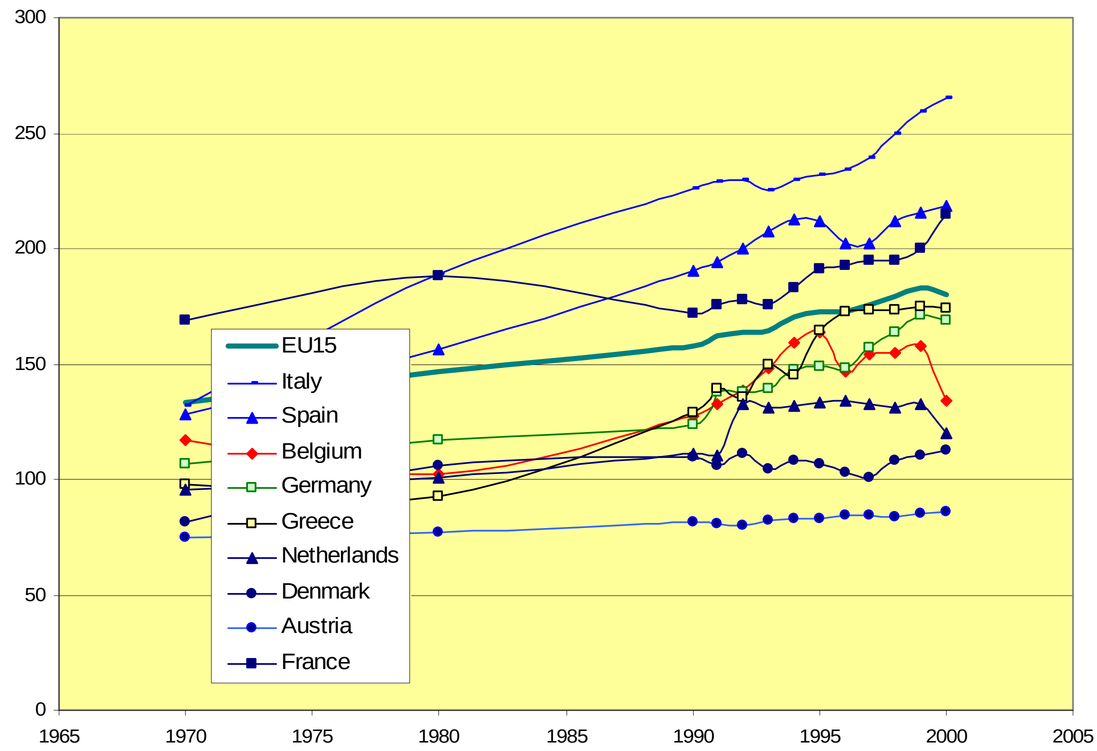
FIGURE 3.2 FREIGHT (ROAD + RAIL +INLAND WATERWAYS + PIPELINE) IINTENSITY 2000



Trends

3.13 Turning to trends in road freight intensity, Figure 3.3 shows the countries within the European Union that have generally experienced an increase in intensity over the period 1970 to 2000. The increase for the EU as a whole is equivalent to an average annual growth rate of 1% per year. The highest annual growth rate for 1970-2000 is Italy with 2.4%. Two countries (Germany and Greece) record a figure of over 3% per annum for the period 1990-2000. France records a figure of just over 2% for the same period.

FIGURE 3.3 INCREASE IN ROAD FREIGHT INTENSITY 1970-2000



3.14 There are 5 countries in the European Union that have experienced a reduction in intensity over the period 1970-2000 (Figure 3.4). In 1970 all these countries were higher than the EU average. By 2000 only Finland was above the average. Four of the countries also experienced a reduction in intensity during the 1990s and Sweden showed no change. In all cases the path during this period was erratic.

FIGURE 3.4 DECREASE IN ROAD FREIGHT INTENSITY 1970 – 2000

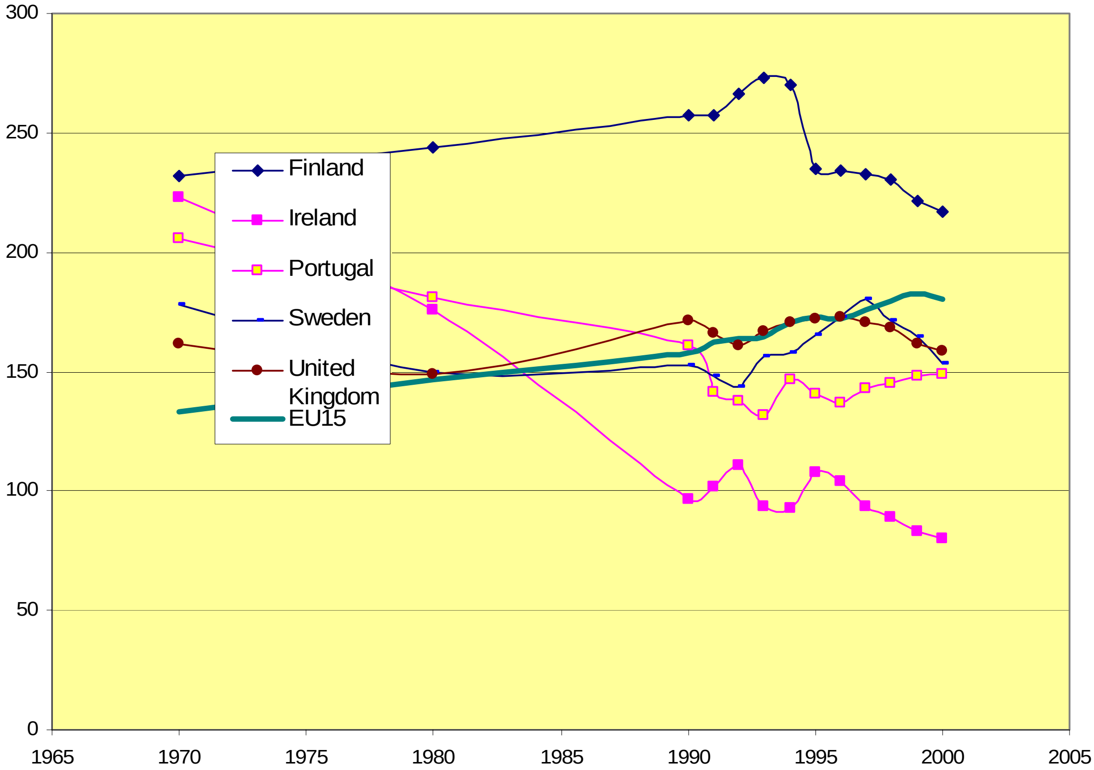


TABLE 3.2 ANNUAL GROWTH RATES OF ROAD FREIGHT INTENSITY IN THE EU

	1970-1990	1970-2000	1990-2000
Belgium	0.40%	0.50%	0.50%
Denmark	1.50%	1.10%	0.30%
Germany	0.80%	1.60%	3.10%
Greece	1.40%	1.90%	3.00%
Spain	2.00%	1.80%	1.40%
France	0.10%	0.80%	2.20%
Ireland	-4.10%	-3.40%	-1.90%
Italy	2.70%	2.40%	1.60%
Netherlands	0.80%	0.80%	0.80%
Austria	0.40%	0.50%	0.50%
Portugal	-1.20%	-1.10%	-0.80%
Finland	0.50%	-0.20%	-1.70%
Sweden	-0.80%	-0.50%	0.00%
United Kingdom	0.30%	-0.10%	-0.80%
EU 15	**0.8%**	**1.0%**	**1.3%**

3.15 In the case of non-EU countries (Figure 3.5 and Table 3.3) two (Bulgaria and the Czech Republic) demonstrated a dramatic reduction in road freight intensity during the 80s and 90s. By 1999 they still recorded figures more than 50% greater than the EU average. Romania experienced a rapid decline in intensity during the 90s and in 1999 recorded a figure about 1/3rd below the EU average for that year (115 compared to 183).

3.16 The only other country to record a figure lower than the EU was Hungary. However both Hungary and Poland showed an overall increase in intensity over the 29 year period. The reason may be to do with changes in modal split and the transfer from another mode (in this case rail) to road.

3.17 Of the two Baltic States for which data is available, Latvia experienced stability over the whole period (with some large fluctuations within the 90s) finishing with a figure 20% above the EU average (218 compared to 183). Estonia's experience was rather different; intensity increased from 1970 to 1990 but then declined during the 90s at 1.5% per year. By 1999 intensity was still 80% above the figure for the EU (333 compared to 183).

FIGURE 3.5 ROAD FREIGHT INTENSITY 1970-2000 NON-EU COUNTRIES

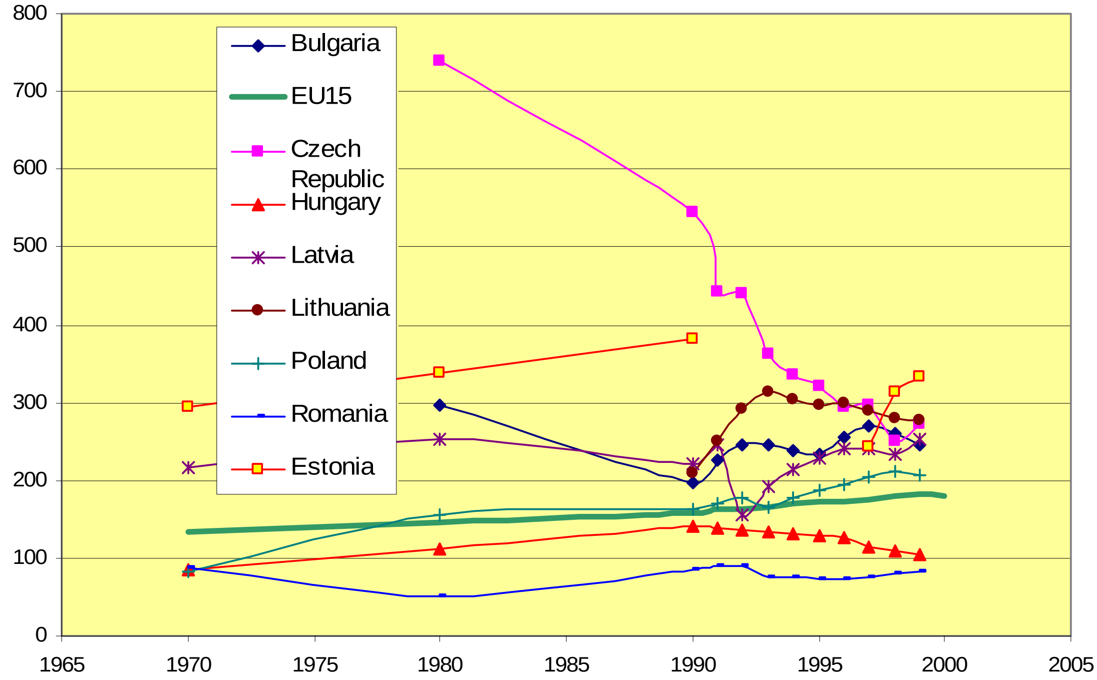


TABLE 3.3 ANNUAL GROWTH RATES OF ROAD FREIGHT INTENSITY – NON EU COUNTRIES

	1970-1990	1970-1999	1990-1999
Bulgaria	n.a.	n.a.	2.5%
Czech Republic	n.a.	n.a.	-7.4%
Estonia	1.3%	0.4%	-1.5%
Hungary	2.5%	0.7%	-3.1%
Latvia	0.1%	0.5%	1.5%
Lithuania	n.a.	n.a.	3.1%
Poland	3.4%	3.2%	2.7%
Romania	-0.2%	-0.2%	-0.2%

Source: Trends in the Transport Sector, ECMT, 2002.

Understanding the Components of Freight Intensity

3.18 Freight intensity is defined as the ratio of freight moved (tonne km) in an economy to the output (measured by GDP) of that economy. Using this definition it is possible to break down the determinants of freight intensity into 4 components using the following identity

EQUATION 1

$$\frac{roadtonnekm}{GDP€} \equiv \frac{roadtonnekm}{totaltonnekm} \times \frac{totaltonnekm}{totaltonnelifted} \times \frac{totaltonnelifted}{totaltonnegenerated} \times \frac{totaltonnegenerated}{GDP€}$$

intensity ≡ modal share x average haul x supplychain structure x product value density

3.19 The identity shows that freight intensity is the product of four factors:

- the modal share of road transport;
- the average haul;
- the number of times a product is handled to final consumption in the supply chain; and
- the average value density (defined as t/€) of final products.

3.20 All changes in freight intensity must logically derive from changes in one or more of these components. The analysis of past trends can use this framework and forecasts can similarly identify the role of individual components contributing to an increase or decrease in intensity. Equation 1 can be transformed to give[1]

$$\%\Delta roadtonnekm \approx \%\Delta GDP + \%\Delta modal\ share + \%\Delta averagehaul + \%\Delta structure$$

[1] Strictly this is an approximation, but for small changes (less than 10%) the error is negligible.

3.21 In order to examine the contribution of various factors to road freight intensity data was assembled from the CRONOS database for 5 countries – Germany, Spain, France, Italy and the United Kingdom. This data comprises tonne km (freight moved) and tonnes lifted by commodity (using the 24 category NST/R classification) and production data. The period for which a consistent set of data exists for this data set is 1982 to 2001 (though even within this there are a few gaps). This detailed data on tonne-km and tonnes lifted refer to national movements.

Impact of Modal Share

3.22 The first step is to analyse the impact of modal share on road freight intensity. During the three decades from 1970 to 2000 there has been a consistent increase in the share of road transport. Share here refers to the combined total freight moved by road and rail transport.

3.23 It should be recognised that pipeline, inland waterways and short sea shipping also move freight. Whilst these can often be significant (particularly short sea shipping) they are not included in this analysis. Their exclusion should not alter substantially the conclusions.

3.24 If the railways had maintained their 1980 share of freight traffic over the next 20 years then the change in road freight intensity would have been much lower. The impact of the decreasing rail share can be estimated by comparing the growth in road freight moved compared with what would have occurred if the share had remained constant.

3.25 As can be seen from Table 3.4 the impact in Germany is a contribution of 1.8% per year. With other countries the share of rail did not fall so fast and the contribution of rail was less than 1% per annum.

TABLE 3.4 SHARE OF ROAD IN ROAD+RAIL FREIGHT MOVED: NATIONAL AND INTERNATIONAL TRAFFIC

	D	E	F	I	UK
1970	0.51	0.74	0.61	0.76	0.77
1980	0.58	0.81	0.71	0.87	0.84
1990	0.69	0.87	0.79	0.90	0.89
2000	0.82	0.91	0.83	0.91	0.90

Source: EU Energy and Transport in Figures, European Commission, 2002

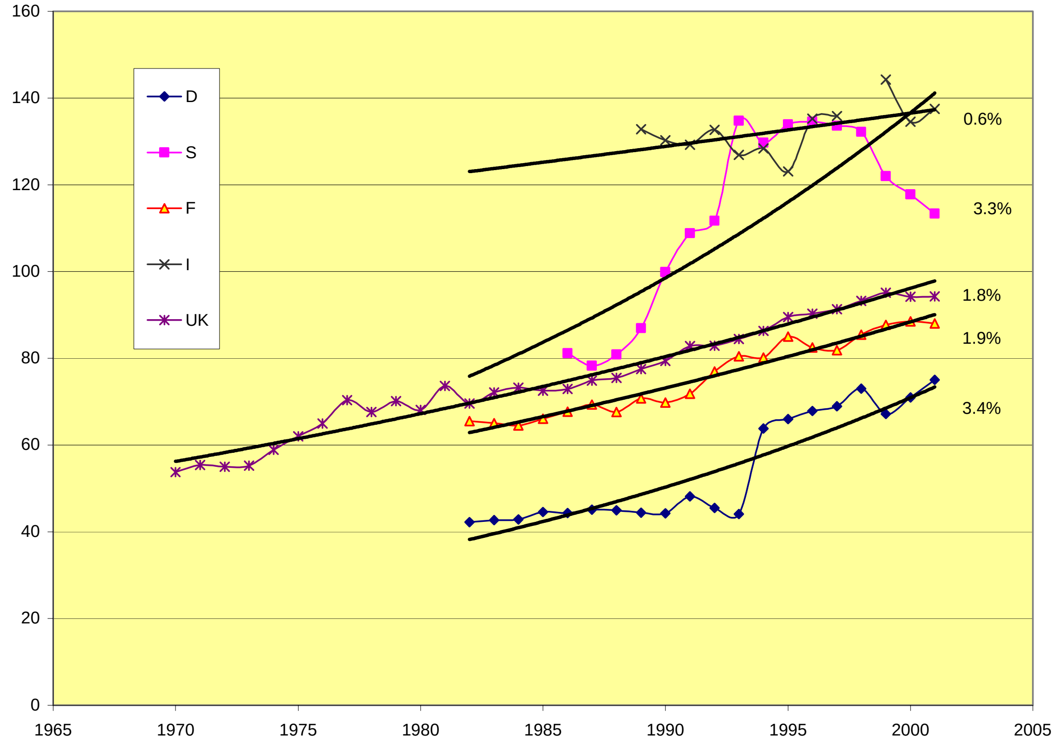
Impact of Average Haul

3.26 When the second factor – average haul – is examined it appears all the countries have experienced a significant increase.

3.27 The trend over the period has ranged from 0.6% in the case of Italy to 3.4% in the case of Germany (Figure 3.6). The latter experienced a sudden surge in 1994 that was almost certainly due to a change in data collection methods. The average growth for the period after 1994 is just 1% a year.

3.28 The series for Spain also shows a rather erratic path which may be attributed to data collection methods. Despite this it is clear that there has been a growth in average haul for all the 5 countries and that it has made a significant contribution to the increase in freight moved.

FIGURE 3.6 AVERAGE HAUL (KM) 5 COUNTRIES 1982 - 2001



3.29 Using the data for the 5 countries it is possible to build up a table of the relative size of the different contributions to the change in freight moved and intensity. The figures refer to the period 1982 to 2001 for Germany, France and the United Kingdom. The period is slightly shorter for Italy and Spain.

3.30 For the period tonne km increased at an average annual growth between 2.5 and 4.7% per annum and except for Spain was greater than the average growth in GDP. Part of the increase in road freight moved can be explained by the change in modal share – Germany provides the most striking example. The increase in average haul over the period also contributed strongly to the growth in freight moved (and by implication intensity). Only in Italy does the contribution fall to the modest figure of 0.3% per annum. The growth in GDP during the period is also shown in Table 3.5.

Supply Chain Structure

3.31 Using the identity of Equation 1 it is then possible to deduce the contribution of Supply Chain Structure and Product Density by subtracting the contribution of the three factors from the average annual growth in road freight moved. In all 4 countries the contribution of the remaining factors was negative.

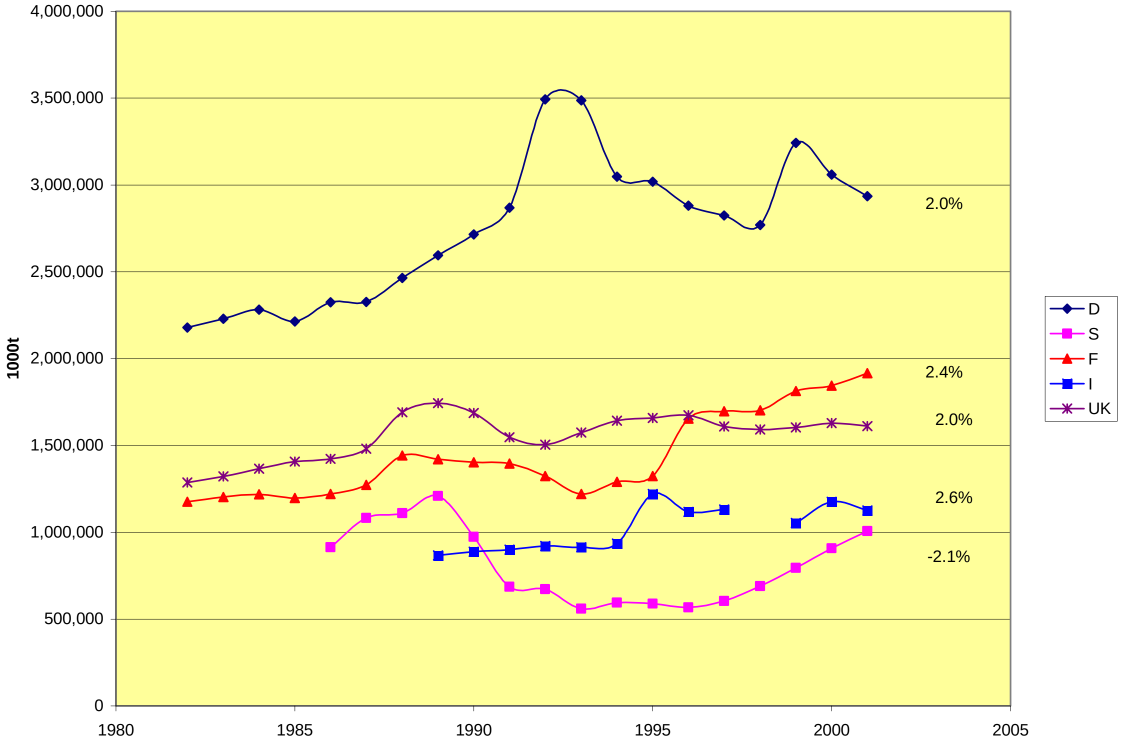
TABLE 3.5 CONTRIBUTION OF ROAD FREIGHT MOVED: AVERAGE GROWTH 1982 - 2001

	D *	E	F	I	UK
Road freight moved	4.7%	2.9%	4.4%	2.5%	3.8%
of which					
Modal Share	1.8%	0.6%	0.8%	0.3%	0.4%
Average haul	3.1%/1%	2.2%	1.7%	0.3%	2.6%
GDP	1.9%	3.0%	2.3%	2.0%	2.6%
remainder					
Supply Chain Structure Product Density	-2.1%/0%	-3.1%	-0.4%	-0.1%	-1.8%
Tonnes Lifted	1.5%/2.6%	0.6%	2.7%	2.2%	1.2%

* Consistent data on Germany is disrupted in the early 90s as a result of reunification. Average haul jumps implausibly by nearly 50% between 1993 and 1994. The second figure for Germany therefore refers to a growth in average haul which is the average for years up to 1993 and after 1994.

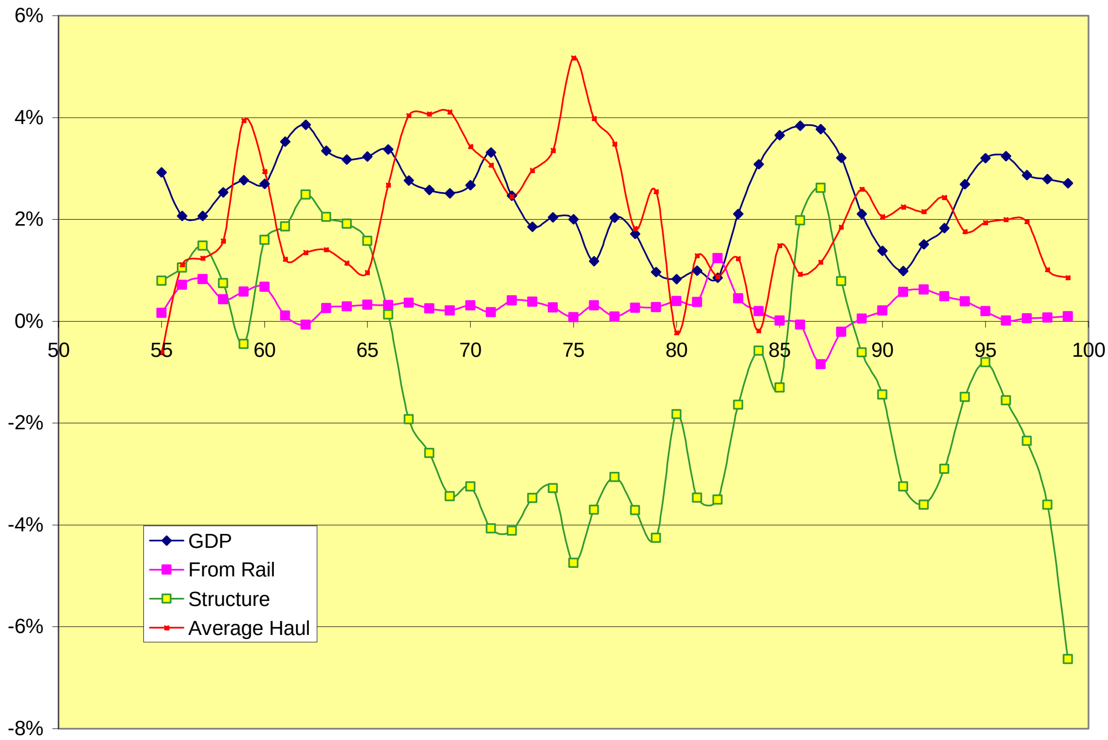
3.32 The other factor that is of interest is tonnes lifted. Related to tonne km by the identity *tonnes lifted x average haul =tonne km* it shows a rate of growth between 0.6% and 2.7%. In two countries the growth rate is slightly higher than GDP whereas in three its growth is rather lower than that of GDP. Table 3.5 shows the average rate of growth per annum from beginning to the end of the period, whereas Figure 3.7 shows the trend over the period.

FIGURE 3.7 TONNES LIFTED 5 COUNTRIES



3.33 In the case of the UK it is possible to construct a long series identifying the different contributions to the growth in road freight moved. This has been done on an annual basis (using a 5 year smoothed average) – Figure 3.8

FIGURE 3.8 CONTRIBUTION TO ROAD FREIGHT MOVED: UK 1955-1999



3.34 Over the period as a whole the increase in average haul has generally added about 2% a year to the growth in freight traffic, remaining generally positive throughout the period. The transfer from rail to road (for various reasons) has added to growth in road freight moved thought the figure is less than 0.5% on average. GDP has averaged just over 2% a year. If these factors are subtracted from the growth in road freight ton-km, one is left with the set of factors referred to as ‘Structure’. Whilst this factor has reduced intensity by almost 2% a year on average it has fluctuated between a positive and negative contribution over the period.

3.35 This detailed analysis of nearly 50 years confirms the important contribution of average haul to increasing intensity and the general impact of ‘Structure’ on reducing it.

Conclusion

3.36 The general conclusion from this analysis of the 5 countries is twofold. Firstly the growth in average haul (~2% per annum for the sample countries) has tended to make an important positive contribution to the increase in road freight intensity. The second conclusion is that factors grouped under the headings of Supply Chain Structure and Product Density have tended to decrease road freight intensity (~-2% per annum for the sample countries). Modal shift to road has by-and-large made a positive contribution to increase in road freight intensity.

Product and industry specific data

3.37 The database for the 5 countries allows a deeper analysis of how different products and industries may contribute to freight intensity. The CRONOS database provides statistics for tonnes lifted and tonnes moved (tonnekm) for 24 different commodity types under the NST/R classification.

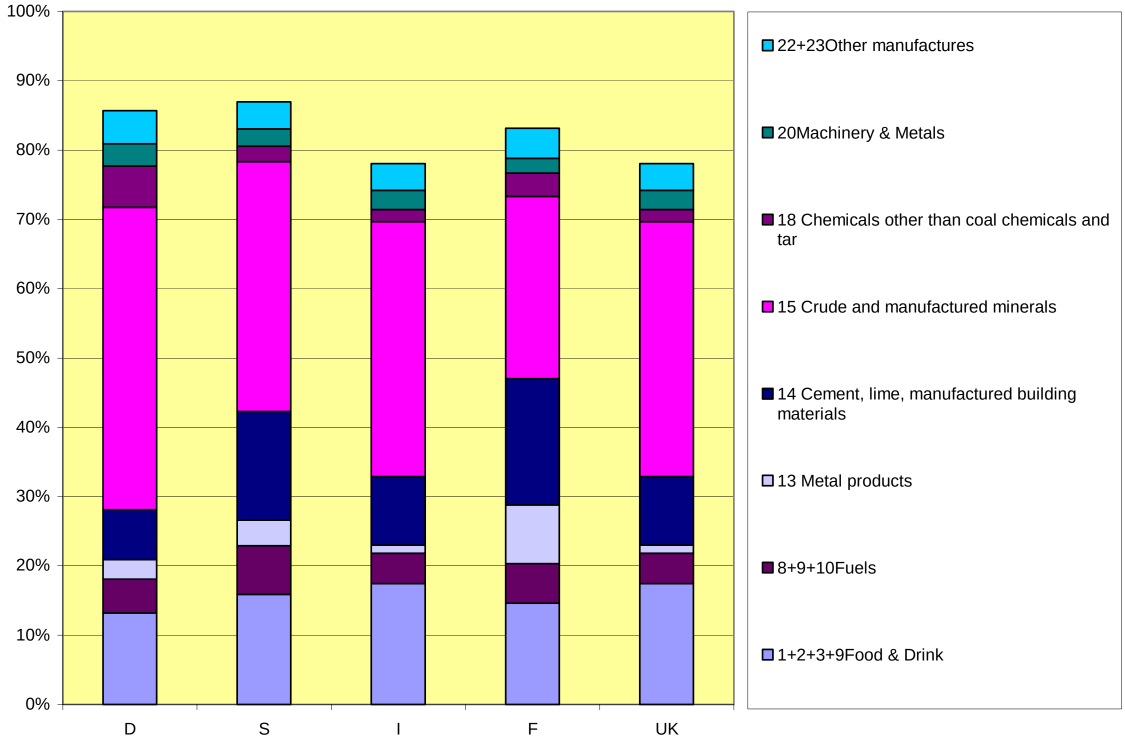
3.38 Figure 3.9 shows the share of different commodities in tonnes lifted in 2001for the 5 countries. The largest category in all countries is *15 Crude and manufactured minerals* with an (unweighted) average of 36%.

3.39 The second largest as shown in the diagram is a combination of 4 categories *1+2+3+9Food & Drink*. This comprises agricultural products as well as processed food moving between processing and the final consumer, and varies between 13% and 17% in the 5 countries.

3.40 The third major category is *14 Cement, lime, manufactured building materials* with a mean of 16% (ranging from 7%-18%).

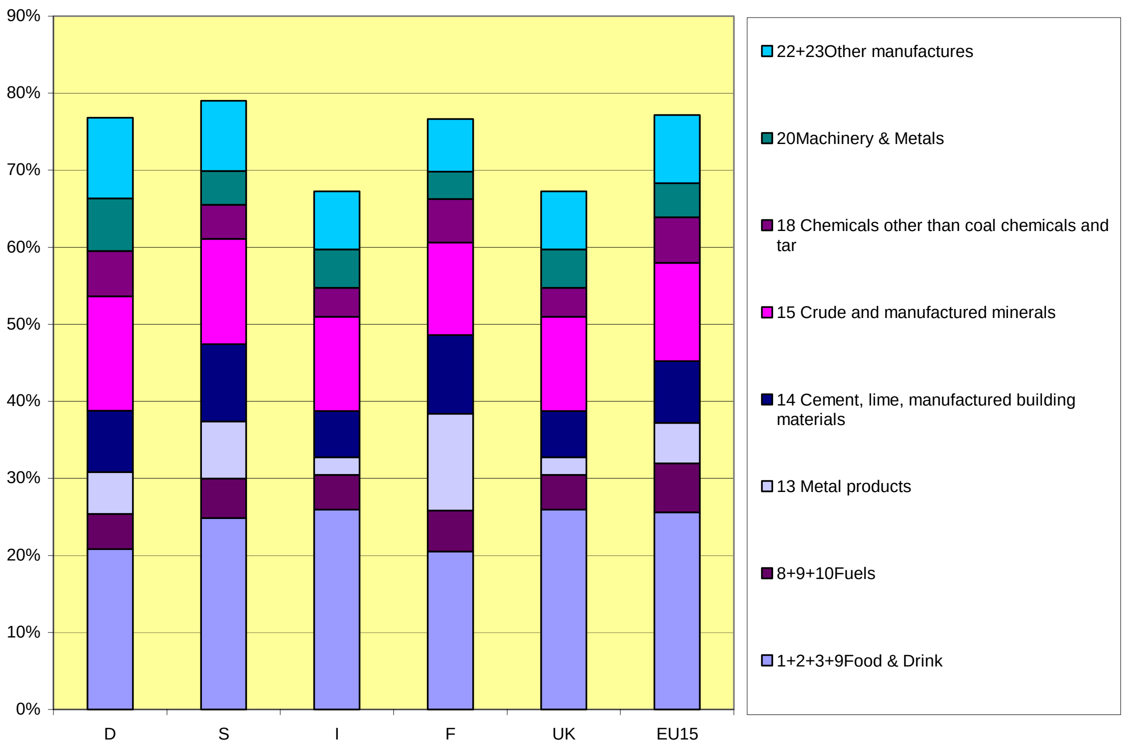
3.41 Due to the classification used it is not possible to give a precise estimate of the proportion of tonnes lifted that is after manufacturing processes. A rough estimate incorporating categories 8, 9, 16, 21-27 (see Table 3.6) is between 30% and 40%.

FIGURE 3.9 SHARE OF TONNES LIFTED - 2001



3.42 The following graph (Figure 3.10) shows the share of commodities in tonne km terms. Post manufacturing rises to approximately 60% of the share of total freight moved. This increase in share from that of tonnes lifted reflects the much greater average haul found in post manufacturing than in the haulage of raw materials and intermediate products.

FIGURE 3.10 SHARE OF TONNES MOVED – 2001



3.43 Table 3.6 shows how the different commodities contributed to the overall growth in tonnes lifted. The (unweighted) average growth for the 5 countries for the period 1982-2001 was 1.7% per annum. The first point to make is that there is very little commonality between the countries (only between the UK and Germany is there a significant positive correlation), and therefore a summary needs to be treated with caution. There seems to have been no tendency for raw or unprocessed materials to grow more slowly than manufactured products.

3.44 Tonnes moved is the product of tonnes lifted and average haul. The figures for average haul by commodity in 2001 show a range from 41 to over 200km for the different commodities using the average figure for the 5 countries (Table 3.7). The figures do show similarity between countries (i.e. high correlation). The traditional interpretation of the dispersion is that commodities with a low product density (€/t) will tend to move shorter distances, and this does appear to be the case.

TABLE 3.6 PRODUCT GROWTH RATES 1982-2001

	D	S	F	I	UK	average per annum
08 Solid minerals fuels	-7%	3%	-5%	-6%	-6%	*-4.2%*
17 Coal chemicals, tar	-10%	-22%	10%	21%	-4%	*-1.0%*
18 Chemicals other than coal chemicals and tar	0%	-2%	3%	0%	1%	*0.6%*
10 Petroleum products	0%	2%	1%	0%	1%	*0.8%*
16 Natural and chemical fertilizers	6%	-2%	2%	0%	-2%	*1.0%*
06 Foodstuff and animal fodder	3%	-2%	2%	1%	1%	*1.1%*
12 Non-ferrous ores and waste	8%	-11%	5%	1%	3%	*1.2%*
20 Transport equipment, machinery, apparatus, engines, whether or not assembled, and parts thereof	5%	1%	4%	-6%	3%	*1.4%*
13 Metal products	3%	2%	1%	3%	0%	*1.7%*
25 Total from group 01 to 24	**2%**	**1%**	**3%**	**2%**	**1%**	***1.7%***
11 Iron ore, iron and steel waste and blast furnace dust	5%	2%	5%	2%	-5%	*1.8%*
03 Live animals, sugar beet	0%	1%	-4%	13%	0%	*1.8%*
21 Manufactures of metal	2%	0%	2%	4%	0%	*1.8%*
07 Oil seeds and oleaginous fruits and fats	5%	-1%	3%	2%	2%	*2.0%*
02 Potatoes, other fresh or frozen fruits and vegetables	4%	-2%	7%	1%	1%	*2.1%*
23 Leather, textile, clothing, other manufactured articles	4%	0%	4%	-1%	3%	*2.1%*
15 Crude and manufactured minerals	1%	3%	2%	5%	1%	*2.1%*
14 Cement, lime, manufactured building materials	3%	3%	4%	1%	2%	*2.4%*
04 Wood and cork	3%	-5%	3%	11%	2%	*2.9%*
01 Cereals	4%	-3%	2%	14%	-1%	*3.3%*
09 Crude petroleum	4%	0%	23%	-7%	-7%	*3.3%*
24 Miscellaneous articles	3%	3%	8%	0%	2%	*3.4%*
22 Glass, glassware, ceramic products	5%	-2%	6%	10%	0%	*3.8%*
05 Textiles, textile articles and man-made fibres, other raw animal and vegetable materials	5%	-5%	4%	20%	1%	*5.1%*
19 Paper pulp and waste paper	11%	4%	6%	6%	3%	*5.9%*

TABLE 3.7 AVERAGE HAUL 5 COUNTRIES 2001

km	D	S	F	I	UK	average per annum
15 Crude and manufactured minerals	25	43	29	63	44	*41*
14 Cement, lime, manufactured building materials	83	72	54	77	73	*72*
12 Non-ferrous ores and waste	107	56	46	154	75	*88*
10 Petroleum products	68	90	90	127	98	*95*
03 Live animals, sugar beet	91	130	72	107	89	*98*
11 Iron ore, iron and steel waste and blast furnace dust	71	123	75	118	108	*99*
08 Solid minerals fuels	88	58	88	171	109	*103*
25 Total from group 01 to 24	**75**	**113**	**88**	**137**	**116**	***106***
01 Cereals	94	135	73	152	93	*109*
17 Coal chemicals, tar	80	174	110	131	103	*120*
09 Crude petroleum	92	124	55	213	135	*124*
16 Natural and chemical fertilizers	67	178	68	203	126	*128*
04 Wood and cork	108	137	104	168	170	*137*
19 Paper pulp and waste paper	84	167	132	210	122	*143*
05 Textiles, textile articles and man-made fibres, other raw animal and vegetable materials	117	200	99	183	138	*147*
21 Manufactures of metal	135	191	145	195	125	*158*
06 Foodstuff and animal fodder	119	185	142	198	174	*164*
24 Miscellaneous articles	141	210	157	218	105	*166*
07 Oil seeds and oleaginous fruits and fats	151	177	148	240	159	*175*
18 Chemicals other than coal chemicals and tar	75	225	187	232	170	*178*
13 Metal products	144	226	167	203	151	*178*
20 Transport equipment, machinery, apparatus, engines, whether or not assembled, and parts thereof	158	200	158	228	155	*180*
22 Glass, glassware, ceramic products	143	274	120	197	174	*182*
02 Potatoes, other fresh or frozen fruits and vegetables	143	215	170	259	198	*197*
23 Leather, textile, clothing, other manufactured articles	169	261	184	225	206	*209*

3.45 Another question to be asked concerning average haul is whether the growth in average haul differs by commodity. There is a difference (Table 3.8), however, it is difficult to discern any obvious pattern. There is little similarity between countries (only Germany and the UK show a small positive correlation) and there seems no criterion to distinguish those commodities with slow growth compared to high growth.

TABLE 3.8 GROWTH IN AVERAGE HAUL 5 COUNTRIES 1982-2001

	D	S	F	I	UK	average per annum
19 Paper pulp and waste paper	-1%	-1%	-1%	-2%	0%	*-1.1%*
22 Glass, glassware, ceramic products	0%	4%	-2%	-5%	3%	*0.0%*
12 Non-ferrous ores and waste	-1%	-4%	2%	2%	1%	*0.0%*
16 Natural and chemical fertilizers	-1%	3%	0%	1%	0%	*0.7%*
07 Oil seeds and oleaginous fruits and fats	1%	-1%	0%	1%	2%	*0.8%*
14 Cement, lime, manufactured building materials	2%	1%	-1%	1%	2%	*0.9%*
01 Cereals	4%	2%	1%	-4%	2%	*0.9%*
18 Chemicals other than coal chemicals and tar	4%	2%	-1%	-1%	1%	*0.9%*
23 Leather, textile, clothing, other manufactured articles	2%	4%	0%	1%	2%	*1.7%*
05 Textiles, textile articles and man-made fibres, other raw animal and vegetable materials	2%	7%	0%	-2%	1%	*1.7%*
15 Crude and manufactured minerals	3%	2%	2%	2%	1%	*1.7%*
03 Live animals, sugar beet	3%	0%	3%	4%	-2%	*1.7%*
08 Solid minerals fuels	7%	-4%	5%	-4%	5%	*1.7%*
11 Iron ore, iron and steel waste and blast furnace dust	4%	1%	3%	-3%	4%	*1.8%*
17 Coal chemicals, tar	2%	8%	0%	3%	-3%	*1.8%*
10 Petroleum products	2%	0%	2%	2%	3%	*1.8%*
21 Manufactures of metal	2%	1%	0%	4%	1%	*1.9%*
25 Total from group 01 to 24	**3%**	**2%**	**2%**	**0%**	**3%**	***2.0%***
13 Metal products	3%	4%	0%	4%	1%	*2.1%*
09 Crude petroleum	5%	0%	-5%	2%	8%	*2.2%*
06 Foodstuff and animal fodder	2%	4%	1%	0%	4%	*2.3%*
24 Miscellaneous articles	2%	4%	1%	1%	3%	*2.4%*
04 Wood and cork	3%	5%	1%	0%	3%	*2.4%*
02 Potatoes, other fresh or frozen fruits and vegetables	3%	4%	1%	2%	3%	*2.7%*
20 Transport equipment, machinery, apparatus, engines, whether or not assembled, and parts thereof	3%	6%	0%	3%	2%	*2.7%*

3.46 Over the period from 1982 to 2001 the mix of commodities may have changed in such a way as to increase the average haul. This effect can be identified by assuming a constant average haul over the period in each commodity group and calculating the effect of the changing mix. From these calculations it appears that the change in mix has changed the average haul in France and Germany by nearly 1% per annum, whereas in the UK the figure is less than 0.5%.

3.47 As a countervailing influence to this effect it may be the case that there is also a change in mix towards lower density commodities. If, as the evidence suggests, a negative correlation between average haul and density then the two effects would tend to work in opposite directions. The move towards commodities with a longer average haul also implies a move towards those commodities with a lower value density (t/€).

3.48 Turning to the possible impact of Supply Chain Structure and Product Density then, if either or both of these effects is strength then one would expect to see a divergence between the gross output of a commodity and the tonnes lifted of that commodity. Unfortunately the matching of commodity statistics based on the NST/R classification and production statistics based on the NACE classification only yield one close match.

3.49 An attempt to examine the match the annual average growth of the two series is shown in Table 3.9. Most of the matches are only approximate and therefore it seems unwise to draw firm conclusions from the evidence. However for some commodities – particularly the textile grouping - there does seem to a rather faster rate of growth in tonne km compared to gross output. The best match in these series is perhaps between *f Construction* and *14 Cement, lime, manufactured building materials*, but this is really only convincing in the case of Germany.

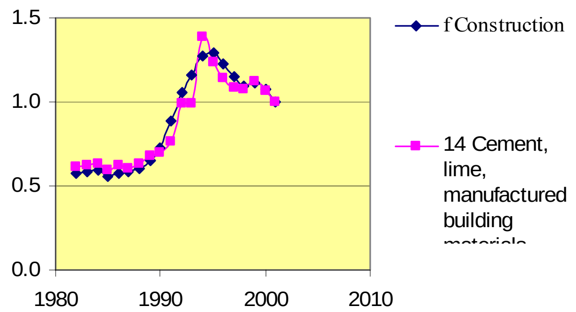
TABLE 3.9 TRENDS IN TONNES LIFTED AND GROSS OUTPUT. ANNUAL GROWTH FOR 3 COUNTRIES 1982-2001

Tonnes Lifted				Production			
NST/R classification	D	F	UK	NACE classification	D	F	UK
04 Wood and cork	3%	11%	2%	dd Manufacture of wood and wood products	2%	2%	-3%
10 Petroleum products	0%	0%	1%	df Manufacture of coke, refined petroleum products and nuclear fuel	-3%	-3%	3%
15 Crude and manufactured minerals	1%	5%	1%	cb Mining and quarrying except energy producing materials	0%	2%	7%
18 Chemicals other than coal chemicals and tar	0%	0%	1%	dg Manufacture of chemicals, chemical products and man-made fibres	1%	2%	3%
13 Metal products	3%	3%	0%	dj Manufacture of basic metals and fabricated metal products	1%	1%	2%
21 Manufactures of metal	2%	4%	0%				

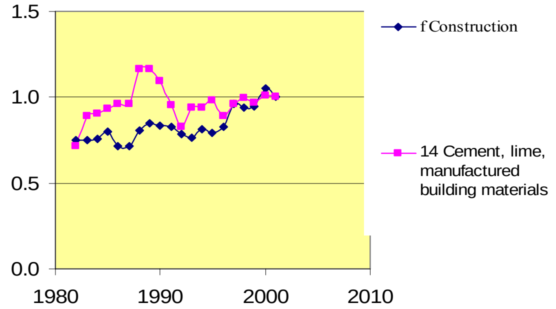
20 Transport equipment, machinery, apparatus, engines, whether or not assembled, and parts thereof	5%	-6%	3%	dm Manufacture of transport equipment	4%	3%	2%
19 Paper pulp and waste paper	11%	6%	3%	de Manufacture of pulp, paper and paper products; publishing and printing	2%	3%	4%
06 Foodstuff and animal fodder	3%	1%	1%	da Manufacture of food products; beverages and tobacco	0%	1%	1%
23 Leather, textile, clothing, other manufactured articles	4%	-1%	3%	db Manufacture of textiles and textile products	-2%	2%	-2%
05 Textiles, textile articles and man-made fibres, other raw animal and vegetable materials	5%	20%	1%	dc Manufacture of leather and leather products	-3%	1%	-5%
14 Cement, lime, manufactured building materials	3%	1%	2%	f Construction	2%	1%	3%

3.50 Figure 3.11 top diagram shows how the two series track an economic boom in the 1990s for Germany, whereas in the cases of Italy and the UK there seems to be little if any relationship for short term fluctuations. This means the attempt to identify divergent trends in the two series cannot be given much, if any, credence.

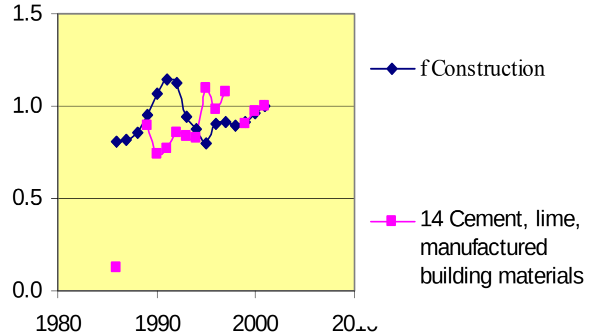
FIGURE 3.11 TRENDS IN CONSTRUCTION OUTPUT AND TONNES LIFTED (ALL SERIES INDEXED TO 2001)



Germany



France



UK

3.51 The previous analysis has examined the trends within production industries. There is, however, another important reason why a divergence between tonnes lifted and GDP might be expected. This is the general trend towards services that modern economies exhibit.

3.52 Table 3.10 shows the experience of growth in industrial production of the 5 countries. If these figures are compared with the growth of GDP over the same period then the figures are 0.5-1.0% lower. If the simple assumption is made that tonnes lifted grows in line with industrial production implying services make no contribution to tonnes lifted then the divergence between tonnes lifted and GDP over the period would be equal to this difference of not more than 1%.

TABLE 3.10 GROWTH IN INDUSTRIAL PRODUCTION 1982 - 2001

D	E	F	I	UK
1.2	1.8	1.2	1.5	1.5

Environmental Cost and Intensity

3.53 The main focus of this report is on intensity of road freight movement. However in the concern with the growth in road freight stems mainly from its impact on the environment. Damage (environmental and ecological) of trucks is the real output of interest for policy – not tonne km *per se*.

3.54 The main components of environmental cost that are of concern are fuel consumption (with its impact on global warming, air pollution and noise pollution). In order to incorporate this policy element the first identity can be incorporated into one that relates the growth in damage to the growth in GDP. This second identity allows one to consider important policy initiatives that not only affect intensity but also the efficiency of truck operations (utilization and lading factor) and the environmental load – 'dirtiness' – of trucks)

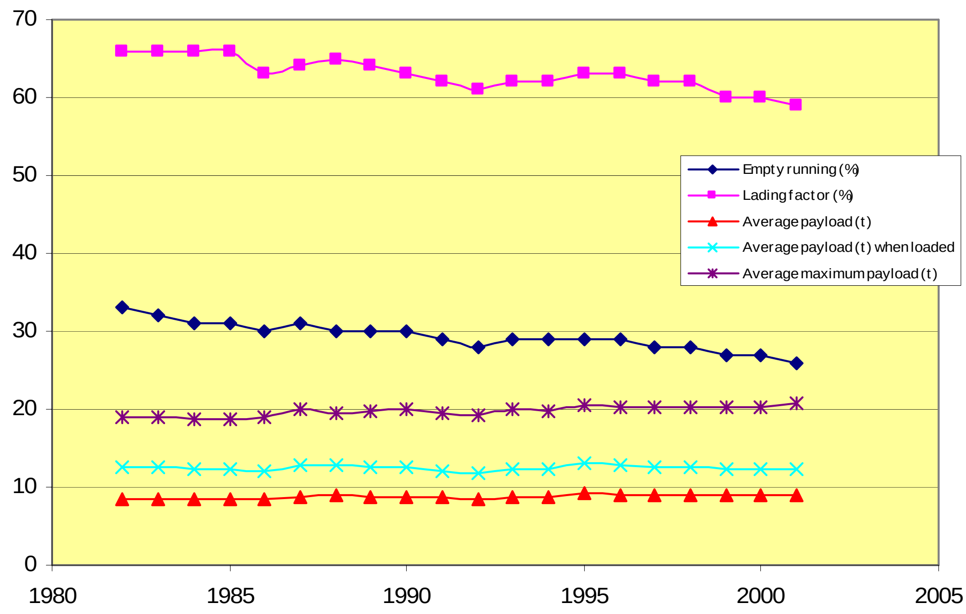
EQUATION 2

$$\frac{environmental\ cost}{GDP€} \equiv \frac{environmental load}{truckkm} \times \frac{truckkm}{truckkmloaded} \times \frac{truckkmloaded}{\max tonnekmloaded} \times \frac{\max tonnekmloaded}{roadtonnekm} \times \frac{roadtonnekm}{GDP€}$$

damage ≡ dirtiness x empty running x average vehicle payload x lading factor x intensity

3.55 In the UK data is readily available on the efficiency factors for road freight movement (Figure 3.12). Over the period 1982-2001 the average payload of goods vehicles (*roadtonnekm/truckkm*) increased from 8.4t to 9.1t (average 0.4% a year). This was partly due to the increase in average vehicle size and the increase in maximum payload (from 19t to 21.8t). The other two factors balanced each other. Empty running decreased from 33% to 26%. On the other side however the lading factor[2] declined from 66% to 59%. This decline may partly reflect the fact that trucks may tend to reach capacity on the grounds of volume rather than weight. This in turn may be derived from the nature of products carried or a change in their volume to weight ratio.

FIGURE 3.12 ROAD FREIGHT EFFICIENCY INDICATORS UK 1982-2001



3.56 A major determinant of environmental impact of a truck km is the fuel efficiency. A number of sources confirm the general improvement in fuel efficiency for trucks. Manufacturers such as Daimler-Chrysler report an average improvement of 1.3% per

[2] The lading factor is the ratio of goods moved (tonne kilometres) to the maximum tonne kilometres achievable if the vehicles, when loaded , were loaded to their maximum capacity.

annum for a 40t truck and trailer from 1970 to 2000[3]. An independent report (NERA, 2001)[4] reports improvements between 1 and 2% during the 1990s though this is restricted to trucks with a Gross Vehicle Weight greater than 14t.

3.57 Various studies (including TRL, 2001. NERA, 2000) delineate the costs of atmospheric pollution and how they differ with different pollution emission standards. Emissions include Carbon Dioxide, Carbon Monoxide, SO2, NOx, PM10, NMVOCs, Benzene and Butiadene. European emission standards are referred to as EURO I (for vehicles registered before 1966), EURO II (Registered up to 2001), EURO III (registered up to 2006) and EURO IV (registration after 2006). The introduction of these standards has seen a dramatic reduction in average truck pollution as the vehicle park gradually sees the departure of the more polluting vehicles. Eventually the atmospheric pollution per truck km should be reduced to less than 10% of the level experienced under the pre-EURO regime.

3.58 Traffic noise potentially affects both human health and the amenity of people in the vicinity. Various countries have adopted mandatory standards since the 1960s. The introduction of a series of stricter limits at the European level meant that by 1990 maximum noise limits of individual vehicles were effectively halved. Additional reductions in truck (and traffic noise generally) came about through the implementation of a new EU directive in October 1996. A steady reduction in noise levels emitted by trucks has therefore been observed. However, most of this reduction has been achieved through reducing engine noise. In the future reductions in vehicle noise will come from reducing the noise emanating from the impact between tyres and road surfaces.

3.59 In all areas therefore – efficiency, noise pollution and atmospheric pollution – there has been a significant improvement in the environmental load of a truck km throughout Europe. In the case of noise and air pollution there is the likelihood of further significant improvements.

Conclusions

3.60 The growth in road freight intensity in the 15 countries of the EU averaged about 1% a year from 1970 to 2000. It varied between countries from a low of -3.6% in Ireland to 2.4% in Italy.

3.61 From a more detailed examination of 5 countries it is clear that the increase in average haul has contributed to the general increase in intensity in the 1980s and 90s. Again there are differences between countries but the figures suggest an average contribution of perhaps 2% a year. Without this increase therefore intensity would have fallen. Part of the trend (less than 1%) may be attributable to the changing mix of commodities over the period, which has seen a move towards commodities with longer average hauls.

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[3] http://www.daimlerchrysler.com/index_e.htm?/environ/report99/produkt/nfz_e.htm

[4] NERA, (2000). "*Lorry Track and Environmental Costs*", London.

3.62 Another important trend derived from the figures for 5 countries is that tonnes lifted have grown more slowly on average than freight moved. Again differences between countries exist but an average difference of 2% appears plausible. Two reasons behind this is the changing mix of production in the economies. The move towards services can explain perhaps 0.5%, and there is another element due to the changing mix within production industries (moving towards lower density products) though it seems this is unlikely to explain more than 0.5%. The negative correlation between average haul and density implies the effects would tend to work in opposite directions.

3.63 The remainder is therefore due to changes in the economy such as Supply Chain Structure and Product Density. Section 4 will examine these contributory factors in more detail.

4. THE DRIVERS OF INTENSITY

Overview

4.1 This Section identifies the drivers of intensity and reviews their impact in more detail. This is used to develop a framework for the assessment of freight transport intensity in relation to production and industrial activity.

Identifying Drivers

4.2 The growth in GDP in EU Member States has been steady during the past 40 years or so, ranging between 2.4% – 4% on average per annum. In the Acceding Countries, the growth rates have been a little lower and at times (especially during the transition of the early 1990s) rather erratic.

4.3 The growth during this period has not been simply a change in scale of production. Whilst GDP may have increased 3 or 4-fold, products have changed and the mix of products consumed is quite different to that of 40 years ago. These changes of mix and type of products have different transport requirements.

4.4 The main drivers influencing the transport requirements over time can be summarised as follows:

- Mix of products and services
- Configuration and design of commodities
- Manufacturing processes
- Warehousing and handling technology
- Information technology
- Logistics management
- Technology of transport systems
- Regulation

4.5 It was shown in Section 3 how the mix of consumption has moved away from commodities towards services, which have a lesser demand on transport resources. At the same time the balance of commodities consumed has moved towards those (such as electrical and electronic goods) that have a higher value to weight ratio. Both these tendencies have contributed to a reduction in the level of freight intensity.

4.6 The major driving force behind the growth of GDP has been the adoption of new technology, which involves not only new, more efficient processes, but also the development of new products. New products often tend to be more sophisticated and are often accompanied by different packaging requirements.

4.7 Allied with changes in the form of products, there has been a tendency for a particular product to be offered in many different forms (variety) and sometimes with the ability for customers to define the configuration that they require (mass customisation). All these factors surrounding new products can therefore be expected to result in different transport requirements.

4.8 Turning to manufacturing processes, technological developments have changed the methods of production. For instance new materials and changes such as the move towards modularisation in certain industries have led to the emergence of new processes. Of particular importance to transport is the possibility that new technology has meant greater economies of scale in production, leading to larger plants and longer distances for products to move (both to the new larger plants and from them to the marketplace).

4.9 Just as technology has resulted in lower costs in manufacturing, the same improvement has occurred in the cost of warehouses and their operation (relative to the intensity of activity taking place there). This has been a contributory factor in the redesign of supply chains in which consolidation centres are used between manufacturing sites and final delivery to retail outlets – a move that has implications for the amount of transport required for a particular product.

4.10 An important driving force for change in the latter half of the 20th century was developments in the field of Information and Communication Technology (ICT). Some of these changes affect transport directly in that they assist the operation of the transport system. Some other developments such as the emergence of e-commerce may affect the use of transport resources in the supply chain.

4.11 The way that industry operates today compared to 40 years ago has clearly been influenced by changes in technology. It can also be argued that new management concepts and techniques have led to changes (which might in turn lead to a greater or lesser use of transport resources). Of particular relevance are developments in logistics management that have influenced the scheduling of product movement. These include Just-in-Time (JIT), Quick Response (QR) and Efficient Consumer Response (ECR). Associated with these is the tendency for customers to require more precision in the timing of deliveries, driven by the desire to minimise the cost of inventory. All of these developments potentially influence the demand on the transport system.

4.12 The final area of technology that needs to be addressed is that concerned with transport itself. Developments in vehicles and highways have reduced their costs dramatically. This has been reflected in reduced road transport prices, and subsequently the demand. Developments in other modes (particularly rail) do not seem to have been so great. The relative advantage, and hence the relative share of modes, has therefore, moved in favour of road.

4.13 Finally there is a selection of factors that have influenced intensity, which are included under Regulatory Regime. Some of these such as changes in restrictions on vehicle size or driving hours lead to a change in road transport's cost or performance. A change of this sort can then lead to a change in the demand for road transport part of which may be diverted from other modes.

4.14 Policy initiatives in areas outside transport can also have an influence on transport resources consumed. Packaging regulations and the general move towards more recycling must have some influence on transport. In the wider area of economic policy associated with the EU, the move towards a single market by the removal of tariffs and other commercial and cultural barriers to trade has undoubtedly encouraged greater movement of goods across National borders with its consequent effect on freight movement.

4.15 In the following sections each of the drivers are examined in more detail.

Mix of Products and Services

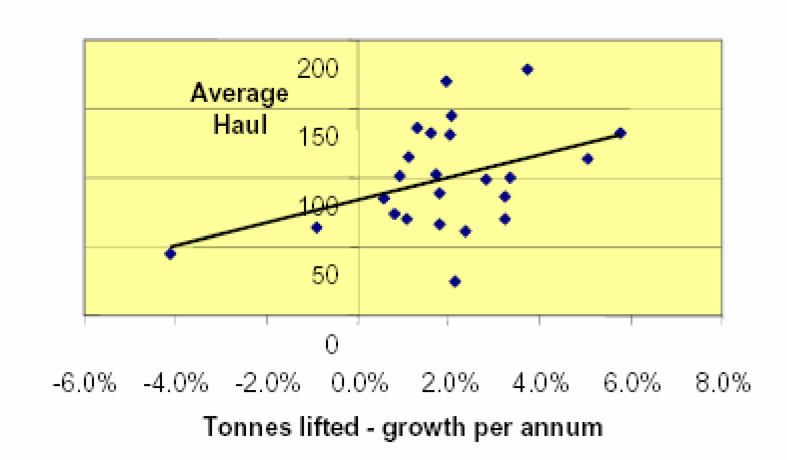
4.16 In explaining the forces behind the development of road freight intensity over the last 20 years an important role must be attached to the change in the mix of products and services in a particular economy. Section 3 has shown the scale of these factors.

4.17 The first important influence is the faster growth in services compared to goods over the last 20 years (and longer) found in all the countries of the EU. This alone can lead to a divergence between GDP and freight lifted of up to 1% (based on the simple but fairly realistic assumption that services (which includes education, health and other public services as well as consumer services) generate little if any freight traffic.

4.18 The next effect derives from the changing mix of commodities (as defined in the 24 category NST/R classification). Over the last 20 years there has been a tendency (in terms of tonnes lifted) for a move away from crude material and energy products towards higher value density manufactured products. No precise measures of value density exist and it is not therefore possible to place a figure on the change in average value density but there is little doubt that it has fallen, contributing to the fall in road freight intensity.

4.19 A related phenomenon caused by the change in the mix of commodities is an increase in the average haul of the total set of commodities. Those commodities that have grown fastest tend to have longer average hauls and therefore as a result the average haul has risen as a consequence. As Section 3 indicated, this effect varies by country but can contribute 0.5-1% to the increase in tonnekm (and therefore intensity) per annum.

FIGURE 4.1 AVERAGE HAUL AND GROWTH IN TONNES LIFTED - 24 COMMODITIES



4.20 The final factor influenced by the change in commodity mix is modal split. Many commentators have noted that the changing mix of commodities in the economy is away from those traditionally carried by railways (bulk, low value density products) towards those where road has a greater relative advantage (e.g. more difficult to containerise, higher value, more urgent delivery requirements). The new commodities may have longer hauls where rail should have an advantage but this does not seem to outweigh the disadvantages.

4.21 The above conclusions refer to a mix referring to 24 commodities. Within these commodities there may also be a move towards lower value density or longer haul products. This is the subject of the next section.

Configuration Design of Commodities

Product Design

4.22 A number of projects (see for instance the EUNET project[5]) have begun to penetrate the area of product value density (€/tonne). The trend in the average value is a function of the mix of commodities in an economy and the trends of individual product value densities. A rather wider perspective (relevant to transport carrying efficiency) examines product design where issues such as packaging and stackability are also considered.

4.23 As regards the direct impact of manufacturing on transport intensity, it is likely to be directly through value density of products and indirectly through the impact of increasing variety on logistics. There are a number of attributes of product design (and packaging) that may affect transport intensity. Some of these are:

- Volume/mass
- Value/complexity/mass
- Variety in logistics – inventory, delivery, customer service
- Limits to mass reduction - food/cars
- Value of variety

Product logistical attributes

4.24 Dowlatshahi[6] identifies four categories of product characteristics that can influence the choice and cost of transport. These can be categorised into 7 attributes

- Physical properties: width, height, length, centre of gravity, etc
  - Weight
  - Size
  - Shape
  - State (solid, liquid, gas)
- Dynamic limitations: acceleration, vibration, deflection, leaking, etc
  - Fragility
- Environmental limitations: temperature, pressure, humidity, etc
  - Perishability and need for temperature control
- Hazardous effects: radiation, explosives, electrostatics, personnel safety, etc.
  - Hazard

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[5] EUNET – Socio-Economic and Spatial Impact of Transport, 4FW RTD Transport Project reported March 2001.

[6] Dowlatshahi, S, (1996), “The Role of Logistics in Concurrent Engineering”, *International Journal of Production Economics*, 44. (Quoted in SULOGTRA).

4.25 Each of the seven factors influences vehicle loading and therefore the maximum weight and volume of goods that can be carried in a vehicle.

4.26 The influence of the first four factors is fairly obvious. The utilisation of vehicle carrying capacity can be defined with respect to weight, deck-area (2 dimensional view) or cubic capacity (3 dimensional view).

4.27 Depending on the product, design capacity will be reached when one of these constraints is met. For some products therefore its volume may be the critical factor rather than weight. For some it may be the lack of ability to stack the product which means the floor area is the key dimension. For others the need for temperature-control means that some of the maximum tare weight is lost. Volume is also lost due to the need for there to be at least 30 centimetres of clear space around the load for air circulation.

4.28 Rules governing the movement of hazardous product can also have implications for the quantity carried and the loss of weight available for the load due to the use of special equipment.

4.29 A simple measure of a product's weight (or tonnekm), therefore, can be a poor indicator of the demands it places on transport resources.

Design and variety

4.30 An important theme over the last 20 years has been resolving the trade-off between "customising" and the traditional economies of scale in manufacturing.

4.31 As more variety or complexity is incorporated into products and delivery, there is more value to the customer, but this is accompanied by a real increase in the price of products. While there are debates about the limits to product variety (when does variation in a product overlap with the most important features of another product) the implication of the "batch of one" manufacturing technology is that it facilitates rather than hinders mass customisation and postponement.

4.32 Little systematic evidence is available on the change in variety and complexity yet this may have an important influence on transport requirements (through consignment sizes or the dispersal of production sites). There are however, an increasing number of studies of product variety and product life cycles. One example is[7] about the UK automotive market and says:

> *This contribution aims at predicting future trends in the automotive industry in terms of product variety, model range and product life cycles in the UK automotive market. The analysis is based on empirical data dating back to 1960, which is extrapolated into future trends. The findings indicate no consistent trend in regards to product variety, which seems to be merely driven by vehicle manufacturer's policy, but could identify a clear trend towards shorter product life cycles and increased model ranges offered in the UK*

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[7] Holweg, M, (date). "Product Variety, Life Cycles, and Rate of Innovation – Trends in the UK Automotive Industry", Lean Enterprise Research Centre, Cardiff Business School, Wales, UK

market. These trends in consequence will force vehicle manufacturers increasingly to design and introduce vehicles that are far less dependent on economies of scale, as the overall volume per model is predicted to decrease drastically. Current efforts of the vehicle manufacturers to meet these requirements, the product platform strategy for example could also be identified.

The effect of environmental policies on product design

4.33 In searching for evidence of links between manufacturing and transport intensity one emerging aspect is clear. There needs to be a more widespread use of complete systems evaluation of value chains (or increasingly value networks).

4.34 The ultimate aim in focussing on transport intensity is to lessen environmental damage. To some extent reverse engineering has started this emphasis on the environment but more recently other drivers for product design have come into play. In this sub-section some preliminary ideas are introduced about the effects of environmental policies aimed directly at the whole life cycle of a product.

4.35 At the moment various policy initiatives are coming together to create powerful pressures on expanding the "design space" of products. These include the Directives in the areas of

- Landfill
- Ozone depletion (fridges and freezers)
- Packaging
- WEEE (electrical and electronic goods)
- End of Life vehicles (ELV) Directive (2000/53/EC)
- Greenhouse Gas Emissions and Climate Change

4.36 Together these are also likely to have a pronounced effect on the Waste Sector through changes in waste logistics, though none are intended to directly alter elements of transport intensity in supply chains.

4.37 ELV[8] is used here as an example because it has a immediate affect on the complex process of car design. In the near future EU policy will require an increasing proportion of the materials in disused cars to be recovered rather than go to land-fill (95% of ELVs to be reused/recovered and 85% reused/recycled by January 2006). Such materials recovery may consist of a range of actions, from recovery and refurbishment of components to the fragmentation of the residual car and subsequent recovery of different materials for raw input into material production chains.

4.38 The overall policy has to be disaggregated into appropriate policy instruments at different spatial scales and thought given to what response there may be and what issues of accountability and enforcement will arise. Percentage material recovery targets imply additional resource costs over landfill. (Although landfill tax has been

[8] Official Journal of the European Communities, L269/34-42

introduced it is still not clear what are the marginal social costs of alternative disposal/recovery options). Who is to pay for this is not entirely clear.

4.39 As for the recovered materials some may be components suitable for refurbishment (by a manufacturer of third party), while necessarily some shells and engine blocks will be fragmented and separated using increasingly "tuned" technology that can detect more subtle differences in materials.

4.40 At a recent conference at Warwick University[9] a number of car manufacturers were represented. Jaguar gave examples of "Design for Recycling", drawing attention to changes in car composition – less metal, introduction of lightweight technologies, more polymers construction. This has, of course, implications through the whole supply network. Land Rover concentrated on the implications of reducing or eliminating heavy metals. It is concerned about the problems of providing spare parts into the future for vehicles of different generations.

4.41 Brunel University gave examples of "Design for Disassembly" through the use of "Shape Memory Alloys and Polymers" while Birmingham University dealt with the "Environmental Aspects of the use of Carbon Fibre Composites in Vehicles – Recycling and Life Cycle Analysis".

4.42 Such events are taking place across Europe and in a wide range of manufacturing sectors. Closing the materials cycle or striving for Mass Balance reveals some considerable difficulties. Although companies such as Volvo have a long history of environmental accounting in design there is no common metric for what is better or worse in the alternative designs. Nor are they adequately linked to environmental costs in manufacturing or to the wider ecological environmental impacts. Nonetheless an exploration of the reversal of environmental impact on design is worth further effort.

4.43 One aspect that has so far only been touched upon is the environmental costs of recycling and materials recovery logistics. Some attempt to include this for Fridge recovery has been made in the UK[10]. In this example the need to process end of life fridges at relatively few sites rather than send them directly to landfill sites meant that greater transport resources were consumed in this final stage of the supply chain. .

Product Value Density

4.44 The interest here is how product value density has changed due to changes in products and manufacturing change. Three sectors are considered in more detail. These are Food, Automotive and Construction. The phrases transport intensity and value density are used rather variably in different papers and reports. This section is concerned with the micro level of transport of products and value density is defined in units of €/tonne and product density as tonne/m3

4.45 In some sectors the trend of weight for a given volume has been downwards as for instance in computers and electrical goods such as fridges. In other products it has

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9 End of life vehicle conference ELV 2000, Warwick Manufacturing Group, Warwick University, 9 Sept 2002.

10 Seaton, R and Black, I, (2002). "Waste catchment evaluation model for recycling, Strategic Logistical Issues in Waste Recycling: Fridges", Cranfield University and Biffaward, 1 April 2002.

been upwards, such as cars. Changes downwards are mostly associated with changes in materials, manufacturing technology and design. Changes upwards are almost always associated with increases in quality or performance.

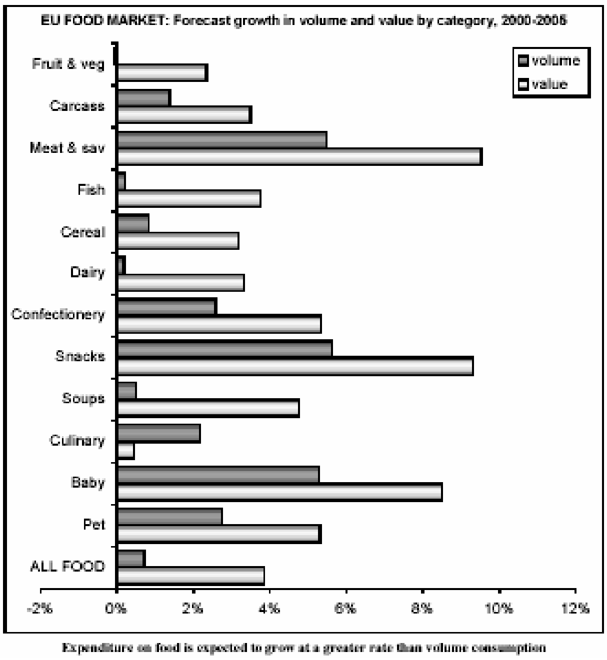
4.46 It is difficult to de-couple changes in value from changes in density for many products since the product characteristics are often modified at the same time to give more performance or better attributes. On occasions, designs achieve a desired increase in volume for the same weight as in some building technologies, while a desired decrease in volume is exhibited by other products for the same weight. (miniaturisation). Both are likely to result in higher value.

4.47 However it should be noted value is not simply the same as market price. Firstly adjustments need to be made for inflation. More difficult is the adjustment for improved performance and sophistication.

Product and Value Density in the Food Sector

4.48 The food sector presents some interesting insights into these issues.. Figure 4.2 shows the divergence between the growth in value and volume of food consumption across EU countries. In all cases (except one) the growth in value is greater than that of volume. For *All Food* the difference is 3% per annum. These trends in food consumption have been extensively covered in a range of publications.

FIGURE 4.2 EU FOOD MARKET: FORECAST GROWTH IN VOLUME AND VALUE 2000-2005



Source: RTS Associates

4.49 One of the prominent trends is the substitution of prepared food for the raw materials. To give some idea about scale the data from one source[11] shows ready meals to average about €4400/tonne. The value density is clearly much higher than for unprocessed ingredients, for instance potatoes are typically around €700 tonne at retail prices.

4.50 There was strong growth in ready meals during the 1980s and 1990s, and between 1996 and 2000, sales of ready meals in the five major markets of Europe rose in value by 19%, from €4.78bn to €5.7bn. Volume sales are estimated to be around 1.3 Mt.

4.51 Although no figures appear to exist that show the precise trend in value density over the past 20 years, the trend exhibited in Figure 4.2 will have occurred to some extent over this period. This trend is also likely to have occurred in different countries.

4.52 Frozen ready meals represented the largest single sector of the ready meals market in 2000, with sales of €2.02m, compared with €1.775m for chilled meals, €1.335m for canned/ambient meals, and €570m for dried meals.

4.53 The food chain also offers one of the most challenging sectors for efficient vehicle operation. Not only are significant proportions moved under chilled or frozen conditions, but there are stringent demands of health to be observed. The key problem for transport intensity is that almost always food in the retail distribution system reaches the volume constraint of vehicles before the weight constraint. This has been studied by McKinnon in the UK, who provides the following comments and data[12].

> *The utilisation of vehicle capacity was measured with respect to weight, pallet numbers and pallet height. As explained earlier, most of the official road freight statistics compiled by the UK government and EU are weight-based. Vehicle utilisation is typically expressed as the ratio of the weight of goods carried to the maximum weight that could have been carried. For the fleets surveyed in 1998, the average weight utilisation was 56%, with wide variations around this mean value […]. This utilisation index can be misleading in sectors, such as the food, where most loads are of relatively low density and constrained much more by the dimensions of the vehicle that by its maximum weight limit. On only 7% of the laden trips were vehicles loaded to 90% or more of the weight limit…*

4.54 Across the total sample of laden journeys, loads on average reached only 50% of the maximum weight limit. There were, nevertheless, wide variations above and below this average, largely reflecting differences in the product density of the product carried, which ranged from crisps to canned food. When measured in terms of pallet numbers, vehicle utilisation was much higher, averaging 78% across the sample as a whole. Overall, around a third of the laden journey legs achieved a pallet utilisation level of 90% or more and were operating close to the deck-area limit. On the other

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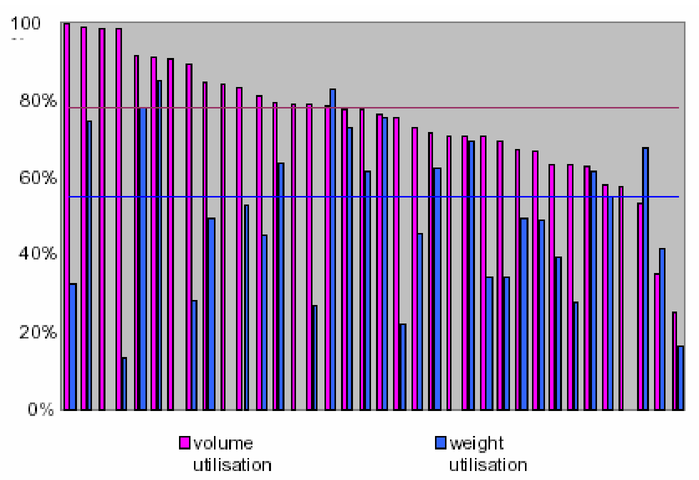
[11] RTS Associates, (2003), "Special Edition", Food Times, March 2003. www.rts-associates.com

[12] McKinnon, A, (1999). Vehicle Utilisation And Energy Efficiency In The Food Supply Chain Full Report of the Key Performance Indicator Survey. School of Management, Heriot-Watt University, Edinbirgh, UK November 1999, http://www.som.hw.ac.uk/logistics/alanpubs.html.

hand, on approximately 47% of the laden trips 25% or more of the floor area was unused, suggesting that there was scope for improving vehicle loading.

4.55 Figure 4.3 below shows the graph of the distribution of results from a range of fleet operators in food chains. Generally volume utilisation of vehicles exceeds weight utilisation substantially though the proportions become more equal as the overall utilisation decreases. The report also breaks down data by vehicle types and sizes.

FIGURE 4.3 AVERAGE WEIGHT AND PALLET UTILISATION OF THE FLEETS



Product and Value Density in the Automotive Sector

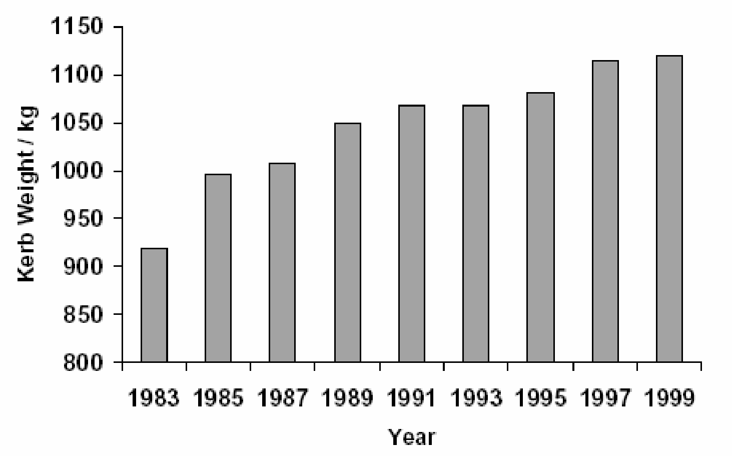
4.56 The automotive sector offers rather mixed insights. Contrary to general belief, cars are getting heavier. The issue here is whether the value in €/tonne has been increasing over time (leading to a decrease in transport intensity) and if so in which sectors and for what type of products. For instance consider a type of car which has been manufactured as much the same model for an extended period. The price of the car has changed from €900 in 1970 to around €12000 in 2003. Much of this change is due to inflation. Changes in productivity will also have influenced the price. From an intensity perspective using GDP then the issue is whether the value in terms of quality and performance has changed.

4.57 In reality cars from 1970 and 2003 differ markedly in value. There have been changes in materials used; the modern engine is more economical and cleaner. It will have audio systems a good heating system and so on. At a given point in time it is these types of equipment which differentiate between basic and higher value models in the showroom.

4.58 Assuming they are the same weight then the value density has increased in line with the quality of the product. In practice cars have actually increased in weight over time for a given model. For the Ford Fiesta, the trend can be shown year by year in Figure 4.4 below.[13]

[13] Longworth S J P (2001) "The Bolting of Magnesium Components in Car Engines",. Newnham College, A dissertation submitted for the degree of Master of Philosophy, to the University of Cambridge. http://www.nadaguides.com in http://www.msm.cam.ac.uk/phase-trans/2001/sarennah/a.pdf

FIGURE 4.4 KERB WEIGHT OF FOUR-DOOR HATCHBACK FORD FIESTA - 1983 TO 1999



4.59 Components are generally denser. The car itself is designed, usually, to maximise volume for a given weight of material. The value of components overall is reflected in the value of the car and thus in value density, although some items will have much lower weights (such as instruments) and higher relative value densities than others (such as seats).

4.60 The history of automotive production over the last 25 years has seen cars fall into a weight spiral. The lightest of cars in 2002, built with weight saving in mind (for example the 2-seater 800kg SMART car) is still heavier than the average cars of 1977 (the 1977 4-seater VW Golf at 778kg).

4.61 In midsize and large vehicles the change is more pronounced with an average increase of around 20kg per year over this time period. The weight increases represent changes in safety, comfort, legislative, quality and interior standards. For example the modern car must have an exhaust after-treatment such as a catalytic converter; is likely to feature crash protection in the way of multiple airbags and side-impact protection bars; most vehicles now have an air-conditioning unit, noise attenuating fabrics under the bonnet etc.

4.62 The overall trend in the value density of cars over the last 20 years is influenced by two countervailing forces. Value per vehicle has been increasing but so has weight. The absence of clear statistics (especially concerning value) mean that a precise evaluation is not possible. On balance, however, it seems that the change in passenger cars over the last 20 years has not led to any great reduction in freight intensity involving the movement of component supplies or finished vehicles. Even if intensity has increased, the movement of finished vehicles is already highly volume constrained so that vehicle km would not necessarily have increased.

Product and Value Density in the Construction Sector

4.63 The construction sector is diverse. It includes such massive scale projects as power stations, roads, dams, oilrigs and very large buildings. At a smaller scale it includes the generality of buildings and small-scale works. The larger, massive construction is the domain of civil engineering with its branches. Much of the remainder is often referred to as the building industry. Increasingly it also includes the refurbishment of premises and facilities. The two activity scales overlap, for instance in the building of a complete new town and their common remit to build structures.

4.64 In considering product density and value density the value chains leading to completed structures can be regarded as supply chains. A distinctive feature of the supply chains is the extent to which “manufacturing” takes place at the location of the usable product commonly described as a “site”. Some prefabrication of sub-assemblies is increasingly taking place because the manufacturing condition of many sites makes some types of assembly expensive. Nonetheless the precise positioning of large amounts of mass, particularly concrete and steel, may require the production of large amounts of concrete and the shaping of many pieces of steel at that location.

4.65 The implications for transport intensity are quite complicated since mass itself is a necessary attribute of many structures such as bridges or dams. In other circumstances the issue is how to obtain better strength to weight ratios as in very large buildings.

4.66 An oil rig can be taken as an example of a structure that requires mass but within limits. The maximum size is dictated by the largest tug that can tow it. Smaller sizes are vulnerable to the risks of weather, impacts etc. so a minimum weight is desirable. An optimum mass is needed depending on the environment it is used in. In any event Quantity Surveyors report that the cost savings from weight reduction are very small compared to the loss of revenue if damaged or the costs of manufacturing a more complicated structure. Nevertheless, within a given design such items as helicopter landing pads and associated structures may be designed from aluminium rather than steel to save weight which can be used better elsewhere.

4.67 In the main, over time, the supply chain will tend to be concerned with much the same weight of materials, though of different proportions of product density. Prefabrication of sub-assemblies is more likely so that tonnes lifted may increase. Overall the functionality of the product is increasing (due, in part to material substitution) so that value density of the total product is increasing while evidence suggests that the constituent parts and their source materials are also increasing in value.

4.68 The other main part of the sector, buildings, can be understood from a simple every day example. Oddly enough there are few sources that provide information on the weight of a building. Take a typical medium 2 storey detached house in the UK of some 200 m^2. A source in the UK[14] gives some standard pricing for the construction not including the cost of the land of about €130,000 – 160,000.

4.69 The weight will depend on choice of materials but is, for a standard brick built house constituted of[15]:

[14] http://www.selfbuildit.co.uk/
[15] Pers com Garrett Construction

TABLE 4.1 STANDARD BRICK HOUSE MATERIALS AND WEIGHTS

Materials	Tonnes
Concrete (foundations etc)	20
Bricks	15
Cement blocks	10
Roof tiles	8
Timber	2
Windows (mostly glass weight)	1
Metals (plumbing, wiring, etc)	1
Total	**57**

4.70 Therefore, the value density overall of the materials is about €1,400/t. For this type of building the trends in product density are rather small and in competing directions. Structural requirements mean that all the heaviest components remain unchanged.

4.71 In the UK the weight of glass has doubled through widespread use of double-glazing, something that has been standard elsewhere in Northern Europe for decades. The introduction of a strong plastic pipe has reduced the metals weight somewhat as has the use of plastic facia and guttering. Prefabrication and better joints have reduced the costs of roof structures.

4.72 In general the value (i.e. price corrected for inflation and quality) of materials at the site has increased, quite substantially for some components. The supply chain that supports this type of operation is highly diffuse. The large number of types of component is supported by specialist suppliers (plumbing, electrics, ceramics) though there is increasing consolidation of these.

4.73 For small scale sites much of the material, except the heaviest, may be collected by the builder from retailers almost all of whom operate large chains with a supporting logistical system. Major companies on large sites will have their own logistical function supplemented by contracts for delivery. Sites are characterised by large amounts of movement of small/medium size vehicles. In general it appears the value density is increasing in the chain as value increases coupled with some modest decreases in weight of some components.

4.74 Once again the reduction in weight of components may not bring with it reductions in transport requirements where volume does not change. Prefabrication will often imply greater transport demands where there is significant increase in volume at the fabrication stage.

Manufacturing Processes

4.75 This section examines trends in product design and variability and customisation in manufacturing processes.

Trends in Manufacturing

4.76 There are a number of sources that provide overviews of changes in manufacturing. One such, the Institute for Machine Tools and Industrial Management (iwb) at the

Technical University of Munich, offers downloadable papers on aspects of its research which offer a typical range of specialisations, including:

- Control Technology
- Failure tolerant controls, model based development of control functions, decentralized control architectures
- Cooperation management
- Cooperation of companies in product development and production
- Development of Production-Systems
- Simulation systems, optimisation of layout and assembly
- Factory Planning and Logistics
- Planning and Control of Factories
- Handling and joining technology
- Robot applications, precision and micro assembly, laser technology manufacturing processes
- Process Prototyping, Rapid manufacturing

4.77 Process engineering focuses around flexible engineering, manufacturing cells and on modes of production around customisation and postponement. Production strategies, which are a common focus of logistics studies, deal with the time/space and organisational aspects of production and it is often the case that these are considered as the "manufacturing process" from a logistical perspective

4.78 Process engineering now has to respond both to the product attributes in each phase of its life as well as the attributes of its customers. The design of machinery, equipment and processes known collectively as manufacturing management is in essence a microcosm of the product world. It has its own internal logistics as well as its need to satisfy environmental objectives, health and safety and so on. The interaction between product and manufacturing process is well understood and developed but the links, through opportunities or constraints, between how something is made and its wider logistical properties is less well understood.

4.79 There is relatively little formal collated information on the interactions between process engineering and plant design and their impact on transport and logistics. There is a two-way relationship between product design and logistics. In some instances, logistical systems need to be adapted to the requirements of new products. In other cases, logistical factors impose constraints on the design of a product or suggest design modifications that can permit more efficient use of logistical assets.

4.80 A brief extract from SULOGTRA[16] about concurrent engineering gives an indication of how the design space is being expanded i.e. how more attributes of a product in manufacture, delivery, use and end of life are being built into this more holistic design process. It will be argued later that the incorporation of logistics considerations into design should be a priority.

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[16] SULOGTRA - Supply Chain Management Logistics and their effects on Transport, (2002), Technical University of Berlin, Logistics Department, Germany, Deliverable Report D2, D3 Work Package 2.

Concurrent engineering' provides a framework within which 'all activities related to the development of a product should be focused on in the early stages of product design so that the greatest benefits of such integration are achieved'. As decisions made early in the design process can have a major impact on the subsequent manufacturing and logistics operation, full account must be taken of these activities right from the start.

The expression 'design for logistics' (DFL) has been used to describe full incorporation of logistical considerations into basic product design. This extends the earlier concepts of 'design for manufacture' (DFM) and 'design for assembly' (DFA) which encouraged engineers to take more account of methods of production when designing new products. DFL contrasts with the traditional situation in which the logistical consequences of NPD were only recognised at a late stage in the process once irrevocable decisions had been made on product design, procurement, marketing strategy and production system.

4.81 There is, however, some difficulty in matching the interactions of materials, production engineering and manufacturing strategy to specific sectors. In part this is because sectors have been defined for historical and macro-level policy reasons. Even now in most classification systems there are more categories of products in industrial manufacturing than in the computer sector despite their relative contribution to GDP. The consequence is that there may in reality be more variance in the abstract attributes of manufacturing within a "sector" than between "sectors".

Product Design

4.82 The emerging themes in product design are in areas such as concurrent engineering with specialist variations such as ecodesign (accounting for environmental impacts of production, distribution, consumption and disposal), reverse logistics (recovery of end of life products and packaging) and design for disassembly (materials recovery through recycling and materials reprocessing).

4.83 A major factor behind product change has been the development through materials science of new materials. One of the most comprehensive resources about materials science and the development and application of new materials is the "European White Book on Fundamental Research in Materials Science"[17]. It defines material science as *"the study of substances from which something else is made or can be made; the synthesis, properties, and applications of these substances"*. Advanced materials include steels and other metallic alloys; superalloys; polymers; carbon materials; optical, electronic, and magnetic materials; superconductors; technical ceramics; composites; and biomaterials.

4.84 One of the main influences of changes in materials and production technology has been to make things smaller and/or lighter, stronger. Often this also increases value. The combined effect of increasing value and reduction in weight tends to reduce transport intensity.

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[17] "European White Book on Fundamental Research in Materials Science", Max-Planck Institute Fur Metallforschung, Stuttgart, http://www.mpg.de/doku/wb_materials/

4.85 The exception is products in which a certain mass or size is critical to their function such as construction products or some components of cars. It is clear that the trends have been towards the use of lighter materials in the higher value areas of manufacturing.

Variety and Customisation

4.86 Another significant trend is towards to increased variety of products available through customisation and the development of "batch of one" production technology. This variety reveals itself as a tendency to reduce consignment size and a consequent increase the amount of transport used (vehiclekm) thus counterbalancing the decrease transport intensity through higher product value. Where variety is associated with an increase in the spatial distribution of production tonnekm will tend to increase and so therefore will transport intensity.

4.87 There is a trade-off between "customising" and the traditional economies of scale in manufacturing. As more variety or complexity is incorporated into products and delivery there is more value to the customers (perhaps accompanied by a real increase in price of some products).

4.88 SULOGTRA[18] offers some views on the drivers behind variety. It is clear that the increase in variety has also been associated with higher levels of customer service, in the form of lead-time, delivery windows etc.

4.89 Another report[19] identifies increased customer sophistication – greater product variety/assortment, more and tailored value added services, custom/tailored products, shorter response times and greater accuracy, and support throughout the product's life cycle – as a major trend spreading into more and more industry sectors. The response of manufacturing has to redesign processes (including) machinery that can respond to these customer requirements without incurring large extra costs.

4.90 Computerisation of machine tools, for instance, when coupled with advances in metals machining (cutting, grinding, drilling etc) is tending to lead to the idea of "batch of one" manufacturing, particularly for low volume throughput. An example of a competitive technology, which could facilitate the "batch of one", is Hot Isostatic Pressing (HIP) [20]. This enables components with heterogeneous properties (e.g. hard surfaces, lightweight insides) to be made, and consequently, radically alters the product design space.

4.91 There are two distinct effects that derive from the trend towards customisation and the 'batch of one'. The first is the impact on product delivery and whether this requires more or less transport resources. The second is whether the change in manufacturing technology leads to a concentration or wider dispersal of production facilities with its consequences for average haul.

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[18] SULOGTRA, op. cit. Deliverable Report D1.

[19] A.T. Kearney (1999), 'Insight to Impact'.

[20] Cordey-Hayes, M., Craig, M. and Seaton, R. (1995) "Wider Economic Benefits from Technology Transfer from the UK Aerospace Industry: A Consultancy Report to DTI", Cranfield University, Cranfield, UK.

4.92 The move towards customisation has important effects on the logistics system. In particular the explosion in the number of products and the need to maintain (or improve) delivery times and availability has important implications for the scale and location of stockholding. This may in itself have implications for transport resources if it leads to a change in the number of stockholding locations.

4.93 There is, however, no consensus on the impact of variety on logistical structure only that it requires a more sophisticated stock control system. The simple assumption that more variety means more stockholding is not supported by national statistics. Faced with the challenge of more variety it appears that the redesign of stockholding systems has counterbalanced any such effect.

4.94 The major impact on transport from customisation will have stemmed from its impact on consignment size. If a need for more frequent deliveries (or shorter response times) accompanies customisation, then the effect will tend to be smaller vehicles and/or poorer lading factors. However this effect should not be exaggerated. Consider the example of retail grocery chain. More variety in food products will mean that consignment deliveries to the Regional Distribution Centres (RDCs) from manufacturers will be smaller. If the production is spread over new manufacturers at different sites this will mean smaller deliveries to RDCs (or a more costly collection round). However if the variety is produced by one manufacturer then consignment sizes might be smaller but they will still be delivered to the RDC as efficiently. The efficiency of the RDC delivery to retail outlets is unaffected.

4.95 The second effect concerns the move towards a 'batch of one' and the argument concerning economies of scale. Some commentators assume that the increase in average haul is entirely or primarily due to production concentration due to economies of scale.

> *Manufacturers have been concentrating production capacities in fewer locations. This has either resulted in a net reduction of the total number of factories or involved greater plant specialisation. The traditional system of nationally based production has in many sectors been replaced by focused manufacturing, where the entire production of a particular product for a continent ... at a single location. Companies can maximise economies of scale in the production operation but at the expense of making their logistics system more transport-intensive and of lengthening the lead time to customers. The results of TRILOG suggest significant geographical concentration of production both, at a European and a global level.* [21]

4.96 Despite this strong assertion no evidence of greater concentration throughout the manufacturing sector is provided in the SULOGTRA report or elsewhere. Industrial sectors will undoubtedly differ in their move towards greater or lesser concentration given their different exposure to innovation in their manufacturing processes.

4.97 The discussions on innovation in at least part of the manufacturing sector suggest a trend towards the ability to produce smaller batch sizes at little or no cost penalty. This

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[21] SULOGTRA, op. cit., Deliverable 1.

seems to be in direct contradiction to the argument for greater economies of scale which has led to more concentration. On the balance of evidence it seems that no reliance should be placed on the assumption that greater economies of scale have lead to greater concentration.

4.98 The conclusion concerning the impact of a change in manufacturing technology favouring smaller batch sizes is that at least it should discourage any trend towards concentration. Thus it should not lead to longer average hauls. One counterbalancing force is that variety under some circumstances can lead to longer hauls.

4.99 When variety is merely brand variety (more colours of trainers, more types of cheese) produced at the same factory then this has no effect on average haul. However where greater variety means more products at different locations (more cheeses from different parts of Europe) then this may lead to more dispersed sourcing and longer hauls. The effect of increased variety therefore can be complex.

Warehouse Technology and Logistical Restructuring

4.100 Improvements in the cost of constructing warehouses and their operation (including the handling of inward and outward goods movement) have occurred over the last 40 years. As the relative cost of warehousing vis-à-vis transport changes the argument in favour of consolidation sites also changes. A low cost of transferring goods coupled with efficient consolidation methods encourages the use of consolidation sites or Regional Distribution Centres (RDCs).

4.101 This process has been particularly noticeable in the grocery trade. Rather than final manufacturers delivering directly to retail outlets, consolidation sites receive goods from many manufacturers and deliver to many retail outlets. The effect of this is to reduce overall delivery costs. Whilst there is a new cost in the form of set of consolidation centres, this is outweighed by the savings in transport.

4.102 These savings stem from the more efficient use of vehicles (almost always larger and often better utilised). The effect on tonnekm of consolidation, however, is to increase it. Rather than go on a relatively direct route from producer to retailer it now has to pass through a distribution centre. At the same time the products are lifted an extra time so goods lifted also increases. The average haul per lift is likely to fall (total distance per tonne increases). The overall result is therefore an increase in intensity but an improvement in overall logistical efficiency and probably also in environmental performance.

4.103 A parallel effect of the improvement in warehouse technology is the tendency for the number of stockholding warehouses in a system to be reduced. The great benefit of this is the reduction in stockholding costs. Again the effect may be a decrease in overall costs but an increase in tonnekm.

4.104 The path of logistical re-organisation in the form of reducing the number of warehouses is well documented[22]. A survey quoted in the same source showed that

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[22] McKinnon, A and Woodburn, A, (1996), "Logistical Restructuring and Road Freight Traffic Growth", *Transportation 23.*

this trend was continuing in the 1990s in the UK and was proceeding even more rapidly on the Continent of Europe.

4.105 The TRILOG study[23] observed, *"Centralisation has also occurred in parcel and mail delivery systems. Unlike break bulk / transhipment systems that are for single users, here companies are dealing with consignments that have already been created and are working for multiple users"*. In its analysis of the impact on transport, it goes on to say that the *"...adoption of hub-satellite systems has increased the volume of parcel movement, measured in tonne-kilometres, amplifying the effect of the steep growth in the parcel business on the transport system..."* but on the other hand it is *"... likely to have had a much smaller effect on vehicle-kms as the load factors on trunk vehicles have been substantially raised"*. Overall it judges that *"... the net effect of the restructuring of parcel delivery networks on traffic levels may have been quite modest*".

Information and Communication Technology

4.106 The Impact of ICT on transport can stem from a number of sources. ICT developments can affect the operation of vehicles directly. This can take the form in the planning phase – allocating loads to vehicles, routing and scheduling – and operations – information about road conditions, new orders as well as tracking and tracing. Rather more complex is the effect ICT has on business operations and its derivative transport requirements. Of particular relevance here is the emergence in the last 10 years of e-commerce.

4.107 The words e-commerce and e-business have been used extensively in the last 10 years to describe

> *"... the exchange of information across electronic networks, at any stage in the supply chain, whether within an organisation, between businesses, between businesses and consumers, or between the public and the private sectors, whether paid or unpaid"* [24]

It includes business-to-business (B2B) transactions as well as business-to-consumer (B2C) links. The increasing use of e-commerce in these fields may lead to changes in freight intensity.

4.108 There have been a large number of studies funded by the EC Framework Programmes that have investigated the use of ICT in freight transport (DRIVE program, Metafora, Eurofret, SURFF, ARTEMIS, Fleet and IFMS). All agree that telematics applications in the road freight sector such as the use of vehicle tracking and in-cab mobile communications has led to greater efficiency with consequent reductions in vehicle km though not necessarily tonnekm.

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[23] TRILOG Europe, Indicator Report, Department of Transportation and Logistics, Chalmers University of Technology, Göteborg, Sweden, September 1999 and TRILOG Europe End Report TNO-Inro, Delft, 1999.

[24] Performance and Innovation Unit (1999) "*E-commerce@its.best.uk"* Cabinet Office, London.

4.109 One particular area where there have been claims[25] of increased transport efficiency is in the growth of online freight exchanges in Europe. With their ability to match the demand for freight movement more closely to the available transport capacity, they should have led to a reduction in empty running and possible increased loading factors. The SURFF project implemented a freight capacity exchange system in Tilburg which claimed savings of 14% for vehicle km.

4.110 An ambitious attempt to estimate the impact of B2B and B2C e-commerce on road freight levels was made in the Netherlands[26]. Mainly focused on forecasts rather than analysis of past trends, it suggested that between 2000 and 2005 e-commerce would add 9% (B2B) and 8% (B2C) to the underlying trend of freight traffic growth. This is equivalent to approximately an extra 3% growth in vehicle km a year.

4.111 Another study[27] provides a striking contrast predicting a dramatic reduction in HGV traffic during this period. But no information is provided about past impacts or evidence to support this prediction

4.112 A further study[28] compared the externalities associated with the distribution of books through a conventional retail channel with one from an online book seller such as Amazon.com. The conclusion was that the latter used less transport resources and (the main focus of the study) was less environmentally damaging.

4.113 One aspect referred to under B2C is dematerialisation in which 'lightweight' or 'weightless' products reduce the need for the production and distribution of physical products. The main impact of this concept on transport is through the substitution of digital transmission for freight transport in such areas as the distribution catalogues, directories, software as well as entertainment and educational materials. Some commentators doubt whether this process has had much effect or whether it will do in the future. Hesse[29] argues that

> *"goods movement is unlikely to 'de-materialise' through the establishment of electronic distribution channels – as telecommuting did not free a majority of people from the daily drive to work, shopping and leisure".*

4.114 In the case of grocery shopping using the internet and home delivery two studies[30] in Finland and the UK suggest that, whilst there may be a reduction in overall traffic levels and environmental pollution, there would also be an increase in tonnekm carried by goods vehicles (substituting it is assumed, car trips to and from the shops).

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[25] Rowlands, P. (2000) "*Online Exchanges: Changing the Face of Road Freight*?" e.logistics magazine, May 2000.

[26] Transport en Logistiek Nederland (2000) '*New Wine in Old Bottles*' Zoetermeer.

[27] Dodgson, J., Pacey,J. & Begg, M., (2001) "Motors and Modems Revisited: The role of Technology in Reducing Travel Demands and Traffic Congestion", NERA, London

[28] Matthews, H., Hendrickson, C. and Soh, D.L. (2001) "*Environmental and Economic Effects of E-commerce: A Study of Book Publishing and Retail Logistics"*. Transportation Research Record.

[29] Hesse, M. (2002) "*Shipping News: the Implications of Electronic Commerce for Logistics and Freight Transport*" Resources Conservation and Recycling.

[30] Punakivi, M. and Holmstrom, J. (2001) "Environmental Performance Improvement Potentials by Food Home Delivery". NOFOMA Conference Proceedings, 2001 and Cairns, S. (1997) 'Potential Traffic Reductions from Home Delivery Services' TSU working paper 97/45, University College, London.

4.115 In the area of B2B a number of commentators have speculated about the impact increased sophistication of electronic commerce. E-marketplaces and e-purchasing may have made it easier for companies to trade with more distant suppliers leading to longer supply lines and average length of haul. If e-commerce is intimately linked with shorter time windows then this can lead to less efficient routing or reduced vehicle sizes[31]. Rather more subtle effects are proposed such as a move towards hub-satellite systems[32] due to the greater use of parcel services and a greater propensity for returning products delivered to the home (as high as 30% for some products). Both these effects, if valid, have led to (albeit modest) increases in tonnekm.

4.116 The potential impact on supply chain structure has also been examined, with one commentator[33] observing a reduction in warehousing as companies chose to ship directly to customers. This may reduce tonnekm. It was also suggested that the number of retail stores may decrease as planners opt for large retail centres.

4.117 In an OECD Seminar of 2001 the impact of e-commerce on transport was regarded as uncertain with one author[34] suggesting the impacts had been exaggerated. However, the effects on dematerialisation and increased goods vehicles flows from home shopping were generally confirmed.

4.118 The uncertainty surrounding the impact of e-commerce was exemplified by a working party of the EC which reported that the *"... utilisation of ICT and e-commerce are no panacea that would automatically change the development trend for transport to a sustainable track."* They went on to recognize the difficulties of analyzing the impacts that *"... form a complex chain of direct and indirect effects, various kinds of interdependencies and unpredictable joint impacts that are intertwined and contradictory".*

4.119 Whilst much uncertainty remains about the future, virtually no evidence exists on the impact of e-commerce in its early years. It does seem that there may have been a very modest increase in tonnekm and intensity, if the arguments concerning home delivery and the more remote suppliers being encouraged by better information are correct. The technology surrounding transport telematics has, on the other hand, appeared to have led to greater efficiency and a reduction in vehiclekm.

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[31] Nockold, C. (2001), "Identifying the real costs of home delivery", Logistics & Transport Focus, 3.

[32] Hesse, M (2002) op. cit.

[33] Kilpala H. et al: Electronic Grocery Shopping and its Impact on Transportation & Logistics with Special Reference to Finland, 2000

[34] The Impact of E-commerce on Logistics Jacques COLIN, Université Aix-Marseille 2, France

Logistics Management

4.120 The practice of logistics management has changed over the last 25 years. A series of new management principles and approaches has emerged over this period including, just-in-time (JIT) [35], efficient consumer response (ECR) [36], quick response (QR) [37], lean logistics[38] and most recently agile logistics[39]. Whilst their objective has been to improve the overall efficiency of the movement of goods through the supply chain, the main focus has tended to be on reducing the level of stockholding and (by implication) accelerating the movement of products through the supply chain.

4.121 The adoption of these new management principles may have contributed to the striking reduction in inventory experienced in all the EU countries[40]. The impact on transport intensity is uncertain.

4.122 An image of JIT is sometimes projected of small consignments (even a consignment of one) arriving just before the component or product is required, thus leading to a decrease in the lading factor and transport efficiency. However there is little firm evidence that there has been a widespread reduction in the size of consignments.

4.123 The retail sector and the automotive industry still tend to receive deliveries in consignment sizes that ensure efficient (i.e. low cost) transport. In the Delphi survey conducted by TRILOG there is some evidence of a continuation of a trend towards lower shipment sizes in national markets but the reverse in international markets.

4.124 Over all supply chains there is no reason to believe the application of these management principles has led to an increase in tonnekm or intensity due either to more tonnes lifted or greater distances. When it comes to vehicle efficiency there may have been a reduction due to the use of smaller consignment sizes, but there is no evidence that this effect is more than very modest.

4.125 A key concept behind these recent development in logistics management is the need to take a systems view of the supply chain, one in which trade-offs between warehousing, stockholding, transport and customer service are transparent. This perspective has been enhanced with the emergence of Supply Chain Management (SCM) [41] in which it is argued decision-making should be based on a view of the extended supply chain and co-operation between chain members.

4.126 Again there is no evidence that SCM leads to more transport movement (tonnekm), although there may be an impact on transport efficiency if an improvement in delivery

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[35] Hutchins, D. (1988)'Just in Time.' Gower Press, Aldershot.

[36] Kurt Salmon Assocs. (1993)'Efficient Consumer Response: Enhancing Consumer Value in the Grocery Industry.'

[37] Fernie, J. (1994)'Quick Response: An International Perspective' International Journal of Physical Distribution and Logistics Management, 24, 6, .

[38] Jones,D., Hines,P. and Rich,N. (1997)'Lean Logistics' International Journal of Physical Distribution and Logistics Management, 23.

[39] Christopher, M. (1998) `Logistics and Supply Chain Management' Financial Times Pitman Publishing,.

[40] Eurostat (2002), "Economy and Finance"

[41] Bechtel, C., Jayaram, J. (1997), Supply Chain Management: a strategic perspective, International Journal of Logistics Management vol 8 no 1, pp. 15-34.

performance (more frequent, more reliable) is inherent in the new management approach.

4.127 One other principle that has informed management decision-making in logistics is concerned with outsourcing. This has been one of the dominant business trends of the 1980s and 1990s[42]. Companies have been following the principle of concentrating their resources on core activities and contracting out ancillary functions. As a consequence transport, and to a lesser extent warehousing, has ceased to be an activity that many companies manage but rather something that they purchase from outside specialists.

4.128 The trend towards outsourcing should have led to more efficient transport and warehousing operations as more competitive and more efficient management takes over contracts from in-house operations. A small improvement in the efficiency of transport operations may be gained from the ability of large third-party operators to pool resources over a number of contracts. The effect of new management practices in this area is also likely to have had an impact on vehicle efficiency rather than the underlying pattern of goods movement (tonnekm).

Transport Technology

4.129 The data on freight intensity trends in Europe show that a major component behind its growth is the increase in average haul. One hypothesis is that increasing economies of scale have lead to larger scale facilities in production. The evidence on the size of plants does not support this[43]. If economies of scale are not the explanation of the increase in average haul then customers, or purchasers, throughout the supply chain must be obtaining goods and materials from more distant sources. The possible reasons for this are the falling cost of movement (including transport, tariff and non-tariff barriers to trade in Europe), the emergence of a wider range of products and greater consumer selectivity on the choice of product.

4.130 There is overwhelming evidence that the real cost of freight movement has fallen consistently over the last 40 years. A detailed study in the UK[44] provided the evidence presented in Figure 4.5 below.

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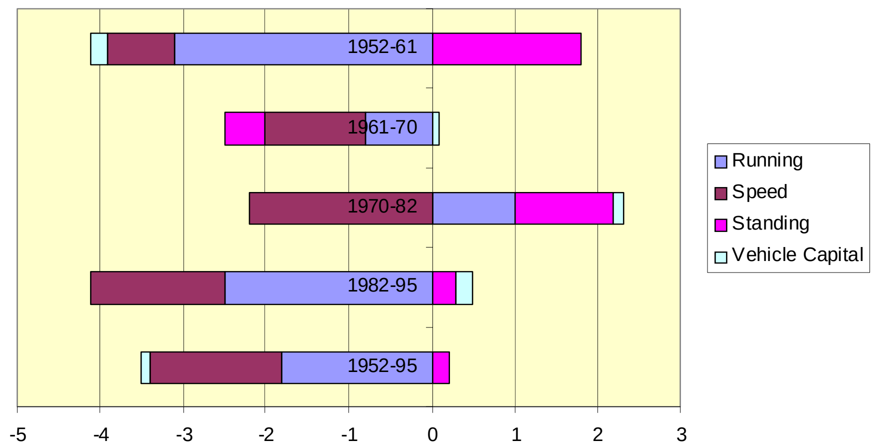
[42] PE Consulting (1996). "The Changing Role of Third-Party Logistics – Can the Customer Ever be Satisfied", Institute of Logistics, Corby 1996

[43] See REDEFINE Relationship between Demand for Freight-transport and Industrial Effects Final Report Netherlands Economic Institute (Co-ordinator) February 1999

[44] Cooper, J. et al. (1999), "Creating the Sustainable Supply Chain" in Banister, D. (1999) "Transport Policy and the Environment" E&FN SPON, London.

FIGURE 4.5 PERCENTAGE CHANGE PER YEAR IN COSTS FOR A 24T GOODS VEHICLE



4.131 This shows that on average for the 1952-95 period the change in annual average cost per km was -1.4%. The reduction was due to higher average speed and running costs that outweighed the increase in standing costs with the change in vehicle capital costs making a negligible contribution to the overall change. The increase due to standing costs is understandable given drivers' wages have consistently outstripped the increase in the retail price index. A reduction due to the fall in running costs, which includes maintenance and fuel, occurs in 3 out of 4 periods. The increase in average speed provides a consistent contribution to the reduction in costs over the period. The speed increased from 10km/h in 1952 to 27km/h in 1992. This increase derives from less idle time, reduced loading and unloading times as well as increased vehicle speed on the road. The last is due partly to higher performance vehicles and partly to superior highways. Examination of other vehicle types confirms the general picture of a decline in real costs.

4.132 The figures refer to one vehicle type. If we take account of the change in the mix of vehicles, then the actual reduction in unit costs per tonnekm is even greater with the move towards larger vehicles with a lower per tonne cost. Evidence on haulage rates is provided by a survey of FTA (Freight Transport Association) members. For the period 1985 to 1995 the index grew on average at 4% less per annum than the retail price index.

4.133 Evidence on the decline in freight prices (and presumably therefore costs) is provided by for the Netherlands. Given the ubiquity of technological improvements to trucks in Europe and the general improvement in road speeds it can be assumed that all countries in Europe have experienced a reduction in unit costs.

TABLE 4.2 PRICE DEVELOPMENT OF INTERNATIONAL FREIGHT TRANSPORT IN THE NETHERLANDS (UNIT: INDICES 1999=100)

Year	Index
1980	157.0
1985	136.0
1990	140.3
1995	106.3
1999	100.0

Source: Eurostat, 2002

4.134 The fall in unit movement costs must be an important influence in explaining the increase in average haul. Producers are now willing to source material and components from longer distances. Similarly retailers are willing to purchase goods from further away when transport costs are reduced. Tonnes lifted on the other hand should remain relatively unaffected by the reduction in unit costs. Though there does remain the possibility that the reduction increases the handling factor, as producers are now more willing to move semi-processed products between production sites.

4.135 Simple time series analysis yields no clear proof of a relationship between average haul and unit costs because of the long response times for a reduction in unit costs to work its way through the system. Cross section analysis based on the decline in movement from a source as cost increases suggested an elasticity of demand with respect to price of -0.7[45], Whilst there must remain some uncertainty about the scale of the effect there can be no doubt that lower prices (stemming from cost reductions) do lead to sourcing from greater distances and longer average hauls.

4.136 Data on the trend in costs of other modes is not readily available. As far as rail is concerned, however, it seems clear that the mode has not enjoyed a similar reduction in costs to road. The general decline in market share is proof of this. However the share of rail has also been influenced by the changing mix of commodities and demand from consumers for increased service levels.

4.137 As has been observed earlier, there has been a move away from high-density bulk commodities which are the traditional market of the railways towards. In itself this would have led to a decline in rail's share of the total freight market. At the same time the increased demand for more frequent deliveries, faster journey times and on-time delivery has been to the disadvantage of the rail sector with its need (in most cases) for road access and transfer to/from the network.

Government Regulation

4.138 Government regulations concerning transport cover a wide area. As far as the EC is concerned DG Enterprise is responsible for legislation on the construction of motor vehicles whereas DG Transport and Energy is responsible for legislation on their use.

[45] Cooper, J (1999), op. cit.

National and local governments also have responsibility for controlling the access (by location or by time) of goods vehicles to the road network. All of these regulations can have an effect on the cost and performance of road freight vehicles which can in turn affect their volume of use.

4.139 Most of the regulations about vehicle construction and their use are concerned with safety and have a small effect on cost. One set of regulations concerned with vehicle size has been identified as important in its role of reducing freight costs. The gradual increase in the maximum size of freight vehicles allowed on the roads of European countries has helped to reduce unit costs and thus, as argued earlier, increase the demand (average haul) for freight movement.

4.140 Packaging and Waste are also the subject of Community legislation. The latest estimate from the European Commission is that around 58 million tonnes of packaging is consumed annually within the European Union. Packaging waste is estimated to represent about 17 per cent of total municipal solid waste (MSW) by weight. To limit the environmental impacts of the consumption of packaging various Directives sets Member States minimum targets for packaging waste recovery and recycling to be achieved.

4.141 The Landfill Directive also requires substantial changes to the way waste is managed. The main objective of the Directive is to ensure high standards for the disposal of waste in the European Union, to stimulate recycling and recovery of waste, and to reduce emissions of methane (a powerful greenhouse gas). The Directive does this by seeking to internalise the costs associated with landfill; ensuring that landfill sites - both open and closed - are adequately managed and monitored; reducing the hazardous nature and volume of waste going to landfill; and banning certain wastes from landfill altogether.

4.142 No detailed study has been undertaken on the effect of these Directives on transport requirements. The suspicion is that rather greater transport resources will be required. Restrictions on where waste can be disposed plus the need to send waste products for recycling means that waste will have to travel further, increasing by implication the tonnekm travelled by a product in the last leg of its journey.

4.143 Impacts on transport can stem from general economic policy. In particular a major aim of policy by the Commission has been the development of a single market. In the White Paper of 1985 three categories of barriers to the free flow of goods, services, labour and capital were identified. These were physical frontiers - especially delays at intra-EC customs points on geographical frontiers; technical frontiers (including restriction that operate within countries) - different technical regulations for goods and services, discrimination against foreign companies regarding subsidiaries or tendering; and fiscal frontiers - variation in VAT or excise duties on goods imported from other EC countries.

4.144 All of these factors can be regarded as deterrents to movement across national borders. In theory they could be compared with the deterrence that freight costs impose on movement between countries. All of these factors can be translated into an increase in the cost per tonne particularly the first, if the delay time and inconvenience is known. One of the main impacts of the removal of these barriers, it was agreed, would be

> "… a reallocation of resources within each industry: the smallest and least efficient production plants would be replaced by larger and more efficient ones which, by means of exports, would find a way to increase the size of their market and thus reduce their costs by exploiting consequent scale economies."[46]

4.145 The gains from trade and economies of scale were analysed for Germany by Muller and Owen's study[47] and for the early years of the Common Market by Geroski and Jacquemin[48]. The analysis of completing the internal market suggested that the removal of barriers was equivalent to a tariff reduction of 2.5% (the costs of customs formalities were equivalent to 1.5%). The result it was suggested would be an expansion in trade, an increase in scale and a reduction in production costs of between 0.1 and 2.5%. The growth in trade was projected as ranging from 15 to 55% in different industries. Clearly these effects were felt in the transport sector which undertook to move the new international trade.

Variation in Supply Chains

4.146 Much of the discussion concerning drivers of intensity tends to be generic implying that all supply chains have experienced similar changes (or will in the future). This section examines the existing evidence in order to draw conclusions about their similarities and differences.

4.147 Particular attention has been paid to three supply chains – retail grocery, automotive and construction. In practice, references to the first supply chain refer to the links from final manufacturers through distribution centres to the retail outlets. Most of the evidence refers to large supermarket chains. In the case of the automotive supply chain most emphasis is placed on the component manufacturers to assembly manufacturer link. Despite its importance in terms of logistics cost, evidence on the construction supply chain is very sparse and never refers to the whole chain from raw materials to the final construction of buildings.

4.148 The first component of intensity – value density – can be seen in terms of density of product and its value per tonne. As the value per tonne increases, transport intensity decreases as also with decreases in the weight of a given product. In the food sector raw and fresh produce is tending to move further as a greater range of food becomes available to consumers. This increases tonne km. The other main feature is the growth in sales of prepared food and meals. This increases value for a product which may be smaller and lighter than the ingredients in unprocessed form.

4.149 In the automotive industry cars are increasing in weight through value added or regulation driven equipment. This weight of material is moved through the whole supply chain so increasing yet this is counterbalanced by the higher value (quality, performance) of the vehicle. The precise effect on value density is uncertain.

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[46] Emerson et al (1988). *The Economics of 1992*, Oxford University Press.

[47] Muller, J and Owen, N (1985). *'The Effect of Trade on Plant Size'*, Berlin

[48] Geroski, PA and Jacquemin, A. (1991). "Industrial Change, barriers to mobility, and European industrial policy"

4.150 Projecting the car case to other sectors to white goods (fridges, cookers, washing machines) and electrical equipment seems much clearer. The quality of white goods has increased whilst their weight has tended to reduce. A similar conclusion applies to most electrical and electronic goods. These trends should have contributed unambiguously to a reduction in freight intensity. However the effect on transport requirements will not necessarily have been so great; whilst the weight may have fallen, the volume (which determines transport resources required) has not necessarily followed.

4.151 In the heavy construction industry weight, and even costs of materials, are of less concern than completion dates and satisfactory long term operation. It appears that much the same materials are now of higher value, so transport intensity is decreasing. The same is generally the case for domestic buildings. Large buildings are the most likely to experience materials substitution because they are the domain of the foremost architects and highly specialised structural engineers.

4.152 One significant feature of the sectors is how the volume of products influences transport operations. Almost all the transport operations in the food distribution chain are limited by the volume capacity of vehicles and load factors, as judged by weight, are low. Car components are very mixed. The denser components, engines, gearbox, suspension, glass are more likely to hit weight limits while electronics, fabrics, and seas could be volume constrained. Volume is not normally the limit for most materials that are used on construction sites but the increase in prefabrication sometimes means that truck dimension are a factor and that very large vehicles may be used for relatively low weights.

4.153 Each of the three chains referred to has experienced rather different changes in manufacturing processes. One of the interesting features of these three sectors is the very different notions of manufacturing they involve. The food sector is closer to conventional production systems but the automotive involves the key element of assembly at a factory where all the components come together before a product can be said to exist. The construction industry is further removed from this in that its factory is at a site which can vary frequently in location and attributes. Some components arrive ready to assemble but a large amount of material making and shaping goes on at the site as well as all the connections and fastening.

4.154 The respective changes in manufacturing processes are an increase in ready meal manufacturing in the food sector. The automotive sector has experienced product specialisation by location, increased automation and innovative manufacturing technology with car designs that increasingly have to facilitate the closure of the materials cycle. The heavy construction sector is inventive about facilitating site work, its equivalent to manufacturing technology and management and the construction sector as a whole is tending to increase its use of prefabrication.

4.155 A considerable amount has been written on the retail grocery chain and their use of retail distribution centres. Whilst the general trend in most European countries has been towards fewer distribution centres, the number seems to have stabilised in the UK, the Netherlands and France. In other parts of the retail trade there is evidence of both a move towards RDCs and where a distribution complex exists for fewer distribution centres sometimes only one per country.

4.156 In the automotive industry the use of distribution centres for consolidation or stockholding is very limited. Sometimes third party distributors consolidate in centres adjacent to the final assembly manufacturer, and in post assembly stockholding centres are sometimes used before final delivery to the retail distributors. There is no discernible trend in this pattern and it appears to not be an important determinant of transport intensity. Some observers[49] note that the pattern of production value adding has changed in the industry. A move towards modularisation of components plus distributors performing product modifications based on customer orders has meant that the value added share of assembly manufacturers has fallen.

4.157 The construction industry supply chain often incorporates a number of warehouses that provide a stockholding role offering immediate availability. There seems little evidence concerning changes in their number at least in the UK[50]. Although the structure of the chain seems to be fairly stable, there has been a move towards modularisation which changes the balance of production value added, but with no important consequences for transport resource use.

4.158 In terms of taking up the use of innovations and adopting the latest thinking concerning logistics and supply chain management, the general opinion is that the automotive and the large retail grocery chains are in the forefront but that *"there is a long way to go before the construction industry is able to match the best of manufacturing and retail businesses in the way in which the supply chain is managed."*[51]

4.159 This may be due to the itinerant nature of much of the construction sector, moving from site to site. It is also likely to vary within the sector. For instance, single site large-scale house building lends itself more readily to supply chain management than road building. For some labour intensive construction the costs of materials is a relatively small proportion of the total value of the project and there is less incentive to apply sophisticated supply chain management. As a result the industry may not have enjoyed the benefits of the latest ICT innovations. As far as developments in management principles such as JIT their limited impact will mean that any effects on transport use and efficiency will not have been felt.

4.160 In the area of transport technology all the three supply chains will have experienced the reduction in road transport costs and the change in its competitive position with rail. The retail grocery and construction industry make very limited use of rail. In the case of automotive the share of rail has risen over the last 20 years for the post final assembly link.

4.161 The analysis of changes to intensity from a supply chain perspective is frustrated by a lack of data. Even the data based on NST/R data offers few clues for specific supply

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[49] TRILOG, op. cit.

[50] Ballard, R.L., Cuckow, H. (2001), 'A view of Logistics in the UK Construction Industry', The Logistics Business, Birmingham, UK

[51] Ballard, R.L. (2002), 'An introduction to good logistics practice and its current state in UK construction', The Logistics Business, Birmingham, UK.

chains. However it is interesting to observe the growth in average haul in the different categories (Table 4.3).

TABLE 4.3 PERCENTAGE CHANGE PER YEAR IN AVERAGE HAUL – AVERAGE FOR 5 COUNTRIES

25 Total from group 01 to 24	**2.0%**
01 Cereals	0.8%
02 Potatoes, other fresh or frozen fruits and vegetables	2.6%
03 Live animals, sugar beet	1.7%
04 Wood and cork	2.4%
05 Textiles, textile articles and man-made fibres, other raw animal and vegetable materials	1.7%
06 Foodstuff and animal fodder	2.3%
07 Oil seeds and oleaginous fruits and fats	0.8%
08 Solid minerals fuels	1.7%
09 Crude petroleum	2.1%
10 Petroleum products	1.8%
11 Iron ore, iron and steel waste and blast furnace dust	1.8%
12 Non-ferrous ores and waste	0.0%
13 Metal products	2.1%
14 Cement, lime, manufactured building materials	0.8%
15 Crude and manufactured minerals	1.7%
16 Natural and chemical fertilizers	0.7%
17 Coal chemicals, tar	1.8%
18 Chemicals other than coal chemicals and tar	0.9%
19 Paper pulp and waste paper	-1.1%
20 Transport equipment, machinery, apparatus, engines, whether or not assembled, and parts thereof	2.7%
21 Manufactures of metal	1.8%
22 Glass, glassware, ceramic products	0.0%
23 Leather, textile, clothing, other manufactured articles	1.6%
24 Miscellaneous articles	2.4%

4.162 With the exception of the *Paper pulp and waste paper* category it offers a picture of consistent growth over the 20 year period. The obvious construction category *Cement, lime, manufactured building materials* has grown slightly more slowly than the grocery related *Foodstuff and animal fodder* and the automotive related *Transport equipment, machinery, apparatus, engines, whether or not assembled, and parts thereof*. Overall these figures imply that for some reason sourcing distances have lengthened and market areas have increased for nearly all products. They must therefore have been subject to similar drivers. As argued before a major driver has been the reduction in transport costs and all supply chains will have experienced this. As far as the other major potential driver – greater economies of scale – is concerned it is unlikely that this will have been a consistent effect over all supply chains.

4.163 Overall therefore it is possible to detect some differences in the three supply chains both in their structure and the drivers which have affected them. However it remains a very incomplete and blurred picture and it is only possible to make simple qualitative statements.

Summary

4.164 Table 4.4 provides a summary of the conclusions concerning the importance of the various drivers. The preceding analysis has identified a long list of drivers. Evidence on the direction of their effect on the components of intensity can usually be deduced from the nature of the driver itself. Quantifying the effect however is far more difficult. Little or no evidence exists on many of the drivers. Often the evidence where it does exist refers to one type of supply chain in one country.

4.165 Examining the components of road freight intensity in turn, average product value density has decreased partly due to the change in the mix of commodities and partly due to the change in design of individual products. Both of these effects can be regarded as important in contributing to a reduction in intensity. Given the steady growth in GDP in European countries and the consequent change in product and service mix this impact will have occurred in all countries.

4.166 In the three areas investigated the evidence points towards a general increase in value density over the past 20 years. This has been partly due to the general increase in sophistication of individual products implying greater value per unit weight. This has occurred throughout the range of products – more processed foods, better performing cars, washing machines, electrical goods etc. At the same time new materials and manufacturing processes have led in many cases to lighter products. This tendency towards lower weight was widespread but not necessarily universal as the example of passenger cars showed. In total the sum of these changes in value density should have made a substantial contribution to a decrease in intensity. European countries have followed a similar path in their adoption of new products and manufacturing processes and therefore this effect should have been common over all countries.

4.167 The decrease in rail's share of the freight market has increased road freight intensity by 0.5% or more in some countries. The reason behind this is partly the relative decline in rail's traditional product market and its deterioration in competitiveness compared to road.

4.168 Evidence on supply chain structure and the handling factor (the number of times a product is lifted) suggests that there has been a steady trend towards fewer warehouses (or consolidation sites) in many logistics systems. The evidence for this is strong in the link between manufacturers and retailers particularly in the grocery trade. The trend has also probably been present in other parts of the supply. Different countries have moved towards greater concentration at different rates, but the trend has probably been present to some degree in all countries. With its implications for higher tonnekm this has been an important factor in increasing intensity.

4.169 Regarding the possible breakdown of the process of value creation into more production sites the evidence is very weak and there is no indication that this has been an important factor leading to an increase in tonnes lifted. A small effect on tonnes lifted may have occurred due to the greater requirements for recycling.

4.170 The increase in average haul is the major component behind the growth in road freight intensity, contributing perhaps 2% per annum to its growth. Again part of this is explained by the change in the mix of commodities. Other contributors are the realisation of a single market through the reduction of trade barriers and increased concentration of production. The scale of the latter is difficult to estimate – a number of commentators suggest it is a strong effect but this is not supported by evidence. The driver that is not usually given much prominence in the explanation of the rapid increase of average haul is the decline in the real cost of freight haulage. This must have been an important contributor to increases in market area and more remote sourcing. Firm evidence of its effect is lacking but, in the absence of other clear reasons for these two trends, it is rated as a very important determinant of the average haul trend. Examination of the growth in average haul for different commodities shows that it has been strong in all parts of the supply chain, in all supply chains and in all countries.

4.171 Taking the sum of these previous four components of intensity, the overall conclusion is that the major driver leading to a reduction in intensity has been the change in average value density. A number of other drivers have led to an increase in road freight intensity. A critical driver has been the change in road freight's relative cost. Increasing economies of scale (leading to greater concentration of production), improvements in warehouse technology (leading to logistical restructuring) and the realisation of the single market have all contributed to the growth in intensity.

4.172 Road freight intensity is not the only determinant of road freight's impact on the social costs associated with the environment and safety. Vehicle efficiency can mitigate the effects of increasing intensity. The limited evidence that does exist suggests that overall efficiency in terms of vehicle km per tonnekm has improved. A large part of this is due to the general increase in vehicle size and improvements in the lading factor and vehicle utilisation may also have contributed. The various factors identified as driving the growth in intensity also often have effects on efficiency.

4.173 The trend towards more variety in products and increasing demands for more frequent and precise delivery times is likely to have had a deleterious effect on both lading efficiency and vehicle utilisation. A counterbalancing force has been the greater use of ICT systems which have led to an improvement in the efficiency of vehicle operations.

4.174 A final point that should be made is that the environmental and accident cost per freight vehiclekm has been falling over the period. Figures for the UK show that between 1990 and 2000 an important component of accident costs - the risk of a fatality - fell from 3.1 to 1.9 per 100 million vehicle km for Heavy Goods Vehicles and from 1.4 to 0.6 for Light Goods Vehicles[52]. At the same time as accident costs were declining total emissions also fell by 24 to 33 % for ozone precursors, secondary particulates and acidifying substances due to the introduction of more friendly vehicles and fuels[53]. Thus whilst intensity may have been increasing modest improvements in vehicle efficiency and significantly more environmentally friendly vehicles have meant the damage cost of road freight movement has grown more slowly than GDP.

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[52] Department for Transport (2000) "Road Accidents, Great Britain: 2000", London.

[53] European Environment Agency, (2003). "Indicator: Transport Emissions of Air Pollutants (2002)".

TABLE 4.4 SUMMARY OF DRIVERS AND THEIR IMPACTS

Changes in	**Product value density €/tonne**	**Key logistic impacts**	**Handling factor**	**Modal share road**	**Average haul**	**Intensity**	**Vehicle payload**	**Lading efficiency**	**Vehicle utilisation**
Mix of products/services	↑			↑	↑↑	↑↑			
Configuration/design of commodities Packaging Variety/ customization Sophistication	↑	Smaller order size			↑	↓		↓	
Manufacturing processes Modularisation Materials Economies of scale	↑ ↑	Vertical disintegration of production Spatial concentration of production; either through reduction in plant numbers, or increased plant specialisation ('focused production')			↑	↑		↓	↓
Warehouse/handling technology Reduced costs		Spatial concentration of inventory Development of break-bulk / transhipment systems Centralisation of sorting operation in hub-satellite network	↑		↓	↑			
Information technology Increased use of ICT Increased use of e-commerce		More efficient transport operations						↑	↑↑
Logistics management Application of JIT principles, quick response and ECR in retail distribution Proliferation of booking-in / timed-delivery systems		Less efficient transport operations						↓	↓
Technology of transport systems Improvement in road's relative cost/performance *Management of transport systems*		Wider geographical sourcing of supplies Wider distribution of finished products Increased use of outside transport / distribution contractors		↑↑	↑↑	↑↑			
Government Regulation Changes in vehicle size regulations Taxation Recycling requirements Realisation of Single Market		More efficient transport operations More movement per product	↑		↑	↑	↑		

5. THE FUTURE COURSE OF INTENSITY

Overview

5.1 The previous Section provided an assessment of the importance of different drivers behind the growth in road freight intensity during the last 20 years. This Section examines the role these drivers play in influencing its growth over the next 30 years.

5.2 Our first assumption is that GDP will continue to grow steadily in the countries of Europe and that the driving force behind this (as in the past) is the emergence of new technology and its gradual dispersion throughout the industries of the countries. However as others have observed[54] the future growth of knowledge (new technology, new management practices) cannot be predicted, and therefore predictions of the future tend to fall back on an assumption that past trends will continue uninterrupted. The approach adopted below is to examine the past trends of the drivers and consider whether these will continue or whether there are reasons to expect them to change.

5.3 The point has been made before that due to the paucity of evidence and the difficulty of matching cause and effect, the conclusions drawn previously have made little distinction between supply chains and between countries. Below we address the issue of how countries and supply chains may differ but, again due to the poverty of past statistics with only limited penetration.

5.4 The European Commission forecast in the White Paper[55] that 'Road haulage is set to grow by 50% between 1998 and 2010[56].' With an average annual growth rate of 3% this implies a slight increase in road freight intensity (of about 5%). The Commission aims "… through an integrated package of measure, … to limit the increase to 38%", which implies a slight reduction in road freight intensity. No detailed explanation is available of the precise assumptions behind these figures.

5.5 A recent EC sponsored project, EXPEDITE, provides freight forecasts up to the year 2020. The results are closely related to those found in SCENES[57]. The prediction for truck tonne-km on EU territory during the period is an average growth rate (4 scenarios are examined) of just under 3% for the 15 countries. This compares with an average growth in GDP of about 2.5%. Together these figures suggest a slight increase in road freight intensity throughout the countries of the EU.

5.6 The discussion that follows provides some explanation of how the components of intensity may evolve and assess their contributions to the change in intensity.

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[54] Originally in Karl Popper's, "*The Poverty of Historicism"*

[55] European Commission, (2001), "European Transport Policy for 2010: A Time to Decide"

[56] The Marco Polo Programme, http://europa.eu.int/comm/transport/themes/land/english/lt_28_en.html#polo

[57] SCENES - European Transport Scenarios (2002), ME&P, UK, Deliverable 7. April 2002.

Configuration Design of Commodities

Product Design

5.7 In Section 4 the basic features of product design and their trends were introduced and the way in which certain attributes interact with transport intensity developed. The main dynamics identified were

- a trend to lighter and smaller products (unless mass is itself necessary for function) though cars, for instance, have increased in weight over a long period
- an increase in variety of products leading to higher value and also longer hauls
- increased sophistication of products through value-added facilities or attributes leading to higher value per product

5.8 There are examples which are counter to these trends. However if they continued then on balance they would contribute to a reduction in freight intensity. The function of this section is to consider what the longer-term changes might be.

5.9 It has already been argued that product design cannot be separated from production technology and developments in materials science. As one report says[58] "*In reality, the development of new technologies is a co-evolutionary process in which social and technical structures are changing, simultaneously influencing each other continuously.*" In other words technology creates opportunities in the consumer design space while consumers evolve their needs and preferences in an interactive process.

5.10 Numerous studies have explored trends in both consumer preferences as well as the demand for intermediate products by industry. The Fraunhofer-Institute report offers some broad ideas about the underlying drivers that might affect product attributes. For instance under the driver of "*Internationalisation of markets (increased competition, culturally differentiated markets)*" they include these likely responses to product design:

- Producing cost effectively in low lot-sizes
- Modularisation of products will draw on the advantages of mass-production while satisfying the need for individual products (mass customisation)

This trend therefore is predicted to continue and seems consistent with increasing product value as products are designed so as to match more nearly both more diverse markets and specific customer requirements

5.11 And under Environmental Concerns (increasing environmental consciousness, conservation of resources, tightening of environmental laws).

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[58] 'The Future Of Manufacturing In Europe 2015-2020: The Challenge For Sustainability, Industrial Approaches - Transformation Processes Strand Report On Work Packages 3, 6 And 10' Second Draft, Fraunhofer-Institute for Systems and Innovation Research, University of Cambridge - Institute for Manufacturing with the contribution of Technical University of Munich and Industrial December 2002.

- In the long run rising prices of resources like fuel and raw materials are expected to initiate severe changes. From today's point of view no shortage of important resources is to be expected within the next 50 years
- Concepts of re-manufacturing (closed loop recycling management) will become essential when resources become scarce.

This is consistent with a number of studies and suggests no constraints on the trends towards lighter products.

5.12 However there are countervailing pressures. For instance, relative growth and competition in the world economy for raw materials could lead sooner rather than later to higher rates of materials substitution and to closure of materials cycles. The idea that industry should "*Manufacture products with high durability and to develop concepts for intensifying their use"* and enable them to be both repairable and upgradeable also suggests that products might weigh more (because components have to be accessible and separable) though, again, probably at higher value.

5.13 Two further points which seem at first sight to act in opposition are:

- According to these experts there will be less willingness to pay more money for green products but rather for special functions (fun society).
- The internalisation of external effects will probably contribute to the competitiveness of green products and green production.

It is not at all clear whether there is any systematic change in product weight with "greenness.

5.14 The notion of sustainability demands that there be adaptive capacity in the producers and in the product using population (other companies, the community at large etc). Amongst the large range of material on this subject only occasionally does the concept of "sustainability" appear and never is it adequately defined. More often than not it is taken to mean a closure of the materials cycle and some aspects of environmental impact and always under the assumption of economic growth.

5.15 It appears therefore that the general trend towards more sophisticated and more personalised products is expected to continue (with its implications for product value). At the same time the trend towards the use of new lighter materials should not be seriously jeopardised by environmental pressures or materials shortages. A steady movement towards higher value density can therefore be expected in both the short and long term.

Product Logistical Attributes

5.16 In Section 4 the logistical attributes of products were identified along the classification of Dowlatshahi[59] and categorised into 7 attributes. Attention was drawn to the extent to which volume limits are reached in transport vehicles rather than weight limits. Unless there is a reversal in the trend for lighter and more diverse products this volume limit is likely to be a more common constraint in the long term. Volume limits

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[59] Dowlatshahi, S (1996) op.cit.

lead to more vehicle km rather than more tonne km. In the long run transport intensity, as a measure of environmental impact, will fail to register this need for more vehicle km deriving from increased volume. Consequently, using tonne kilometre alone may lead to a bias if used as a headline indicator for sustainable development.

5.17 An increasingly large proportion of the movement of food is for processed chilled and frozen products. These need temperature-control resulting in loss of maximum tare weight. Even some ambient food products need precise temperatures to reduce degradation. Increasingly other products are designed to operate within rather precise environmental conditions and should not be exposed to extreme conditions in transit. Increasing amounts of "environmentally" conditioned movement is likely to be associated with a decrease in effective fleet capacity. Again it might be expected that tonne km will not increase but vehicle km will. Product values are likely to be higher.

5.18 Hazardous products tend to use specialised vehicles with a lower net weight capacity because of on board equipment or the weight of special containers. These materials are often sent by other modes where at all possible. An increase in these products can be expected in line with manufacturing growth. In addition more materials may be declared hazardous as sensitivities to products grow.

Product and Value Density in Sectors

5.19 Much of the discussion concerning drivers of intensity tends to be generic implying that all supply chains have experienced similar changes (or will in the future). This section examines the existing evidence in order to draw conclusions about their similarities and differences.

5.20 Particular attention has been paid to three supply chains – retail grocery, automotive and construction. In practice references to the first supply chain refer to the links from final manufacturers through distribution centres to the retail outlets. Most of the evidence refers to large supermarket chains. In the case of the automotive supply chain most emphasis is placed on the component manufacturers to assembly manufacturer link. Despite its importance in terms of logistics cost, evidence on the construction supply chain is very sparse and never refers to the whole chain from raw materials to the final construction of buildings.

Food

5.21 A UK overview of the food and drink sector[60] offers some insight into the underlying dynamics of food products. Food and drink processing is a relatively stable and mature industry with expectations of around 1-2% in value growth and less by weight. Value density is thus still increasing but slowly at about 3% per annum and transport intensity is thus reduced.

5.22 Food processing in the UK accounts for 80% of the industry's total sales, of which meat, dairy and bakery products account for about half. The industry, while dependent on agriculture is essentially based on manufacturing and distribution. Processed foods

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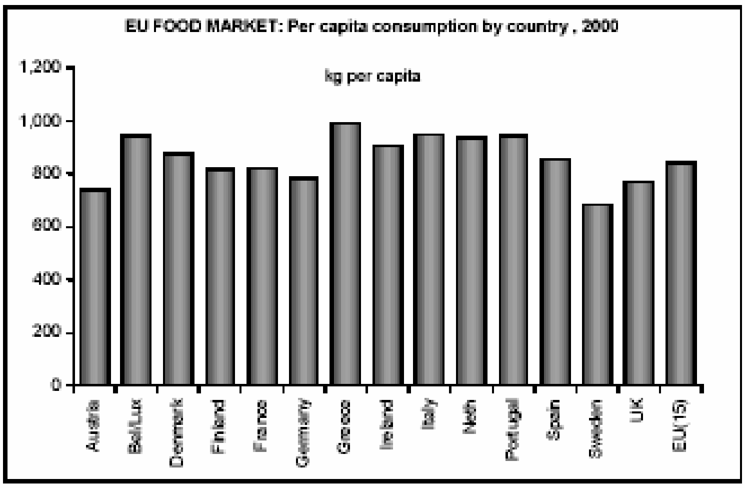
[60] Barclays Bank, (2002). Food and Drink Processing, www.business.barclays.co.uk November 2002.

are higher value for the same weight and their share will continue to grow, making a contribution to the reduction in transport intensity.

5.23 Product diversity and branding continue to exert a considerable influence on this industry sector. This leads to stockholding of wider ranges of products. Changing lifestyles and eating habits have encouraged growth in the consumption of healthy foods, snacks and soft drinks. It may be expected that organic foods will reach a critical threshold at which there are economies of scale in production and distribution. However, the sourcing of these products could become from further if variety is a driver. On the other hand environmental and ecological pressures might lead to a reduction in "food miles" and the buying of more local products. There are implications for both changes in tonnekm and in tonnes lifted as well as a trade-off with value.

5.24 Two further factors may be relevant. Food safety has become a major issue across Europe. At the same time there is increased interest in organic foods. In both cases information about the product and its life cycle must be provided. The interest in food and personal health has also increased the amount of fresh fruit and vegetables consumed. The sourcing of these is sometimes from a long distance (Africa, S America) and tonne miles will increase (largely through air transport).

FIGURE 5.1 EU FOOD MARKET: PER CAPITA CONSUMPTION BY COUNTRTY, 2000



Source: RTS Associates

5.25 The USA[61] has a somewhat distinctive position on the development of food products. In looking to "Provide Research Base for New and Differentiated Products" it emphasises

- Identifying products with greatest potential for adding value to raw agricultural materials.

[61] Improve Global Competitiveness of U.S. Food, Agricultural, and Forest Products www.nal.usda.gov/services_and_products

- Developing and evaluating physical, chemical, genetic, and other approaches to modifying plant or animal materials used in making new products.
- Devising processing controls that measure and monitor physical, chemical, and thermal properties for cost-effective production of safe, high-quality products that meet market demands.
- Developing quick, cost-effective ways to improve product safety and quality during processing.

5.26 And the expected outcomes are

- More value-added products for export.
- Development of new products and new uses for agricultural products.

5.27 The major thrust is expected to be towards food engineering and manufacturing in such a way as to increase product value. It is unlikely that average food consumption by weight in the USA could increase very much so the net effect of increasing value is to decrease transport intensity. It might be argued that such policies could not arise in Europe where there is a much more critical view about the safety of engineered food (See CIAA Survey)[62]. This may provide some constraint on the development of processed food but, if the experience of the past 20 years is relevant, it will not inhibit its growth.

5.28 A public's perspective on the underlying attitudes to food (and hence to future food products) can be found in a cross European survey by The Institute of European Food Studies (IEFS)[63]. The main barriers to healthy eating were:

i. lifestyle factors such as irregular work hours and busy lifestyle
ii. giving up favourite foods and willpower; and
iii. price of healthy foods.

Most subjects (i.e. 97%) have some opinion of what healthy eating involves. Many concepts were used to describe healthy eating and definitions varied greatly across the EU. Nutrition guidelines such as eat less fat, eat more fruit and vegetables and balance/variety featured as common definitions for healthy eating.

5.29 It is the dynamics of these types of public opinion and actions that are unpredictable but capable of stimulating substantial changes in the food chain, potentially away from highly processed foods, and in contradiction to the high tech approach of the USA. Some recent information from CIAA is shown in the figure below.

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[62] CIAA (2002). "*What do European consumers think about their food?"* European Food Survey, Brussels 11 April 2002.

[63] Institute of European Food Studies (date). "A pan-EU Survey on Consumer Attitudes to Food, Nutrition and Health".

TABLE 5.1 OVERVIEW WORLD MARKETS FOR ORGANIC FOOD & BEVERAGES (ESTIMATES 2000) ORGANIC FARMING IN EUROPE

	Retail Sales Million $	% of total food sales	% of expected growth medium term
D	2,100-2,200	1.6-1.8	10-15
UK	1,100-1,200	1.0-2.5	15-20
I	1,000-1050	0.9-1.1	10-20
F	800-850	0.8-1.0	10-15
B	100-125	0.9-1.1	10-15
DK	350-375	2.5-3.0	10-15
Ő	200-225	1.8-2.0	10-15
NL	275-325	0.9-1.2	10-15
S	175-225	1.0-1.2	10-15
CH	450-475	2.0-2.5	10-15
Other Europe*	400-600	-	
Total Europe	**7,000-7,500**	**-**	
USA	7,500-8,000	1.5-2.0	20
Japan	2,000-2,500		
Total ca.	**17,500**		

(*) Finland, Greece, Ireland, Portugal, Spain, Norway

Source: CIAA using International Trade Centre

5.30 The implications of these consumers' (and environmetalists') concerns might be to push for extensive low input farming, more added value processing in developing countries, a new preference order for ingredients based on ecological metrics and a reaction against engineered food and GM. At the moment these are not seen as likely developments.

5.31 The Confederation of the EU Food and Drinks Industry provides some basic data on CEEC economies[64]. Similar information about the automotive and construction sectors does not seem to be available. The information (Table 5.2) suggests that initially these countries will contribute to the food chain through provision of basic agricultural produce – with low value density and, fairly lengthy hauls to Western Europe (leading to an increase in intensity). In practice there is already some international movement of food products from these countries.

[64] The Confederation of EU Food and Drink Industry, www.ciaa.be.

TABLE 5.2 FOOD INDUSTRY PRODUCTION CHARACTERISTICS IN CEEC ECONOMIES

Estimates 2001	Production (€ billion)	Employees (x 1000)	Companies	Main sectors (% of food industry production)
Estonia	0.62	21	120	Dairyprod. (29), beverages (18)
Hungary	7.20	119	3,195	Meat, poultry and fish (29), dairy prod. (11)
Latvia	0.75	27	225[1]	Various food prod. (24), dairy prod. (20)
Poland[2]	21.10	346	2,939	Meat (21), various food prod. (21)
Czech Republic	7.30	117	1,023	Various food prod. (24), meat (20.5)
Slovakia[1]	2.44	46	346	Various food prod. (22), beverages (20)
Slovenia[1]	1.84	18	97	Various food prod. (20), meat (19)
Lithuania	1.34	44	467	Dairy prod. (26), various food prod.(19)
Romania[1] (Acceding 2007)	4.20	165	1,725	Beverages (31), various food prod. (23)
Bulgaria (Acceding 2007)	1.50	92	n.a.	Beverages (26), various food prod. (20)

[1]More than 20 employees [2]More than 5 employees (n.a.) not available
The category "various food products" comprises amongst others confectionary, biscuits and food preparations. Source: CIAA using CEC Federations data.

5.32 In the longer term these countries may be expected to move from predominantly basic food production and processing and to develop food manufacturing on a scale similar to existing EU countries. Where the Acceding countries currently produce specialist foods, or foods with a seasonality that complements producers in other parts of the EU and the wider food economy, there may be an increase in the amount of agricultural products moved internationally. This could happen fairly quickly as trade barriers are removed though it also depends on the amount and type of any surplus food production. Depending on the location of markets within the wider EU this could lead to longer hauls.

5.33 The long-term prospects are far from certain. For instance, changes in EU agricultural policy could favour a reduction in “food miles” and more local buying of produce while food product manufacturing (and hence value density) would be likely to grow in the Acceding countries. In any event considerable developments in logistical efficiency may be expected overall in these countries. In turn this may reduce transport costs. If that reduction is passed to the customer in order, perhaps, to gain market share the value density might actually decrease or average haul increase. In addition, many of the Acceding countries have significant amounts of arable land and rainfall patterns and hydrology that favour agricultural production. In the very long term, as their agricultural sectors become more efficient it is possible that the geography of EU food production may change considerably, particularly since the loss of agricultural land and water difficulties are so widespread in the South of the EU. This larger geography is more likely to generate longer average hauls which may in turn be balanced to some extent by increasing value density through food manufacturing.

Automotive

5.34 The issue here is whether the product value (in €/tonne) of cars will increase or decrease over time (leading to a decrease in transport intensity for the delivered product) and whether the average haul of components will rise or fall. The components are assumed to follow a similar weight trend to the assembled car, though other materials used further back in the supply chain might also be taken into account. The number of tonne km moved by components depends on what goes into the assembled car and any changes in spatial distribution of the supply network. Examples are given in REDEFINE of the logistical pathways of some typical car components.

5.35 There is a very wide range of source material about the automotive industry, its product, technology and manufacturing developments and futures but when it comes to the particular attributes of product value density and average haul that are relevant to transport intensity there is very little material. However, a significant source of information about the future of the automotive sector is the recent report by Wengel, Warnke, and Lindbom.[65] The report offers a small amount of information specifically about weight.

> *In order to reduce the fuel consumption, designers in the automotive industry are aiming at reducing the weight of cars as far as possible. By 2020, the weight of a car is expected to be reduced by 17% (250 kg). Accordingly, weight reduction is one of the main drivers of material selection in automotive industry.*

This is in some contradiction with the information offered earlier about the previous tendency towards increasing weight of cars. Sometimes only the body weight of a car is referred to as the weight of a car. If this is not the case then quite a substantial change is taking place. Miniaturisation of some components would support this trend, as would materials substitution. There are also some reports of attempts to spin carbon fibre to form complete body shells. Any trend towards cars powered by hydrogen or some new form of batteries would have implications for weight. Information should soon be available concerning the former since Madrid now has a hydrogen powered bus in operation and in Rome it is reported by the motorcycle press that some fuel cell powered scooters are under test. Battery vehicles in their current design are certainly heavier than petrol driven cars.

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[65] Wengel, J, Warnke, P and Lindbom, J, (2002), "The Future Of Manufacturing In Europe 2015-2020: The Challenge For Sustainability" Draft Case Study: Automotive Industry – Personal Cars, *Integration Of Results From Wp2-11 For Selected Key Sectors*, Fraunhofer Institute for Systems and Innovation Research, Karlsruhe, December 2002.

5.36 The main socio-economic influences identified by the report form the basis of the commentary below followed by some further points including an observation about tonne km in the components supply network.

5.37 ***Increasing individualisation.*** There are already signs of increasing variety in the cars available within a given model. The variabilities include engine size, suspensions, braking systems, wheels and tires at the engineering level and then a host of features from body additions to sound systems. This paper (and a range of other sources) expects variability to match highly specific customer requirements to increase, at least for the existing markets where car ownership will tend towards saturation over the next twenty years. The paper notes that "*Several experts from the automotive sector think that customers will be ordering their individual car to be manufactured in 2020.*" This is also consistent with one view of the future structure of manufacturing where larger numbers of smaller, high tech plants, make bespoke cars.

5.38 ***Changing social attitudes.*** Safety has always been a preoccupation of manufacturers and government and safety equipment has generally led to heavier vehicles. The time may come when further safety improvements are no longer demanded. It is thought by some psychologists that many people drive to some constant marginal risk – the safer the car or the conditions the faster they will go and that further improvements in safety may not be needed. A different approach to safety (but also driven by the need to use road capacity efficiently) is the proposal for electronic control and guidance systems. These might tend to increase weight, though only slightly. It is conceivable that at some stage cars might become more uniform in design, for such reasons, and that customer demand for self-identification through the distinctive features of a car might decline. This would tend to decrease weight.

5.39 ***Demographic change.*** Europe as a whole has an ageing population. This means that there are more and more drivers who have preferences for comfort and ease of driving. For conventional engine technology this could result in more use of automatic gearboxes (and more weight/value trade-offs). Fuel cell or battery technologies would have variable transmission through other features of the technology.

5.40 ***Natural Resources.*** At the moment the finding of oil resources is faster than the growth in use, and will be so for some time. There are, however, very large growing economies in the world (China, India, S America) who will compete for those natural resources. Quite apart from the environmental objections to burning fossil fuel prices could be driven up and precipitate a structural change in how its use is viewed. Either fuel substitution would be accelerated or cars would have to be very efficient (technology ecologists talk about 30-40 km/litre) and to do so would have to be much lighter. A number of studies suggest that shortages of the other materials are unlikely over the next 40-50 years.

5.41 ***Environmental legislation.*** In one sense this is a matter social change. Recovery of materials from "end of life" (ELV) cars might actually increase weight because of the demands of disassembly methods. In addition no one has yet done the calculations about the impact on transport intensity of the recovered materials.

5.42 ***Ownership v use.*** Another possibility is that the nature of ownership might change so that people would hire the use of car on a recurrent basis. This could be in conjunction with access to other modes of transport – a sort of variation on car-hire. As the report says, "*This would certainly have consequences for the design of cars (modularity, robustness, upgradability, etc.) as well as for the design of other modes of transport and the infrastructure, and in turn for the manufacturing process*."

5.43 ***Average haul.*** In considering the tonne km moved by components it is clear that some experts see the potential for high tech small-scale factories producing different designs of car to order for relatively small populations. At one limit this might be able to manufacture almost any car but, assuming large companies want independence, then there may be a prospect of franchising such units. Almost all of the commentators on manufacturing see smaller scale activities implying shorter supply chains and therefore lower transport intensity.

5.44 ***Variety.*** It is worth repeating in this context a quote used earlier based on a UK study about variety in vehicle types, remembering that in general variety tends to increase value for the same weight and thus product value density.[66]

> *"This contribution aims at predicting future trends in the automotive industry in terms of product variety, model range and product life cycles in the UK automotive market. The analysis is based on empirical data dating back to 1960, which is extrapolated into future trends. The findings indicate no consistent trend in regards to product variety, which seems to be merely driven by vehicle manufacturer's policy, but could identify a clear trend towards shorter product life cycles and increased model ranges offered in the UK market. These trends in consequence will force vehicle manufacturers increasingly to design and introduce vehicles that are far less dependent on economies of scale, as the overall volume per model is predicted to decrease drastically. Current efforts of the vehicle manufacturers to meet these requirements, the product platform strategy for example, could also be identified."*

5.45 The balance of these factors points towards an increase in product value together with a reduction in weight. Both of these changes might be quite modest over a period of 20-30 years. The latter may be inhibited by requirements of new systems (particularly if these involve new motive systems). Together however they should ensure that there is a modest increase in value density.

Construction

5.46 Although this is a major sector in terms of transport movement and production it does not appear to have received quite the attention of other sectors. In 1998 the UK Institution of Civil Engineers undertook a substantial foresight activity. A notable part of that was the emphasis on environmental improvement and sustainable development.

5.47 A recent study of the logistics on building sites in the UK estimated that waste materials through poor management might be between 5% and 20%, with heavier items such as bricks being the worst. Any substantial reduction in waste would reduce

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[66] Holweg M op cit.

transport intensity though earlier it was noted that weight of materials is not a sensitive issue for many large constructions.

5.48 Extracts from an American view[67] about the future of the construction industry relevant to freight intensity are shown below.

- More prefabrication of components — everything from interlocking structural systems to integrated water, wastewater, and energy utility systems — could lead to more tonnekm as this stage is inserted into the supply chain
- Higher energy costs will drive the availability of mass produced units/modules and may obviate the need for some design and construction functions – may lead to more concentrated production facilities with implications for average haul
- The integration of components could also mean that functions will be integrated as well; the high cost of energy may mean that rather than just requesting a wastewater plant, clients may require an integrated water, wastewater, and energy plant, or may ask for an integrated waste management plan rather than just a landfill or incinerator – could mean more concentrated production
- Environmental concerns will likely be built into the design of the project rather than seen as an add-on to mitigate the impacts of a conventional design.- could add weight to components
- Productivity of energy and materials could be a key design criterion as the real cost of resources rises. Also, carbon credit trading could alter project economics.- if this is reflected in transport costs average haul could be reduced
- Infrastructure may get smaller and more decentralized with technology miniaturization – should mean lower weight per product unit
- Knowledge of advanced materials will be recognized as an essential competitive asset; new materials introduced into practice could provide cost effective advantages – likely to lead to lighter products
- Advanced biotechnology will be the leading source of innovation in environmental engineering – likely to lead to lighter products..

5.49 Interpreting the precise impact on transport intensity of such speculation is problematic but the themes of prefabrication, reduction in size and the introduction of new materials associated with reduction in maintenance and reduction in life cycle costs can be expected to favour a reduction in value density but this will be balanced by an increase in average haul in this sector. The issue of improved logistics management, which might lead to changes in the structure of the supply chain and the scheduling of products, may prove to be important.

5.50 The role of prefabrication is consistent with the findings of EU logistics case studies. The effect of prefabrication is to increase value while often the prefabricated item is lighter than one constructed on site. On the other hand the items are large and have to be transported on large vehicles whose weight capacity is not fully used. The distance of the weight moved has to be compared to that moved by bulk materials and this will clearly vary from one location to another but a somewhat greater distance for

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[67] The Future of the Design and Construction Industry CERF, 2131 K Street NW, Suite 700 Washington DC 20037. www.cerf.org

prefabricated items might be expected. The combined effect of reduced weight, increased value and increased distance probably tends to reduce transport intensity.

5.51 Reduction in size partly is not so much about the size of the construction but refers to components and sub-systems of construction. For instance, a new generation of membrane technology enables water treatment and recycling to be undertaken cost-effectively at the scale of large buildings or a small estate of houses. More generally structural changes in the spatial distribution and in the adaptability of buildings probably will result in more “clever” systems, lower weight and more value. The trend is likely to contribute to a reduction in transport intensity.

5.52 The use of new materials is likely to either reduce costs or add attributes which are desirable to the user and which add value. It may contribute also to a reduction in weight and to a reduction in maintenance and therefore replacement. To the extent to which such changes are associated with specialisation then the distances moved may be more (for less weight). The overall effect on transport intensity is, at worst neutral, and probably better.

5.53 A point noted earlier is that fixtures and fittings for buildings have increasing variety. For instance there is a much larger range of ceramics available now then twenty years ago. Some of these fittings are much cheaper in real terms, while at the other end of the scale are high quality and specialist items.

5.54 Quite what the building landscape across the EU will look like in 20-30 years would require a complex interdisciplinary exercise to even generate sensible scenarios. On the basis of what we know at the moment it is likely that the increase in average haul may outweigh any reduction n value density meaning tonne km will increase.

Acceding Countries

5.55 Lack of useful information limits any understanding of how changes in products and manufacturing might affect transport intensity in the Acceding Countries. For the three sectors - food, automotive, and construction - it is possible at least to give some context to future changes in these countries although more detailed analysis will have to await more data.

5.56 A most useful contribution to understanding manufacturing and other sectors in the Acceding Countries (PAC’s) has been made in a report by of IPTS, Seville[68]. It is based on a questionnaire survey in the spring of 2001 of people with particular knowledge about the science and technology base and trajectories in these countries. Its main aim was to identify features of science and technology policy but it also provides a convenient proxy as a comparative description of the industrial bases of these countries. Where relevant sectors are mentioned they have been highlighted.

- Two groups of sectors can be distinguished. The first group, with. an average technological position, consists of telecommunications and ICT, energy, banking

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[68] Tübke, A (2001). “Technology Assessment and Foresight in the Accession Countries: A Question of Policy Priorities?” Institute for Prospective Technological Studies (IPTS) European Commission, Joint Research Centre, Seville, Spain.

and insurance, chemicals, **construction and civil engineering**, **wholesale and retail trade**, and knowledge-intensive services.

- The technological position of the second group is rather weak, comprising the sectors electronics and electrical equipment, transport, **manufacturing of basic components**, **agriculture** and forestry**, manufacturing of machinery**, and **car manufacturing**.
- During the next ten years, improvements of the technological position are expected in all sectors. According to the respondents, the biggest improvements of around 30 % will accrue to electronics and electrical equipment, **manufacturing of machinery**, and telecommunication and ICT.
- Improvements of less than 10 % are expected to arise in the energy sector, in **car manufacturing**, and the chemical industry. **Car manufacturing** and the chemical industry are sectors largely determined by foreign companies.
- Five groups of countries emerge when examining the present technological position per country with respect to the EU-15. The Central and Eastern European Countries (CEECs), consisting of the Czech Republic, Hungary and Poland, do not show relative weaknesses in specific sectors and provide the most competitive energy sector, chemical industry and transport sector.
- The other two bigger countries Bulgaria and Romania also show a relatively homogeneous distribution of their technological position among the sectors, but at a lower level than the CEECs and with a considerable weakness in **car manufacturing**.
- The smaller countries reveal a bigger dispersion of their technological position among sectors. The Baltic countries Estonia, Latvia and Lithuania have a relatively strong telecommunication and ICT sector and a more competitive banking sector than the other PACs. However, they are relatively weak in **car manufacturing**.
- The Mediterranean countries (Cyprus, Malta and Turkey) show a similar pattern like the Baltics, but with a considerable weakness in the knowledge intensive services sector. Smaller weaknesses in comparison to the Baltics exist in the telecommunication and ICT, the energy, and the banking and insurance sectors. The Mediterranean countries have a stronger position than the Baltics in **car manufacturing**.
- Slovakia and Slovenia follow a pattern comparable to the Mediterranean countries, but with a weaker position in agriculture and forestry and a stronger position in **car manufacturing**. The CEECs expect improvements in the telecommunication and ICT, energy, and electronics and electrical equipment of around 20 % during the next ten years.
- Slovakia and Slovenia, for example, expect very high changes in the energy and knowledge-intensive services sectors. Bulgaria and Romania hope for considerable improvements in the electronics and electrical equipment, agriculture and forestry, and **car manufacturing** sectors. It is interesting to note that the other countries have moderate to negative expectations for the **car manufacturing** sector.

5.57 The insights into potential changes in technological position (not necessarily translated into growth in the economy), based on expectations of policies and the technological state of the economies in various sectors as derived by Tübke (2001) are shown in

5.58 **Table 5.3** below. These seems consistent with the findings of the TRILOG Delphi survey[69] discussed earlier, which suggests that Eastern Europe as a whole will be attractive for manufacturing in the short term (to 2005).

TABLE 5.3 CHANGES IN TECHNOLOGICAL POSITIONS AND POLITICAL PRIORITIES

	Bulgaria	Czech Rep	Cyprus	Estonia	Hungary	Latvia	Lituania	Malta	Poland	Romania	Slovakia	Slovenia	Turkey
Telecom and ICT	++	+	+	+	+	+	+	+	+	++	+	+	+
Energy	++	++	++++ +	+++	++	+++	+++	++++ +	++	++	++++ +	++++ +	++++ +
Banking and Insurance	++	+	o	o	+	o	o	o	+	++	o	o	o
Chemical Industry	+	+	+	+	+	+	+	+	+	+	++	++	+
Construction	+++	+	+	+	+	+	+	+	+	+++	+	+	+
Wholesale and Retain Trade	++	+	+	++	+	++	++	+	+	++	+	+	+
Knowledge-Intensive Services	+++	++	+++	++	++	++	++	+++	++	+++	++++ +	++++ +	++
Electronics and Electrical Equipment	++++ +	+++	++	++	+++	++	++	++	+++	++++ +	+++	+++	++
Transport	+++	++	++	+++	++	+++	+++	++	++	+++	+++	+++	++
Agriculture	++++	+	o	+	+	+	+	o	+	++++	+	+	o
Manufacturing*	+	+	+	+	+	+	+	+	+	+	+	+	+

Note + indicates a 10 % expected improvement of the technological position until 2011 o indicates no expected change of the technological position until 2011 a field indicates a policy priority * manufacturing comprises manufacturing of basic components, manufacturing of cars and manufacturing of machinery Source: Tübke (2001).

5.59 The interest from a transport intensity viewpoint about the commentary above is whether the experiences of the EU 15 will be translated into a deferred experience in the Acceding Countries or whether they will follow a range of idiosyncratic pathways. A relatively rapid increase in GDP might involve an increase in transport intensity if these countries are the focus of the changes in manufacturing towards more (focused) specialisation. That in turn will depend on the sector specialisations of the countries as well as the efficiency of their freight transport operators.

[69] McKinnon, A., Forster, M., 'European Logistical and Supply Chain Trends:1999-2005.

5.60 The development of road freight intensity over the last 20 years was strongly influenced by the change in the mix of products and services experienced by economies as their GDP increased. The forecast for the future is that the share of services will continue to rise (and the share of manufacturing fall). This trend is predicted for all countries of the EC as well as the Acceding Countries[70].

5.61 Given the lower levels of GDP (and lower share of services) found in the Acceding Countries the level of road freight intensity in these countries should be higher than their EC counterparts and this is borne out by the evidence of Section 3. (The average figure in 1999 was at 220 t/k€ about 20% above EU15). In the future the decreasing share of services should contribute to a reduction in freight intensity as GDP grows in these economies.

5.62 It could be argued that the reduction in the share of manufacturing in the Acceding countries will be greater than in the EU15, because the *rate of decline* in the share in the latter must start to fall as the figure approaches zero.

5.63 Section 3 also suggested that the mix of commodities may have moved towards higher value density (and at the same time longer haul) products. As far as the change in the mix of products is concerned the Acceding countries should experience an increase in average value density as GDP rises to EC levels. Whether future changes in the mix in EC countries will lead to a change in average value density is more speculative. Construction with a relatively low value density makes a large contribution to tonne km and can be expected to maintain its share of GDP.

Logistics and Manufacturing

Warehouse Technology and Logistical Restructuring

5.64 The path of logistical restructuring is dependent on trends in warehousing and transport costs. As their relative cost changes so does the argument in favour of more or less distribution centres, or the introduction of hub and spoke systems. Costs are not necessarily the only driver. The move towards better customer service may influence the number of stockholding locations.

5.65 In the TRILOG Delphi survey conducted throughout Europe in 1999[71] the pace towards stockholding centralisation showed no tendency to slacken.

> *At a European level, the degree of inventory concentration is forecast to increase by a third, twice as much as at a national level. A significant minority of the panel (around 15%) indicated that within countries there would be net decentralisation of inventory, with firms increasing their number of stockholding points. The prevailing view, however, was that inventory centralisation, which has been one of the main logistical trends over the past 30 years, would continue apace for at least the next 5 years.*

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[70] Directorate General for Economic Affairs, ‘Evaluation of the2001 Pre-Accession Countries’, Jan 2002.

[71] McKinnon, A., Forster, M., ‘European Logistical and Supply Chain Trends:1999-2005

5.66 The general impact of centralisation is to increase tonnekm. If as argued in below the real cost of transport starts to rise (due to limited technological improvements, higher road congestion and policy initiatives to impose environmental taxes) then the move towards centralisation will be reduced. Given the obvious strength of the trend, it would require a large increase in transport costs to halt the trend in the next 10 years.

Manufacturing

5.67 There are two main implications of change in the future. The first is to do with likely changes in tonne km and tonnes lifted as a result of new spatial structures of manufacturing and the way in which this influences transport intensity. The second is the extent to which a more holistic design of product, manufacturing process and logistics will take account of the real costs of road freight transport.

5.68 To understand something of the future of spatial structures of manufacturing in Europe it is necessary to delve into a specialist report on that topic, the Delphi survey undertaken as pert of the TRILOG Project. The time reference was from 1999 to 2005, so it is not long enough for long term thinking but none the less it gives useful pointers.

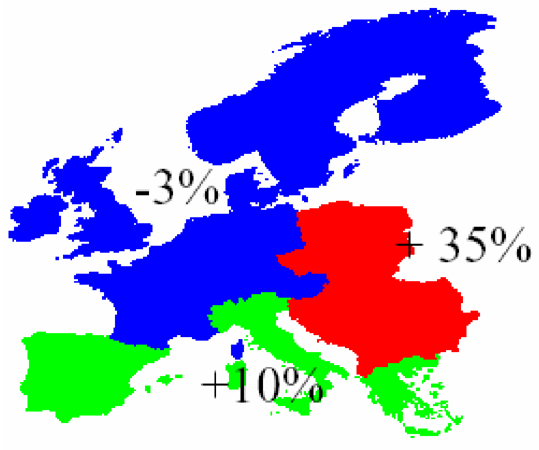
5.69 The report indicates, "*The move to focused production, where firms retain the same number of plants but increase the degree of plant specialisation, was predicted to increase by a greater margin than general industrial concentration. Again it was expected to occur more strongly at European and global levels than within individual countries. Across Europe it will increase by roughly 30% by 2005."*

5.70 The issue of customisation has been raised a number of times. To achieve this value added operations are often carried out closer to the customer. However there should be no noticeable effect on tonne km providing the process does not require the insertion of new distribution centres. The TRILOG results suggest that

> *"It has become increasingly common for manufacturers to defer the final customisation of their products until they reach a regional market. This often results in the customisation being performed at distribution centres rather than production facilities. It is predicted that the amount of product customisation undertaken at distribution centres will increase by 28%"*

5.71 It is clear from a number of studies including this TRILOG project that sourcing of supplies is declining within firms home markets "*the value of goods imported from elsewhere in the European Economic Area would grow by 11%, from Eastern Europe by 21% and from the Far East by 14%. At both national and European levels an increasing proportion of supplies will be drawn from warehouses rather than factories."* This is likely to increase tonne km and thus transport intensity. In the context of the Acceding Countries it is interesting to note the forecast change in the relative attractiveness of three areas in Europe as manufacturing locations (Figure 5.2).

FIGURE 5.2 FORECAST CHANGE IN ATTRACTIVENESS OF AREAS AS MANUFACTURING LOCATIONS: 1999 – 2005[72]



Information and Communication Technology

5.72 The impact of ICT on transport has two main strands. Firstly is its direct impact on the efficiency of transport operations. And secondly via the impact of ICT on the emergence of e-commerce and new ways of structuring the supply chain.

5.73 Developments in ICT are credited with improvements in operating efficiency of transport systems and customer satisfaction in a number of areas. The use of existing methods of ICT for online freight exchanges, planning operations, vehicle tracking and dynamic scheduling can be expected to be more widely adopted both throughout industries and countries.

5.74 Further developments in ICT or applications may yield further efficiency savings but given the research devoted to telematics in recent years it is unlikely any great prizes will emerge. Overall it can be expected that ICT will continue to improve the efficiency of transport operations with savings in vehicle km though not necessarily tonnekm.

5.75 As far as e-commerce and e-business are concerned there is general agreement on future trends. The TRILOG Delphi study is typical in predicting "*Important changes [will]… occur on the last link in the supply chain to the customer's home. The conventional mode of shopping, involving the customer travelling to the shops and carrying home their purchases, will decline slightly, while various forms of home delivery will significantly increase*".

5.76 There are a number of studies predicting their likely impact on freight transport. One source[73] forecast that between 2000 and 2005 e-commerce/e-business could add 9% (B2B) and 8% (B2C) to the underlying trend of freight traffic growth. An alternative

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[72] McKinnon A and Forster M (op cit)

[73] Transport en Logistiek Nederland (2000) '*New Wine in Old Bottles'* Zoetermeer.

viewpoint[74] however predicts a reduction in HGV traffic during this period. But no clear argument or evidence is provided to support these predictions.

5.77 Much emphasis has been placed on dematerialisation in which digital transmission reduces the need for the production and distribution of physical products. There is no doubt that this can extend to such areas as catalogues, directories, software, entertainment and educational materials. Recent commentators (e.g. Hesse[75]) have generally downplayed the total impact of dematerialisation on the freight.

5.78 A large amount of attention has been given to the impact of home delivery on transport[76]. There remains uncertainty about the eventual penetration of home shopping into the different retail markets. What does seem to be agreed is that use of the internet in this context will lead to a reduction in car vehicle trips there will be an increase in tonnekm carried by goods vehicles substituting the previous car trips to and from the shops. As far as freight market is concerned there seems every reason to expect a modest increase in vehiclekm and tonnekm carried by goods vehicles.

Logistics Management

5.79 The main area of impact of the new methods[77] of logistics management and supply chain in the last 25 years has been a reduction in the level of stockholding and acceleration in the movement of products through the supply chain. The main impact on transport has been on efficiency through the trend towards smaller consignments and more frequent deliveries.

5.80 Associated with the development of management methods has been customers' demand for more frequent and more precise delivery times. Again the impact of this will be felt in a decline in efficiency of the transport sector (through use of smaller vehicles, poorer lading factors or more empty running).

5.81 There is no reason to believe that the adoption of these new methods has run its course. Many industries (such as construction) are lagging behind the leaders, and therefore any such trend will continue in the future.

> *The Quick Response trends which have been firmly established in the retail sector for the past decade are projected to continue, with delivery frequency increasing by 26% and average order size declining by 9%*[78].

5.82 Future developments in best-practice management are difficult to predict, but there still appears to be further developments in procurement and outsourcing strongly

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[74] Dodgson, J., Pacey,J. & Begg, M., (2001)'.Motors and Modems Revisited: The role of Technology in Reducing Travel Demands and Traffic Congestion', NERA, London

[75] Hesse, M. (2002) "*Shipping News: the Implications of Electronic Commerce for Logistics and Freight Transport*"' Resources Conservation and Recycling.

[76] See for instance Punakivi, M. and Holmstrom, J. (2001) 'Environmental Performance Improvement Potentials by Food Home Delivery'. NOFOMA Conference Proceedings, 2001 and Cairns, S. (1997) 'Potential Traffic Reductions from Home Delivery Services' TSU working paper 97/45, University College, London.

[77] See Section 4.120, page 53.

[78] TRILOG Delphi Survey (op. cit.) referring to the period up to 2005.

supported by ICT that will lead to greater integration between supply chain members and faster delivery of products to the final customer. The general trend towards integration and collaboration between supply chain members seen over the last 15 years can be expected to continue.

Transport Technology

5.83 Evidence presented earlier demonstrated that the real cost of road freight movement has declined significantly over the last 40 years. The reduction was due to a number of factors - the reductions in vehicle capital cost, the reduction in maintenance and running costs, higher average speeds and the use of larger vehicles.

5.84 There seems a serious prospect that the period of declining real costs is coming to an end. Whilst there may be opportunities for further decreases in vehicle capital costs and improvements in fuel consumption these are limited, as is the potential reduction in maintenance costs. There have been no significant changes in maximum vehicle size in recent years or any prospect of a large increase. No great reduction in unit operating costs can be expected from this source.

5.85 Finally the prospect for vehicle speeds seems to be on a cusp. Due to a combination of more powerful vehicles and better roads average speeds have increased over the last 40 years contributing to a notable decrease in operating costs per km. The prospect for the future seem to suggest demand will outpace supply on the road network and vehicle speeds will fall. Detailed forecasts for this fall are provided in the UK[79]. Indications from other sources concerning the TEN network in 2010[80] confirm that congestion is likely to deteriorate in the future.

5.86 The overall conclusion from this is that the real cost of transport will not decrease in the future and may actually rise. (With the prospect for higher taxes discussed in the next chapter it will certainly rise.) This will have implications for average haul and possibly the design of logistics networks.

5.87 The impact of rising road freight costs on average haul is open to much uncertainty. One source quoted in Section 4 suggested an elasticity (of average haul with respect to price per km) as high as -0.7. Another source[81] suggests a figure as low as -0.1. Which figure is chosen has implications for not only forecasts but also the efficacy of policy initiatives that affect unit costs of freight movement. Certainly given the long run nature of decisions about sourcing, market areas and logistics networks the impact of a change in real costs will take sometime to emerge and would not be obvious for some years.

5.88 The strong current trend towards longer distance sourcing is confirmed by the TRILOG Delphi survey that predicted

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[79]Delivering Better Transport: Progress Report at http://www.dft.gov.uk/trans2010/progress/index.htm

[80] European Commission DG-Energy & Transport, 'Trans-European Transport Network Outline Plan (2010) - Roads'

[81] The UK government in http://www.roads.dft.gov.uk/roadnetwork/nrpd/heta2/nrtf97/nrtf19.htm

"… this trend would continue at least until 2005, with the real value of supplies obtained from home markets forecast to decline by 5%, while the value of goods imported from elsewhere in the European Economic Area would grow by 11%, from Eastern Europe by 21% and from the Far East by 14%".

5.89 The rising cost of road freight movement should also help to improve the balance of competitive advantage of other modes. (Once again this trend should be confirmed by policy initiatives). Rail and intermodal transport should benefit. The change could also arrest the general decline in their share of the freight market. Certainly there will be no dramatic decline in the share of rail seen in the last 20 years and with assistance from policy, there seems every prospect that the share of rail in the freight market may actually stabilise.

5.90 The overall impact of this change in the trend of road freight costs should contribute to a reduction in road freight intensity in two ways. Firstly the growth in the average haul should be mitigated to some extent (though the effect may take some time to appear). And secondly the increase in road freight intensity due to modal transfer (particularly from rail) will be severely reduced and may disappear altogether.

Government Regulation

5.91 Regulations permitting increases in maximum vehicle size have played an important role in reducing road freight costs. Whilst proposals may emerge in the long term there seems no prospect in the next 10-20 years that there will be a significant increase maximum vehicle size throughout Europe. As was argued earlier the road freight industry will therefore not enjoy reductions in cost from this source in the foreseeable future.

5.92 Legislation concerning Packaging and Waste together with the Landfill Directive will continue to affect transport. One tentative study[82] undertaken on the effect of these Directives points to a rather greater consumption of transport.

5.93 The creation of a Single Market in the 15 countries of the EU is nearing completion. Physical frontiers - delays at intra-EC customs points, different technical regulations for goods and services, discrimination against foreign companies regarding subsidiaries or tendering; and most importantly fiscal frontiers - excise duties on goods imported from other Member States have now nearly been eliminated. Their removal has encouraged the growth of international trade (and its consequence average haul). Perhaps the impact of their removal is coming to an end. Perhaps the delay in responding to their removal coupled with remaining cultural barriers means that the trend towards greater intra-community trade will continue at the high rate of growth experienced in the past.

5.94 With more certainty we can conclude that the process of the Acceding Countries joining the Union will lead to greater levels of trade, longer average hauls and higher freight intensity.

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[82] Philipp, B. (1999) "*Reverse logistics: analysis and evaluation of co-operation forms within the indirect logistics channel*." in Proceedings of the Logistics Research Network Conference 1999, University of Northumbria, Newcastle-upon-Tyne.

5.95 It is in the final area of policy that we can expect an important contribution to a reduction in road freight intensity. The White Paper explains that the approach adopted for policy 'comprises a series of measures ranging from pricing to revitalising alternative modes of transport to road and targeted investment in the trans-European network.' The impact of this approach is to '… allow the market shares of the other modes to return to their 1998 levels and thus make for a shift of balance from 2010 onwards'.

5.96 As a result of these measures road movement would increase by 38% rather than 50% in the period 1988 to 2010. The predicted growth in total freight during the period is predicted at 38%[83]. If therefore these policies come to fruition and realise the impact predicted the reduction in road freight intensity is approximately 9%. The precise assumption about GDP is not revealed but if the forecast is 3% per annum, the growth in road freight movement of 38% suggests hardly any change in overall road freight intensity.

5.97 Section 6 considers in more detail the effect of government intervention in the arena of transport policy.

Summary

5.98 Table 5.4 provides a summary of the conclusions concerning future importance of the various drivers of intensity. A shaded box shows where a trend is predicted to change in the future compared to the past. These trends do not distinguish between sectors, countries or, indeed, periods in the future. Such refinements are too demanding but some impressions are included below.

5.99 The mix of products in the economies of Europe will continue to change towards services and products with longer average hauls. This trend may be stronger in Acceding Countries leading to a greater contribution to increasing freight intensity. This effect can be expected to reduce over time as the manufacturing sector's share in an economy falls.

5.100 Trends increasing product value density stemming from development of products and manufacturing processes will continue in most product areas. The effect will be to reduce intensity. The trend is likely to be strongest in sectors where the opportunities for technological innovation (which may increase value and reduce weight) are greatest. Experience from the past suggests that there will be a common development of products throughout Europe, and therefore any benefits from its impact on freight intensity will be experienced in all countries.

5.101 The most significant change arises from the prediction that road transport unit costs will increase in the future (due partly to a slowdown in technology improvements, deteriorating road speeds and policy initiatives). This will be experienced to a varying degree by all countries and all supply chains. Eventually it should lead to a halt in the relentless rise in average haul seen in the last 50 years. Its exact timing is impossible

[83] "economic growth will almost automatically generate … increase(s) in demand of 38 % for goods services…", Policy Guidelines of the White Paper.

to judge as decision makers only react slowly concerning location of facilities or sourcing. The impact of falling freight costs is probably not yet fully exhausted. The effect should start to emerge within 10 years. (There is tentative evidence that the trend has halted in the UK[84])

5.102 At the same time the increasing competitive advantage of road compared rail experienced in the last 40 years will not continue, and with assistance from policy it may actually be reversed. Precise estimates are impossible but there seems every prospect that this change will stabilise the share of rail in the freight market (as predicted in the White Paper).

5.103 Taking all these considerations into account it seems highly likely that the gradual increase in road freight intensity experienced in EU15 as a whole will eventually change to a situation of relative stability in the index with the possibility of decline in the longer term. The balance of the arguments presented here suggest that road freight intensity will be significantly lower (perhaps 20%) in 2030 than now. There are uncertainties behind this of which the assumption that average haul will not experience the rapid growth of the past is crucial. Countries will not follow precisely the same paths. Idiosyncrasies are apparent in past trends for the 5 countries presented in Section 3. The precise forces behind these different trends (and different levels) of intensity cannot be identified. The future path of individual countries is likely to be erratic (partly due to the vagaries of the data collection process) and it will take some years for the long term trends to emerge.

5.104 The prospect for a reduction in freight intensity in the Acceding States is even stronger given the likelihood that they will move towards a larger share of services in their economies.

5.105 In the area of vehicle efficiency there are a number of trends working in different direction. There is no evidence to suggest that the balance of these effects is likely to lead to greater or less efficiency.

5.106 Finally, to repeat a point made earlier the environmental damage of road freight vehicles is predicted to decline. The social cost of air pollution (per vehicle km) is expected to fall by at least a half in the UK[85] between 1995 and 2005 mainly due to legislative measures relating to new trucks. This trend will also occur in other countries responding to EURO II & EUROIV standards. The White Paper targets a 50% reduction in deaths from road vehicles between 2000 and 2010. Most of this can be achieved by all countries approaching the rates found in the UK and Sweden. No specific targets are set for freight vehicles or for the total social costs of road accidents. By implication the expectation is that a large reduction (perhaps not 50%) can be achieved in this period. Noise levels of freight vehicles should also decrease (though only to a minor extent). Even greenhouse gas emissions should decline (per vehicle km) with improved fuel consumption from larger vehicles and technological improvements. The only social cost that is projected to increase is that related to the congestion – the delay imposed by one vehicle on other vehicles using the network. In

[84] See Department for Transport, (2003). "Continuing Survey of Road Goods Vehicles: 2002".

[85] Department of Environment, Transport and the Regions (1999) "Sustainable Distribution: A Strategy", London.

the short term (up to 2010) the prospect is for total social cost (per vehicle km) to decline by as much as 25-50%. Eventually once the major gains from air pollution reduction and safety improvement have been reaped, the increasing levels of congestion coupled with a tendency for environmental costs to carry a higher value as income grows will see the downward trend reversed.

TABLE 5.4 SUMMARY OF FUTURE DRIVERS AND THEIR IMPACTS

Shaded cells represent change in future

Changes in	Product value density €/tonne	Key logistic impacts	Handling factor	Modal share road	Average haul	Intensity	Vehicle payload	Lading efficiency	Vehicle utilisation
Mix of products/services	↑			↑	↑				
Configuration/design of commodities Packaging Variety/ customization Sophistication	↑	Smaller order size			↑	↓		↓	
Manufacturing processes Modularisation Materials Economies of scale	↑ ↑	Vertical disintegration of production Spatial concentration of production; either through reduction in plant numbers, or focused production.			↑			↓	↓
Warehouse/handling technology Reduced costs		Spatial concentration of inventory Break-bulk / transhipment systems Centralisation of hub-satellite network	↑		↓	↑			
Information technology Increased use of ICT Increased use of e-commerce		More efficient transport operations						↑	↑
Logistics management Application of JIT principles, quick response and ECR in retail distribution Proliferation of booking-in / timed-delivery systems		Less efficient transport operations						↓	↓
Technology of transport systems Improvement in road's relative cost/performance *Management of transport systems*		Wider geographical sourcing of supplies Wider distribution of finished products Increased use of outside transport / distribution contractors			↑	↑			
Government Regulation Changes in vehicle size regulations Taxation Recycling requirements Realisation of Single Market		More efficient transport operations More movement per product	↑	↓	↑	↓			

6. POLICY MEASURES AND THEIR EFFECTIVENESS

Introduction

6.1 The previous Sections have described the trends in road freight intensity (both in the past and the future) and the reasons behind them. This Section goes on to explore policy initiatives that can reduce road freight intensity. There are two important dimensions to policy initiatives that may influence freight intensity. These are closely associated with the two elements in the evolution of road freight intensity which emerge as relatively influential - the increase in average length of haul and the increase in value density.

6.2 The first dimension of policy is intimately linked to average haul, which has been influenced by changes in transport costs together with logistics and sourcing strategies, the latter often driven by enhanced customer needs. There are many factors including EU and government policies which are aimed at, or effectively impact upon transport costs and hence lead to changes in average haul. Few, if any, policies have any great impact on tonnes lifted. In this context the aim of policy is rather more complex than simply reducing intensity, and involves a balancing of factors such as environmental, safety and user costs of freight transport. The main thrust of policy is to ensure that road freight users pay the full marginal social costs of transport. Whilst these (and other) initiatives can be expected to have some effect on road freight intensity, their aim is not to reduce intensity per se.

6.3 The Gothenburg European Council (quoted in White Paper European Transport Policy 2010: A time to decide) stated that ‘a sustainable policy should tackle... the full internalisation of social and environmental costs’. Whilst it goes on to state that ‘(a)ction is needed to bring about a significant decoupling of transport growth and GDP growth, in particular by a shift from road to rail, water and public passenger transport’, it is not clear that these actions are separate from the cost initiatives’. The White Paper goes on to say that the thrust of Community action should be to replace gradually existing transport system taxes with more effective instruments for integrating infrastructure costs and external costs. If the correct marginal social cost of freight transport is applied then account has been taken of the “damage” from vehicle use compared to other socio-economic activities and no other action is needed.

6.4 The second dimension is potentially concerned with value density (€/tonne), which is driven apparently by increase in variety and sophistication of products, supported by emerging new technology. At the macro level there is clear evidence of the importance of the change in the commodity mix influencing intensity. At the individual product level there is evidence that value-density has changed to benefit road freight intensity.

6.5 However there are no apparent formal policies aimed directly at changing value density. Indeed some government policies concerned with materials research (for instance in nano-technology), promotion of innovation as well as some environmental policies aimed at factories and waste may actually stimulate or facilitate more product sophistication and higher value density (though this is never a performance criterion used). At the same time changes in manufacturing strategies (such as “batch of one”) result in more variety. It is also the aim of some environmental policies, for instance ELV, to stimulate materials substitution, leading to lighter products. Policies towards packaging may also have an important influence on the value density of the delivered product.

6.6 The transport sector is already the target of EU and Government transport policies which will affect directly or indirectly road freight intensity. Policy analysis do not always make clear what component of road freight intensity will be influenced by policy initiatives, but the main influence can be expected to be changes in modal split and average haul. There may conceivably be an influence on the handling factor but this is not usually considered important. As far as value density is considered this is almost totally ignored by current transport policy. The main reason for this is that policy initiatives are mainly directed at the cost of freight transport and the purchasers of transport.

6.7 In the case of value density decisions here about changes are made by product designers in manufacturing. Most of the changes in product design are driven by policy at the company level in response to its customers and competitors. These may impact on value density and hence transport intensity in a variety of ways, but these impacts will rarely be considered. While policies about research and innovation facilitate technological change in particular, those responsible for product design are not targets and hence recipients of specific policies about transport intensity.

6.8 It can be argued therefore that given the apparent lack of influence of current policy initiatives on product designers, policy should somehow be specifically directed at influencing product design in order to reduce freight intensity. However it is difficult to imagine a sensible and coherent policy based on legislation aimed directly at influencing product designers, which could precipitate a given change in value density that is considered desirable.

6.9 The ideal solution is that product designers in the process of designing and evaluating these designs should be made aware of the true costs of transport (including the full social costs). If they then take full account of these costs in the product design process then the correct trade offs will be made and optimum decisions made. Effectively then the product design decisions would then be made on the same basis as modal split and average haul decisions, with full and accurate recognition of the true social costs of transport.

6.10 Conceptually the product design decision involves trade-offs between transport, logistics, manufacturing costs and customer satisfaction. Indeed part of the argument of Aronsson (see Section 4) is that cost functions along the whole system from procurement to customer are poorly understood and analysed but ought to be seen as a complex set of trade-offs.

6.11 If road freight movement is charged at the proper marginal social cost, some component of transport cost increases may be a legitimate trade-off (from the perspective of industry) between transport and more valuable products or efficiencies in the manufacturing processes.

6.12 In a somewhat simplified interpretation, policy initiatives then fall into two broad areas. EU and Government policies (of which there are already many proposed) are aimed at transport users and their decision making. Some of these are aimed at directly at reducing environmental impacts and others at developing more efficient transport operations. Internal efficiency within logistics and supply chains is a further target.

6.13 In this context other policies are designed within and by industry to generate efficiency in the form of, for example, good practice in value chain, life-cycle analysis and similar techniques. These are the policies that need to ensure that manufacturers take full account of transport cost implications in their decision making about design. If, as should be the case if the current policy intentions come to fruition, the transport cost includes taxes to reflect the marginal social cost (including environmental effects) then such a path takes full cognisance of environmental imperatives.

Charging for Road Use and the Environment

Evidence from RECORDIT

6.14 The White Paper "European Transport Policy 2010: A time to decide" referring to the need for '... the full internalisation of social and environmental costs….' identifies the relevant policy instruments - firstly, charging for infrastructure use, which manages congestion and reduces environmental impacts, and, secondly, fuel tax, which 'lends itself well to controlling carbon dioxide emissions'. A recently completed project RECORDIT[86] identifies the likely scale of charges required and their impact.

6.15 The imposition of such charges will clearly influence the growth in tonnekm. In turn they would be revealed as a "cost" to transport customers, who in turn may make trade-offs between different logistics cost functions up-stream and between logistics and manufacturing costs.

6.16 The choice of mode would also be influenced by these changes in relative costs. Location decisions and spatial structures would be also influenced. Further intervention in transport and logistics would be unnecessary under such circumstances since road freight transport would be "correctly" priced. Any further tendency towards road freight intensity would be caused by inappropriate decisions in the manufacturing/logistics value chain and the wider supply chain network.

6.17 Road pricing in which charges change according to the location on the road network is more sophisticated since it can vary according to local pollution and congestion levels. The most efficient economically (by km by road type, by traffic conditions) is also the most technically difficult to implement.

Derivation of Charges

6.18 The various figures for external costs and taxation are brought together in the Table 6.1 and Table 6.2 below. The logic of marginal cost pricing requires that the price perceived by the mode choice decision maker is equal to the marginal total resource costs, where resource costs refer to those of operation, infrastructure and externalities. Three elements need to be considered:

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[86] RECORDIT (REal COst Reduction of Door-to-door Intermodal Transport) http://www.recordit.org/

- Fuel and circulation taxes. In the case of road the average over all countries is equivalent to €0.15 /vkm for an articulated truck. For an equivalent slot on rail it is only €0.01.
- Infrastructure charges are in general lower than marginal infrastructure costs. In the case of road the average over all countries is equivalent to €0.05 /vkm for an articulated vehicle but the figure by rail is less at €0.04 for a slot equivalent to an articulated vehicle.
- External costs. For road the average figure is €0.32/articulated vkm and €0.31 /rigid vkm whereas for rail it is only €0.07.

TABLE 6.1 THE DERIVATION OF CHARGES – ROAD (2001)

	ROAD Artic €/vkm				ROAD Rigid €/vkm			
Countries	Taxes	Infrastructure Net Payment1	External Cost	Extra Charge	Taxes	Infrastructure Net Payment1	External Cost	Extra Charge
Austria	0.14	-0.13	0.36	0.35	0.08	-0.10	0.37	0.39
Croatia	0.12	-0.06	0.26	0.19	0.07	-0.04	0.23	0.19
Denmark	0.09	-0.09	0.33	0.33	0.06	-0.06	0.34	0.34
France	0.14	0.00	0.31	0.17	0.09	0.00	0.29	0.20
Germany	0.13	-0.05	0.30	0.22	0.08	-0.04	0.32	0.28
Greece	0.17	-0.07	0.40	0.30	0.10	-0.03	0.41	0.34
Hungary	0.11	-0.06	0.35	0.29	0.07	-0.04	0.32	0.30
Italy	0.09	-0.01	0.30	0.22	0.08	-0.02	0.28	0.22
Netherlands	0.15	-0.08	0.29	0.22	0.09	-0.05	0.31	0.27
Poland	0.14	-0.06	0.28	0.20	0.09	-0.04	0.26	0.21
Slovakia	0.12	-0.06	0.39	0.33	0.08	-0.04	0.37	0.34
Slovenia	0.12	-0.05	0.54	0.47	0.08	-0.04	0.53	0.49
Spain	0.12	0.00	0.33	0.21	0.08	0.00	0.32	0.24
Sweden	0.09	-0.04	0.24	0.19	0.06	-0.01	0.26	0.21
Switzerland	0.16	-0.15	0.36	0.35	0.09	-0.11	0.39	0.41
United Kingdom	0.34	-0.18	0.36	0.20	0.21	-0.09	0.37	0.25
Weighted average	0.15	-0.05	0.32	0.21	0.10	-0.03	0.31	0.25

1 Marginal Infrastructure Payments minus Costs.
Some rows may not add due to rounding.
Source: RECORDIT

TABLE 6.2 THE DERIVATION OF CHARGES – RAIL (2001)

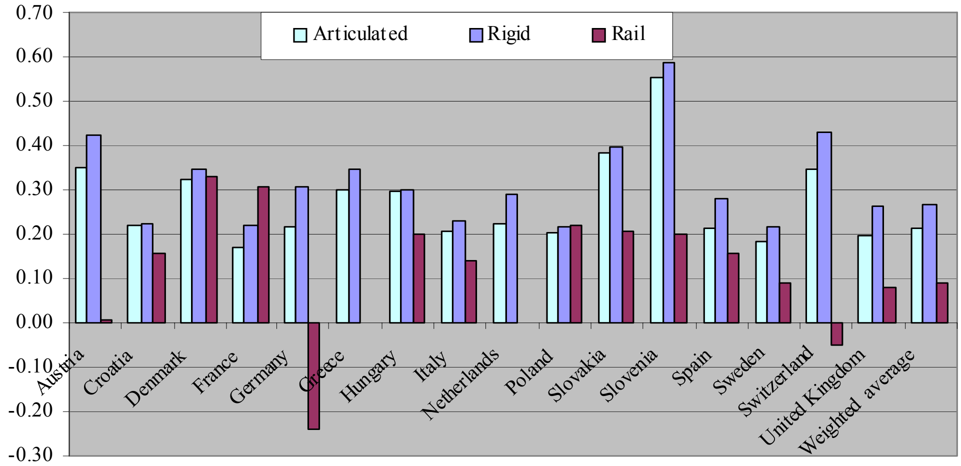
RAIL €/km				
Country	Taxes	Infrastructure Net Payment	External Cost	Extra Charge
Austria	0	0.04	0.05	0.01
Croatia	0	-0.09	0.06	0.16
Denmark	-0.24	-0.02	0.08	0.33
France	-0.2	-0.07	0.04	0.31
Germany	0.19	0.12	0.07	-0.24
Greece	n.a	n.a.	n.a	n.a
Hungary	0	-0.09	0.09	0.2
Italy	0	-0.07	0.07	0.14
Netherlands	n.a	n.a.	n.a	n.a
Poland	0	-0.09	0.13	0.22
Slovakia	0	-0.09	0.12	0.21
Slovenia	0	-0.09	0.11	0.2
Spain	0	-0.09	0.07	0.16
Sweden	0	-0.06	0.02	0.09
Switzerland	0.08	0	0.05	-0.05
United Kingdom	0	-0.05	0.05	0.08
Weighted average	0.01	-0.04	0.07	0.09

Marginal Infrastructure Payments minus Costs.
Some rows may not add due to rounding
Source: RECORDIT

6.19 From the tables it can be seen that this average shortfall (extra charge) is (for EU countries) about €0.21/vkm (articulated vehicle) and €0.09 for rail equivalent. Strict application of marginal cost pricing principles would therefore require taxes to be raised on average by these two figures on the two modes.

6.20 The graph below shows that the average figures mask some quite large variations between countries. In Germany the taxes and infrastructure charges paid on the rail system suggest that these exceed the external costs by a large margin. In the United Kingdom the high rates of tax on road (compared to other countries) are only slightly below the external cost estimates. However, there is a larger shortfall on infrastructure payments than for all other countries which suggests prices need to rise by about €0.20/artic vkm, close to the average.

FIGURE 6.1 EXTRA CHARGES – ARTICULATED, RIGID AND RAIL (ARTIC EQUIVALENT)



6.21 Given these findings about the relative level of taxes and resource costs, and the general impression that taxes on the road system are too low, there are two critical decisions in the choice of taxes

- 1. Whether to aim to for a level that ensures the correct relative level of prices between road and rail, or to also ensure that prices on these two modes have the correct relationship with other goods and services in the economy. The logic of the second requires taxes to be raised by €0.21 per artic vkm, €0.25 per rigid /vkm and €0.09 per artic equivalent railkm. On the other hand in order to only maintain the correct balance between the two modes a tax equivalent to €0.12vkm (articulated) and €0.16/vkm(rigid) would close the gap between the two modes.
- 2. The amount of differentiation in the taxes used. The White Paper states that taxes should vary in line with marginal social cost 'according to category of infrastructure used, time of day, distance, size and weight of vehicle, and any other factor that affects congestion and damages the infrastructure or the environment'. Fuel taxes by their very nature cannot meet all these requirements. More sophisticated charging by the roadside or devices located on the vehicle can but at rather greater expense. The decision is therefore likely to depend on a trade-off between the extra costs of such methods against the extra benefits that they bring.

6.22 In order to explore the impact of different charging policies it is necessary to make some assumption about the impact of price changes on the use of the two modes as summarized in the elasticity of demand.

Elasticity and Benefits

6.23 The benefits of marginal cost pricing from an efficiency perspective depend critically on the response of mode decision makers to any change in prices. If the response to tax increases is limited in terms of modal transfer and reducing overall movement then the benefit will be small. The benefit, therefore, depends on the elasticity of demand.

6.24 If it is assumed that the price of road freight transport increases with other prices remaining unchanged (due to a fuel tax increase for instance) then there are two distinct impacts. In the first place the demand for movement by competing modes should increase. And secondly the total demand for freight (measured in tonne-km) should fall.

6.25 This latter effect might be expected to take rather longer to materialise. The main source of any reduction in total movement can be expected to stem from a fall in length of average haul. This is likely to be far more important than changes in tonnes lifted (which is intimately connected to the level of output in the economy) or better utilisation of vehicles (this has been remarkably stable over a long period without any apparent change due to previous changes in real costs).

6.26 Various estimates exist of elasticity though none carry real authority. One estimate[87] of the elasticity of road freight with respect to price suggests a range between -0.2 and -0.7 for different commodities with a mean near to -0.6. Turning to the second impact cross elasticities (the percentage change in rail demand with respect to the price of road) revealed a wide range for commodities from 0.2 to 1.9. The (unweighted) mean was near to 1.0. A number of studies carried out in Europe over the last 10 years have developed more complex modal split models of the freight market. These include STEMM[88], and STRATEC[89] in 1999-2000. Taking account of these various studies RECORDIT used a cross elasticity of 1.7 and an own elasticity of –0.3 in response to a change in the price of road freight.

The Benefits

6.27 The main policy examined leads to an increase in the average cost of road (per articvkm) by €0.12 (€0.21-0.09 in different countries), which ensures that the relative cost of road and rail are in balance. This is equivalent to an average cost (and eventually price) increase of about 10%.

6.28 The first impact of such charges is to lead to a transfer of road freight to other modes – rail, intermodal, inland waterways and Short Sea Shipping. The second impact over and above this transfer is to lead to a reduction in the demand road freight movement. The elasticities used do not reveal whether the source of the reduction is in tonnes lifted or average haul. The major impact is likely to be on mitigating the increase or even reducing the average haul.. The decrease in road freight movement (btonkm) is between 3 and 4%. Road freight intensity therefore should be reduced by a similar amount. If the interest is in all mode freight intensity then the reduction is about half this figure.

6.29 The benefits of the transfer of freight from road to intermodal rail is a net saving in resource costs. Consignments are transferred from road with its high external costs to

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[87] Baum H et al (1990) Aufbereitung von Preiselastizitaten der Nachfrage im Guterverkehr fur Modal Split Prognosen. Untersuchung im auftrag des Verkehrsforums Bahn e.V., Essen.

[88] STEMM, http://www.cordis.lu/transport/src/stemmrep.htm

[89] Lobé, P, (2001) Computation Of A Perception Index In Intermodal Transport PTRC, 2001

intermodal with its lower external costs, but this is to some extent at the expense of increased operating (resource) costs as freight is transferred from road to intermodal.

6.30 The welfare benefit (resource cost reduction) to members of the EU of the modal transfer can be calculated as about €44M per year in 2001 (the calculation is based on the sum of environmental and operating costs for intermodal and road transport.). All these benefits it should be emphasised are sensitive to the price elasticities (cross and own) adopted, and depend on the speed of response from actors. In the case of impacts on average haul this effect may take years to emerge.

Comments

6.31 This section demonstrates the factors that are needed to identify the benefits of marginal cost pricing policies in the context of freight movement and intermodal transport options in particular. It shows the crucial line of argument that is needed if estimates of the effect of policy (in this case pricing) are to be calculated. The reasoning and justification of different interventions in EU policy papers is rarely accompanied by quantitative estimates of the benefits to be derived from policy interventions. There are a number of uncertainties in findings such as those presented above. Perhaps the major source of uncertainty in the final results arises from the limited information available on the relevant elasticities used above. New lower elasticity estimates might halve the figures for impacts.

Transport Policy

Impact of policy measures

- The REDEFINE[90] project specifically set out to determine the impact of different policy measures on externalities (environment, safety and congestion) and by implication transport intensity. It also analysed the effectiveness of the different policies. In the discussion of policy two groups of measures can be distinguished: those aimed at a particular product market and those aimed at the transport market, transport systems and transport technologies. Table 6.3 gives an overview of the policy measures for the later.

Options to Reduce Road Freight Transport Externalities

6.32 Measures other than taxes or charges have in general a much more focused but also more limited impact on the decision making of transport users. These measures are best grouped according to the option for the reduction or improvement of road freight traffic which they are aimed at viz;

- Reduction of overall tonnekm.
- Modal shift from road to alternative modes
- Increased efficiency of vehicle use (improving the vehkm/tonkm ratio)
- Use of better vehicles and/or fuels to reduce environmental impact
- Better use of vehicles.

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90 REDEFINE op cit

6.33 Not included in this list is the option of reducing transport by cutting the level of production. In line with the REDEFINE objectives, reducing the level of economic activity is not considered among the options to reduce freight traffic related externalities. The instruments, or measures, are defined as varying from coercion (bans etc), transactional (payment systems) to persuasion.

TABLE 6.3 POLICY MEASURES CLASSIFIED BY INSTRUMENTS AND OPTIONS

	Reduce tonnekm	**Modal shift**	**Increased efficiency**	**Better vehicles/ fuels**	**Better use of Vehicles**
Coercion		Ban on long distance transport by road		Differentiate spatial and/or temporal driving bans for road freight vehicles according to their externalities Tighten emission standards for new vehicles Require the use of safety devices in road freight vehicles Require the use of safety devices in road freight vehicles Introduce/tighten inspection and maintenance programmes *Impose the use of emission and/or fuel use reducing devices/technologies*	Introduce/extend bans for truck traffic in spatial terms *Introduce/extend bans for truck traffic in temporal terms* Introduce/extend congestion related bans for truck traffic *Limitation of speed and/or overtaking by trucks* Reduce maximum driving times *Enforce driving regulations (speed, driving times) more effectively*
Lift coercion		Give preferential treatment to intermodal pre- and end-hauls	Allow larger and/or heavier trucks		Introduce freight transport vehicle lanes
Coercion/ Transaction	Introduce tradable vehicle-km permits *Introduce tradable emission permits*	Co-ordinate land-use planning and transport planning *Introduce tradable vehicle-km permits* Introduce tradable emission permits	Co-ordinate land-use planning and transport planning *Introduce tradable vehicle-km permits* Introduce tradable emission permits	Introduce tradable emission permits	
Transaction	Introduce/increase road-pricing on a per-km, per-trip or per passage basis *Increase fuel tax generally* Introduce on-board measuring and debiting for emissions	Introduce/increase road-pricing on a per-km, per-trip or per passage basis *Introduce/increase road-pricing on a per-year basis* Increase fuel tax generally *Increase vehicle tax generally* Introduce on-board measuring and debiting for emissions *Give preferential treatment to intermodal pre- and end-hauls*	Introduce/increase road-pricing on a per-km, per-trip or per passage basis *Introduce/increase congestion pricing* Increase fuel tax generally *Introduce on-board measuring and debiting for emissions* Encourage the set-up of transport-intensive production and logistics activities at or their re-location to more suitable locations *implementation Support for shared distribution facilities*	Increase fuel tax generally Differentiate fuel tax by fuel type, according to externalities Differentiate vehicle tax according to emissions and/or fuel efficiency Introduce on-board measuring and debiting for emissions	Introduce/increase congestion pricing *Increase fuel tax generally* Introduce on-board measuring and debiting for emissions
Transaction/ Persuasion		Invest in intermodal infrastructure			Improve/extend the road infrastructure
Persuasion	Encourage the set-up	Use persuasion to	Use persuasion to	Use persuasion to	Use persuasion to

	of transport-intensive production and logistics activities at or their re-location to more suitable locations *Finance R&D of technologies/practices reducing tonnekm* Introduce logistics "Eco-label"	decrease modal share of road transport *Finance R&D of technologies/practices decreasing modal share of road transport* Standardisation of load units (intermodal equipment, pallets) *Introduce logistics "Eco-label"*	bring about efficiency increases in road freight transport *Finance R&D of technologies/practices increasing transport efficiency* Standardisation of load units (intermodal equipment, pallets) *Introduce logistics "Eco-label"*	realise use of better vehicles/fuels *Finance R&D of technologies/practices improving vehicles/fuels* Introduce logistics "Eco-label"	realise better driving behaviour *Finance R&D of technologies/practices improving use of vehicles* Introduce logistics "Eco-label"

Source: Adapted from REDEFINE[91]

Impacts of Options

6.34 The first stage is to understand the effect of the policy options on intensity, vehicle efficiency and environmental loads of vehicles. REDEFINE has been used to build up Table 6.4. Each policy option is analysed for its impact on various ratios concerned with road freight intensity. The order in terms of priority anticipates the next section which looks at the effectiveness of the policies.

6.35 There is no attempt to provide a scale of the impact merely the direction. There is little controversy about the possible direction but the scale is more difficult. For instance in the table many of the policies that increase taxes and charges reduce average haul and the modal share of road. The effect of charges should be similar to those reported above but the scale of the effect clearly depends on the scale of the tax or charge.

6.36 Rather more controversial is the suggestion that such taxes/charges will improve vehicle efficiency in terms of reducing empty running and increasing the lading factor. There is no empirical evidence to support these claims.

[91] REDEFINE op cit

TABLE 6.4 OPTIONS AND THEIR IMAPCTS

	Road freight intensity - tonnekm			Efficiency			Env load
Policy measures (in order of priority)	Modal split	Supply chain structure	Average length of haul	Vehicle payload	Lading factor	Empty run-ning	
Introduce on-board measuring and debiting for emissions	⇩	⇩	⇩		⇧	⇩	⇩
Increase fuel tax generally	⇩	⇩	⇩		⇧	⇩	
Introduce logistics "Eco-label"	⇩	⇩	⇩		⇧	⇩	⇩
Introduce tradable emission permits	⇩	⇩	⇩		⇧	⇩	⇩
Introduce road-pricing on a per-km, per-trip or per passage basis	⇩	⇩	⇩		⇧	⇩	
Introduce tradable vehicle-km permits	⇩	⇩	⇩		⇧	⇩	
Introduce congestion pricing	⇩	⇩	⇩		⇧	⇩	⇩
Co-ordinate land-use planning and transport planning	⇩	⇩	⇩				
Encourage the set-up of transport-intensive production and logistics activities at or their re-location to more suitable locations	⇩	⇩	⇩				
Standardisation of load units (intermodal equipment, pallets, etc.)	⇩	⇩	⇩	⇧	⇧	⇩	
Introduce road-pricing on a per-year basis	⇩	⇩	⇩				
Increase vehicle tax generally	⇩	⇩	⇩				
Differentiate fuel tax by fuel type, according to externalities							⇩
Differentiate vehicle tax according to emissions and/or fuel efficiency							⇩
Differentiate spatial and/or temporal driving bans for road freight vehicles according to their externalities							⇩
Tighten emission standards for new vehicles							⇩
Require the use of safety devices in road freight vehicles							⇩
Require the meeting of tighter fuel efficiency standards for new vehicles							⇩
Introduce/tighten inspection and maintenance programmes							⇩
Impose the use of emission and/or fuel use reducing							⇩

	Road freight intensity - tonnekm			Efficiency			Env load
Policy measures (in order of priority)	Modal split	Supply chain structure	Average length of haul	Vehicle payload	Lading factor	Empty run-ning	
devices/technologies							
Use persuasion to realise use of better vehicles/fuels							⇩
Finance R&D of technologies/practices improving vehicles/fuels							⇩
Introduce freight transport vehicle lanes							⇩
Introduce/extend bans for truck traffic in spatial terms							⇩
Introduce/extend bans for truck traffic in temporal terms							⇩
Introduce/extend congestion related bans for truck traffic			⇧				⇩
Limitation of speed and/or overtaking by trucks							⇩
Improve/extend the road infrastructure			⇧				⇩
Reduce maximum driving times	⇩	⇩					
Enforce driving regulations (speed, driving times) more effectively	⇩	⇩					
Use persuasion to realise better driving behaviour		⇩					⇩
Finance R&D of technologies/practices improving use of vehicles		⇩					⇩
Give preferential treatment to intermodal pre- and end-hauls	⇩	⇩					
Ban on long distance transport by road	⇩	⇩	⇩				
Use persuasion to decrease modal share of road transport	⇩	⇩					
Finance R&D of technologies/practices decreasing modal share of road transport	⇩						
Invest in intermodal infrastructure	⇩						
Support the implementation of shared distribution facilities			⇩		⇧	⇩	
Use persuasion to bring about efficiency increases in road freight transport					⇧	⇩	
Finance R&D of technologies/practices increasing transport efficiency			⇩		⇧	⇩	
Allow larger and/or heavier trucks			⇩	⇧			
Use persuasion to reduce freight intensity			⇩				
Finance R&D of technologies/practices reducing freight intensity			⇩				

Prioritisation of Policy Measures and Recommended Measures

6.37 The REDEFINE project interviewed a large number of experts to determine the relative effectiveness of the various policy measures. This approach leads to the final prioritisation of policy measures according to their likely effectiveness to reduce the externalities of road freight transport.

6.38 Some policies may be very effective in reducing externalities but only have a small or negligible effect on intensity (those related to cleaner vehicles for instance). On the other hand those measures that reduce intensity will always lead to a reduction in externalities.

6.39 In the measure of effectiveness a distinction is drawn between those that should be effective in all supply chains (universal measures) and those that may be effective in some supply chains only ('broad effective' means in at least five of the twelve supply chains considered). In summarising the recommended measures the REDEFINE project identifies six key measures, namely:

- Fuel-consumption-based or emission-based charge
- Logistics Eco Label
- Tighten Emission Standards
- Enforcement of Existing Driving Regulations and Measures to Realise Better Driving Behaviour
- Larger Trucks
- Investment in Intermodal Infrastructure

Conclusions

6.40 The exploration of results from RECORDIT and REDEFINE has shown the full range of policy measures proposed by policy makers concerned with transport at local and national levels as well as in the EU. These policy measures are responding primarily to a sustainability agenda and the need to reduce the externalities of freight transport. Reducing freight intensity is a key means of reducing the level of externalities. Whilst the list of policy measures is long, the critical theme surrounds the need to increase charges in order to reflect external costs. This is where policy is likely to have a major impact on externalities and by implication intensity. Parallel to this theme are the measures to reduce the environmental impact of vehicles mainly through legislation (EURO III, IV regulations).

6.41 The impact of policy on road freight intensity is imperfectly understood. In particular knowledge about the elasticity of response (to price changes) is very limited. Where the impact falls is also uncertain. Modal split will certainly be affected by many measures. Of the other components to be affected average haul seems most important. The handling factor representing the number of times a product sold to the consumer has been lifted may change but is not likely to be very sensitive to changes in cost. At the same time there appears to e little evidence that value-density changes in response to transport costs. A major reason for this is that product designers responsible for determining that ratio take little or no account of it. The next section considers how designers should take account of transport considerations and, if they did, how this might affect intensity.

The Manufacturing Perspective

The Issues

6.42 So far the perspective on road transport intensity has been that of the transport policy maker. Assuming that the correct transport policy instruments were applied then, in principle, the manufacturer would be faced with road (and other modes) transport costs which correctly reflected the true consumption of resources including external costs. The next issue to consider is to what extent manufacturers and product designers actually respond to that cost message and which costs they should consider in the wider evaluation of their decisions about product development and manufacturing technologies. Any failure to take full account of these transport costs in a proper manner could lead to the excess use of transport resources and by implication a higher road freight intensity than is necessary.

6.43 The emergence of new products in manufacturing is influenced in part by (non-transport) government policies. Policies can affect the particular products and their attributes in a way that changes transport intensity. In Section 4 materials research was identified as an influence on product development but it was not possible to estimate rigorously the impact on intensity. There does seem to have been a tendency towards to greater sophistication and more attributes per individual product (leading to more value per tonne), and lighter products (also more € per tonne) through miniaturisation and/or new materials. Research policy in materials science and technology is therefore one indirect factor.

6.44 Another significant source of policy influence is that set of environmentally inspired policies towards materials recovery and materials balance such as WEEE and ELV. These apply pressure on innovation in materials choices, reverse engineering etc but have not been generated with any obvious regard to, or prior estimate of, the impact on manufacturing and logistics and hence transport intensity.

6.45 There is some evidence that only a small proportion (perhaps less than 10%) of manufacturing companies, mostly large and international, have data recovery and analytic tools suited to a comprehensive analysis of the manufacturing and logistical implications of new products. It follows that if transport costs (and policies that influence them) are to be properly considered in the product design phase, leading (potentially) to a reduction in transport intensity, then more companies need to be encouraged to undertake some form of "value chain analysis" and "total life cycle analysis" in which transport costs are taken into full account.

6.46 One of the difficulties, however, with this approach is that there may be many players in the total supply sequence (component manufacturers etc) and no one player may be able to see the overall picture concerning transport cost implications and the system within which useful cost trade-offs could be made. Indeed, the origins of "manufacturing logistics" lie in identification of cross boundary trade-offs which lead to an overall more efficient system than can be achieved by optimising each sub-system separately. SMEs, particularly those in component supply, are the most likely to be vulnerable to lack of expertise and access to this wider view of the overall system within which they are embedded.

6.47 Therefore, in order that a full appreciation of transport costs is taken account of by manufacturers and new product designers there are two issues that need to be addressed:

- The diffusion of appropriate expertise

  This is basically a responsibility of the manufacturing sector itself and could involve the self-promotion of good practice within the sector. There may, however, be a role for intervention policies by governments that have an educative and facilitating role.

- The provision of a wider system view concerning transport costs to all participants.

  This has been an issue in other fields such as intermodal transport where transparency of costs and prices is a prerequisite for competitive operation. Some effort may therefore be needed for the independent development of sub-sector models of cost functions, though commercial confidentiality presents a constraint to this. An important consideration here is the growth in outsourcing of transport. This may lead to an initial reduction in transport costs, but in the longer run it is likely to reduce awareness of, and interest in, changes in design and packaging that improve the efficiency of transport operations.

6.48 While it is clear that a range of policies influence the development of manufacturing sectors none of them are specifically directed at transport intensity and its component - value density – that is determined by the decision makers within manufacturing. To repeat the point made earlier - if industry is aware and takes full cognisance of the damage cost of transport then it is free to make the correct trade-offs about product design, manufacturing, supply chain structure and logistics. However the point is also made that if manufacturers are unaware of changes in transport costs (perhaps due to the imposition of environmental charges) then decisions about product design or sourcing are likely to lead to excessive use of transport. The aim must be to ensure that manufacturers do take account of transport impacts, and act on these findings. To do this they need a framework and guidance on how to incorporate transport considerations into their decision making.

6.49 The following sections develop a brief description of the methods that manufacturers could apply so as to ensure transport costs are included in their evaluation of product design and manufacturing systems. Within this the relative scale and variability of transport and logistics costs is explored using recent EU projects and a miscellany of other sources.

Manufacturing Management and Product Design

6.50 The main driving force for manufacturing is innovation and redesign of products and manufacturing processes. It is within this context that the links between transport intensity and manufacturing have to be managed. A particularly useful overview of this topic can be found in the report SULOGTRA[92].

6.51 Logistics encompasses both the costs of movement and those of storage (in warehouses etc). The point that during the process of product change consequent changes in transport costs need to be taken into account applies equally to consequent changes in all logistics costs. It is also useful to differentiate between new product development and product redesign because the manufacturer's rationale for each is somewhat different. Redesign is often associated with cost reduction after a product has been launched. In an ideal situation a company would know all of their cost functions and their likely revenue functions and would be able to position their new product design and its manufacture to maximise long term profit. This might mean foregoing short term profits to obtain market share and hence access to long term profits with a focus on reliability of delivery and adequacy of stocks throughout the supply chain (fulfilment) rather than transport costs. Longer term, thought may be given to redesign and the tuning of the logistics and transport processes.

6.52 What constitutes a new product? How much variation from another product defines it as "new"? There are studies of product variety (for instance personal computers) which show the phenomenon of "cannibalisation", where variety in one product line detracts from demand for another product from the same manufacturer. In practice a product can be "new" when introduced into a geographical territory previously unexposed or to a sector of the population previously unable to exercise choice. That is, novelty is in the eye of the beholder.

6.53 Although an increasing proportion of sales are for new products the failure rate of innovatory products has been of considerable concern to all EU governments for decades. Studies of the receptivity of potential industrial customers[93] (Seaton et al) suggest that the failure rate of new products may be associated with a failure to identify the organisational adaptation needed by the potential user in order to exploit new attributes. The literature does not suggest, however, that transport efficiency is a significant factor.

6.54 The wider context in which transport may be considered in product design can be seen in a diagram that refers to logistics as just one consideration.

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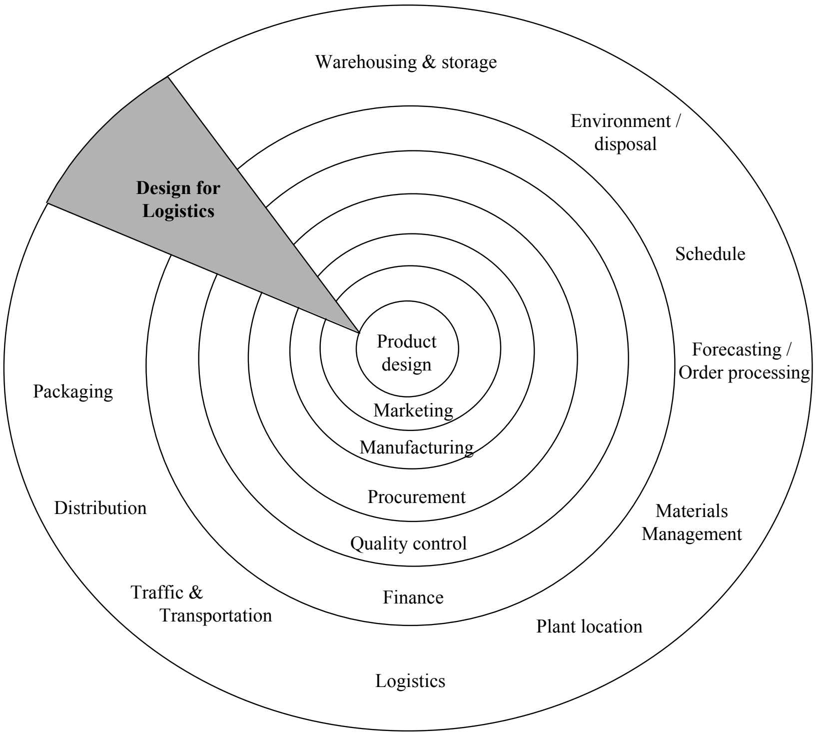
[92] SULOGTRA (op cit) D2b+3b

[93] Seatn et al, op. cit.

FIGURE 6.2 DESIGN FOR LOGISTICS VS. SEQUENTIAL APPROACH TO PRODUCT DESIGN



Source: Dowlatshahi, 1996

6.55 Full consideration of logistics impacts can be seen as a need to integrate a new function into to the process of New Product Design (NPD). This integration of a new function can take various forms. For instance 'Quality Function Deployment' (QFD)[94] provides a formal framework for co-ordinating the various functional inputs into the NPD process. It uses a series of 'interaction matrices' to help cross-functional teams to translate customer needs into physical products. The table shows how QFD differs from the more conventional 'phase review' process.

TABLE 6.5 COMPARISON OF THE PHASE-REVIEW AND QFM APPROACHES

QFM Approach	Phase Review Approach
Simultaneous development across functions	Sequential interactive development
All functions participate from the start	Functional involvement by phase
Team empowered to make decisions	Management approval after each phase
Consensus decisions about trade-offs	Functionally led trade-off decisions
Working meetings to develop results jointly	Presentation meetings to report results

[94] Zairi, M (1993). "Quality Function Deployment: A Modern Competitive Tool" Technical Communications

6.56 However it is clear from this literature that the functions considered dominant in this process are R&D, engineering, manufacturing and marketing Logistics or transport are seldom included. This is consistent with other studies which show that transport and logistics are still often low in status in organisational hierarchies.

6.57 Another context is product redesign. This is where innovation takes place in a product (or in manufacturing technology) which changes the attributes of a product from the producer's point of view. Over the last fifty years the techniques of Value Analysis and Value Engineering have been developed to explore this possibility.

6.58 The aim of both Value Analysis and Value Engineering is to eliminate any feature of a product which adds costs but does not enhance value. This is done by analysing the function of components and finished products, examining different designs that might achieve this function and comparing the costs of the various alternatives.

6.59 As noted earlier the effect of many environmental policies (WEEE, ELV, Packaging etc) is to force manufacturers to consider a much larger "design space". In pursuit of these environmental requirements, "Design for Disassembly" (which enables complicated assemblies of components be taken apart efficiently) can be added to those above. "Design for Logistics" an by the same token be used to describe the process of incorporating logistical considerations into basic product design.

6.60 The main effect of these new pressures on design are, however, a concern about "life cycle costs" in which the costs throughout manufacturing and distributing the new products and also of maintaining, repairing and, possibly, recycling or disposing them are calculated. Logistics and transport costs are reckoned to be a higher proportion of these life-cycle costs than for conventional design, manufacturing and distribution, though detailed evidence is sparse.

6.61 Hart and Baker[95] propose a 'multiple convergent processing' model showing how the inputs from the various business functions and external agencies can converge at different points in the NPD process (see Figure 6.3). This network model notably makes no explicit reference to logistics.

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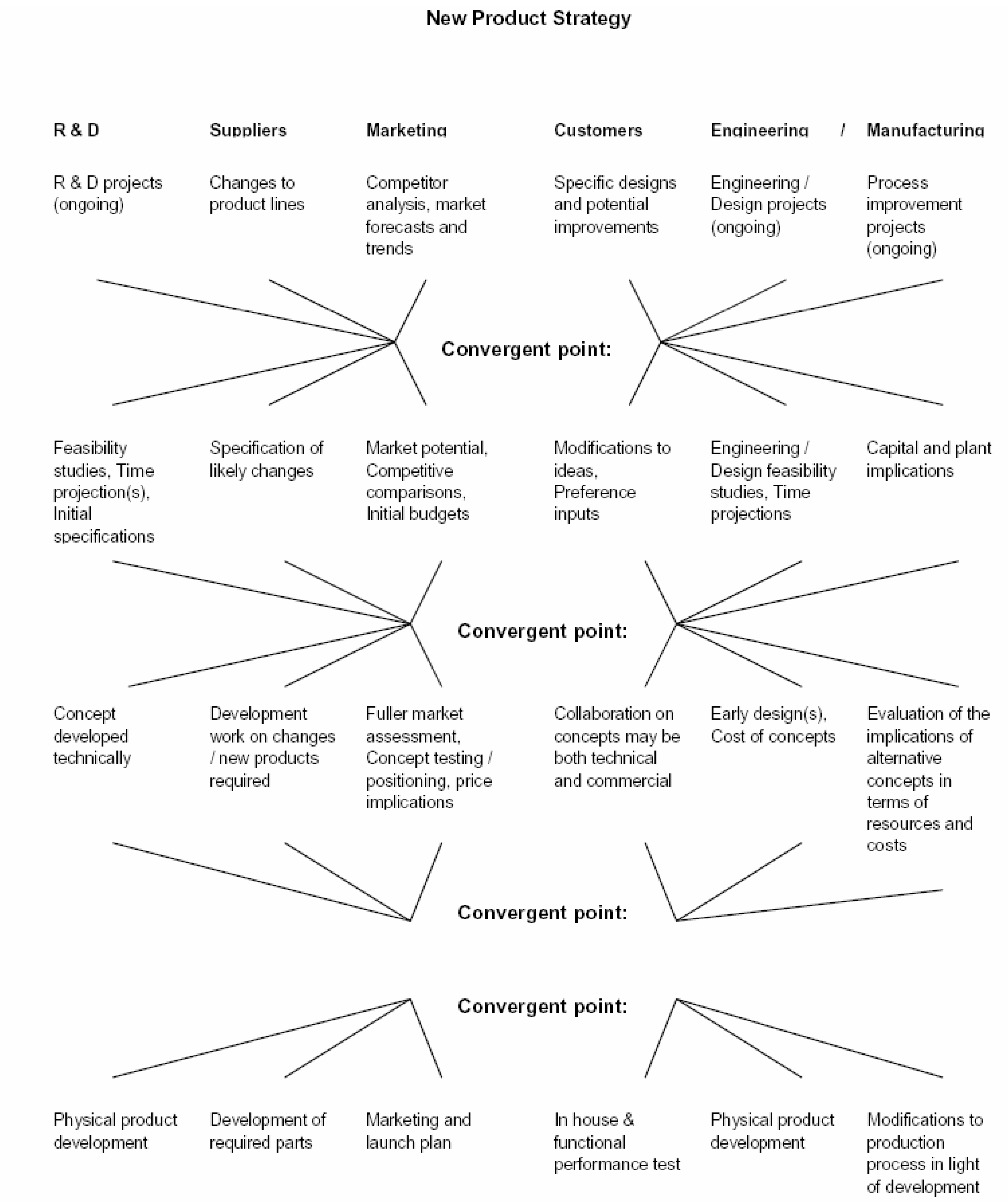
[95] Hart, S.J. and Baker, M. J. (1994) "The Multiple Convergent Processing Model of New Product Development" *International Marketing* Review, 11, 2.

FIGURE 6.3 EARLY PHASES OF CONVERGENT PROCESSING



Source: Hart and Baker, 1994

6.62 Whilst some of these approaches make a passing reference to logistics, none of them indicate how transport and logistics should be incorporated into the NPD process. If such consideration is to be made by manufacturers then some guidance on methods is required that is both convincing and readily applied. It can be argued that even this approach is too parochial a view of product design and that it should be extended to the whole materials cycle, so that impacts on raw material extraction, processing and transport, through intermediate manufacture to end of life are all valued. One view is that "socially responsible" products ought also to value the costs or benefits of changes in the primary and secondary stages of the developing economies from which many materials are obtained.

6.63 The implications of the above are very different for different sectors and countries.

- In some sectors such as those involving considerable mechanical, electrical and electronic expertise and quite complicated assemblies, design techniques are generally quite far advanced. In as much as companies in these sectors are at least European in scale, if not global, then knowledge about techniques can be expected to diffuse across countries and increasingly to smaller companies further back in the supply chain.
- In less technologically advanced sectors, such as construction and building materials or textiles and clothing, although product design techniques may be advanced, improvements in packaging for distribution could still provide opportunities for optimising transport.
- The Acceding states are themselves differentiated in terms of the development and specialisations of their manufacturing economies and some considerable analysis of their access to these techniques is urgently needed.
- Within the existing EU states the evidence is that SMEs may well be struggling to adopt the more complicated techniques and also lack access to the wider information about the supply chains within which they are embedded.

6.64 The need to consider transport implications in the new product design process can be contrasted with the development of Integrated Product Policy (IPP) being pursued by DG Environment. It specifically recognises that all products cause environmental degradation in the processes of manufacture use or disposal and IPP seeks to minimise these by looking at all phases of a product's life-cycle.

6.65 The life-cycle of a product includes all the areas 'from the extraction of natural resources, through their design, manufacture, assembly, marketing, distribution, sale and use to their eventual disposal as waste'. It also recognises that decision making is complex involving many different actors including designers, producers, marketing people, retailers and final consumers. IPP attempts to stimulate each part of these individual phases to improve their environmental performance.

6.66 There are currently a whole variety of tools (voluntary and mandatory) that are used to achieve the objective of minimising environmental damage. Whilst these include measures such as substance bans, voluntary agreements, environmental labelling etc product design guidelines are also seen as an important tool. A relevant tool here is the use of Environmental Product Declarations (EPD). At the moment the methods behind EPDs – ecodesign, life cycle analysis – pay scant attention to tranport implications and their associated environmental impact. If it is considered beneficial to consider transport implications of product design then the legislation and practices surrounding IPP are a widely used system that offers a rapid and coherent means to ensure transport impacts are considered.

Transport and Logistics

6.67 Road freight intensity, it has been argued, may be higher than necessary due to inefficient use of transport by manufacturers. This may arise from inappropriate specification from the core manufacturing process about logistics or from inefficiency in the function itself. Transport is itself only one part of logistics and the role of logistics within companies has changed over the last fifty years in parallel with developments in product design and manufacturing.

6.68 Many manufacturing companies are not in control of the whole set of activities required to procure, manufacture and distribute to final user. They form elements in a more complicated sequence of interactions between a number of companies. Many of them are small or medium size who, even if they individually operate efficiently, cannot guarantee an overall efficient and effective system.

6.69 It appears that the main focus for this approach has been to minimise inventory (the stock of components or finished goods) in the whole supply chain especially where demand for products is more volatile or there is uncertainty about supply. To achieve this requires a great deal more company to company interaction and negotiation about trade-offs and therefore a more trusting culture. It is now common to think in terms of supply networks rather than simple chains because of the spatial distribution of specialised activities and suppliers of many large international companies

6.70 The scale of transport that a manufacturer generates is dictated by a number of factors in a hierarchy which are somewhat idiosyncratic to each company or supply chain.

- **Logistical structures:** numbers, locations and capacities of factors, warehouses, terminals, shops.
- **Supply chain configuration:** patterns of trading links within these logistical structures.
- **Scheduling of flows:** manifestation of these trading links as discrete freight movements.
- **Management of transport resources:** relating to choice of vehicle, utilisation of vehicle capacity, routing of delivery etc.

6.71 SULOGTRA offers a breakdown of the "Impact of Management Decisions on the Freight Transport Parameters" related to core business processes. The Table below shows those transport variables which are regarded as significantly influenced by each of the thirteen types of management decision:

TABLE 6.6 IMPACT OF MANAGEMENT DECISIONS ON THE FREIGHT TRANSPORT PARAMETERS

	Freight tkm	Mode choice	Vehicle Type	Vehicle Utilisation	Routing	Scheduling
Product Development						
Product design	+	+	+	+		
Packaging	+	+	+	+		
Product range	+	+	+	+		
Marketing planning / Sales acquisition						
Market area	+	+	+		+	
Marketing channels	+	+			+	
Sales strategy / promotional activity	+	+	+	+		+
Order Fulfilment						
Location of production and distribution facilities	+	+			+	
Sourcing of supplies	+	+			+	
Production system	+		+	+		+
Inventory management	+	+	+	+		+
Materials handling	+	+	+	+		
After sales service	+		+	+		+
Recycling/reverse logistics	+	+	+	+	+	

Conclusions

6.72 What is clear from all the projects reviewed for this report is how much variation there is even within the same market in amount of transport needed. This in turn will depend on a number of decisions in different functions some of which impact upon the spatial structures and others on transport operations.

6.73 Product development incorporating product design, packaging redesign and the determination of product range are all considered to impact on freight volume, mode choice and vehicle efficiency. Unfortunately the assertion is not backed up with any examples or indications of the scale effects.

6.74 Other issues surrounding a new product may impact on transport, particularly decisions concerning sourcing or market area of the product. These can have a large and direct impact on average haul. If the new product leads to a different distribution of production locations then this too will have an effect on freight intensity.

Scale of Logistics and Freight Transport Costs

6.75 It has been argued that manufacturing companies ought to take account of transport costs in design of products and manufacturing systems. It is also apparent from the literature that in many situations these costs have a low priority or may be disregarded by manufacturers during the design process because they are regarded as a small and hence negligible proportion of total costs. The effect of policy initiatives (such as marginal cost pricing) on product design is also likely to be minimal unless, as argued earlier, management systems are well tuned. In order to demonstrate the possible impact of transport costs on manufacturing product design, the following sections show the way in which product attributes affect road transport costs. In addition they provide a selection of information about the variability in the scale of transport and logistics costs in the final sale price of various products. External costs of transport are briefly highlighted and finally the potential effect of marginal cost pricing is discussed.

Mechanisms

6.76 Earlier in this report the description of product attributes from a transport perspective was discussed (Dowlatshahi, 1996). The way in which these can impact on transport costs include the following;

- Weight
- Size and Volume
- Shape
- State (solid, liquid, gas)
- Fragility and Stackability
- Perishability and need for temperature control
- Hazard

6.77 Note that the definition of a product includes packaging. Packaging is itself the subject of legislation and can have an important impact on attributes such as volume and stackability. It has been shown that the design of packaging in the grocery trade can have a large impact on the costs of transport, particularly through its impact on the efficient packing of pallets and vehicles. Associated with this is the use of unit loads in many areas[96].

6.78 Turning to the vehicle its carrying capacity depends on how much weight it can take, the surface area of the load deck and the overall volume available. In general, the capacity is reached by only one of these constraints at a time. Goods with a high density will meet weight limits, those with high surface areas the deck area limit and low density products the volume limit. There is evidence that increasingly manufacturers are running into volume constraints rather than weight constraints. Deck area constraints apply in such sectors as the construction industry. If the weight of a product is reduced for the same volume then more product can be carried up to the weight limit (providing this is the next constraint). A similar argument applies to decreasing volume of a product subject to weight limits. Certain shapes or weights or volumes may require a different type of handling equipment and lead to an increase in cost per unit lifted. The nature of the production or supply system may change around

[96] A T Kearney "Efficient Unit Loads", Report to ECR Europe.

a new or revised product resulting in changes to say, distance to components suppliers or involving an addition (or reduction) to tonne km.

6.79 Transport managers are always trading off service levels against the size (hence cost) of vehicles and the utilisation of a given vehicle in the light of pressures from lead time, delivery windows and service frequency. So even if a vehicle could be filled to one or more of its limits it is seldom that they are. The dropping off of products on a delivery cycle, and the return to base inevitably compromise the full use of the vehicle. The extreme case occurs as products and delivery become more specialised so that a specific delivery has to be made for a specific product at a specific time. In one sense this is the front line of the revenue cost trade-off since service quality is revenue related. At this level of service transport and logistics costs have their greatest influence and need to be integrated in the wider context of product development.

Logistics and transport costs

6.80 Ideally we would like to know what the proportion of logistics costs compared to manufacturing across a range of products and sectors. The majority of investigations which might reveal some features of the relative transport costs do not always include all the relevant cost elements of logistics. The tendency is to concentrate on output or input logistics but not both. This may partly be because many studies use a company as the basic element of analysis, rather than the total supply chain, in order to reflect the management issues facing them. In practice there is virtually no systematic data on the full transport (or logistics) costs in the supply chain of a product. There are however a number of estimates of the share of logistics in the total economy.

6.81 Logistics accounts for a significant proportion of a country’s income or GDP. An estimate for 1996[97] suggests that approximately $3,425 billion was spent worldwide on freight transport, warehousing and related IT and administration. A recent report from Michigan State University[98] shows logistics as a percentage of GDP for a number of major countries. The figures in Table 6.7 show logistics costs as a percentage of GDP ranging from 10.5 % in the U.S. to 14.9% in Mexico. The US value is widely considered to reflect a high level of expertise in logistics.

6.82 Additional studies suggest that, when the interest involved in holding inventory is added, total logistics costs may represent as much as 17-18% of the GDP of developed countries. Variations in these estimates are partly due to differences in the method of collecting statistics and even the precise definition of logistics. Where figures exist the share of transport in logistics is between 30 and 50%. For European countries therefore freight transport might represent between 3 and 5% of GDP. The service sector in modern economies comprises about 40% of GDP. Excluding this sector we can conclude that for the remaining products in the economy the total freight transport component is in the range 5-8%. These remaining products comprise final sales to consumers including products of the construction and energy industry as well as manufactured products. In terms of the share of transport costs after final manufacture

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[97] Bowersox, D. and Gloss, D. (1996), "Logistical Management - The Integrated Supply Chain Process", McGraw-Hill, New York, 3rd edition

[98] Michigan State University (1999), “A Survey of Logistics Costs”, MSU.

the figure can be expected to fall to 2.5-4%. This range represents the uncertainty about average transport share. Over the range of products the share of transport is likely to vary widely.

TABLE 6.7 LOGISTICS COSTS AS A PERCENTAGE OF GDP BY COUNTRY

Country	GDP in US$m	Logistics in US$m	% of GDP
Mexico	334,726	49,753	14.9
Ireland	67,392	9,611	14.2
Singapore	94,063	13,074	13.9
Hong Kong	153,068	20,992	13.7
Germany	2,352,472	306,264	13.0
Taiwan	273,440	35,686	13.0
Denmark	174,237	22,440	12.8
Portugal	101,182	12,871	12.7
Canada	585,105	70,191	12.0
Japan	4,599,706	522,982	11.3
Netherlands	392,550	44,495	11.3
Italy	1,214,272	137,027	11.2
UK	1,151,348	122,344	10.6
US	7,576,100	795,265	10.5

Sources: Michigan State University Study 1999, based on 1996 statistics

6.83 One sector which has been regarded as strongly competitive is food and it has therefore been the focus of considerable analysis. In 1999[99] the average grocery distribution costs as a percentage of sales turnover were reported as 3.3%. Their data shows a range from small to large retail chains and a range of costs from 6% to 2.2%. It must be emphasised that this only represents the costs after final manufacture and does not reflect the upstream transport costs. More recent data for 2002 has been added to the table below. Distribution as a percentage of sales turnover was 3.4%. Within this % the breakdown of functional costs is:

[99] 'Retail Logistics 1999', Institute of Grocery Distribution, UK

TABLE 6.8 LOGISTICS COST BREAKDOWN

Function	% 1999	%2002
Transport Costs	35	34.8
Warehousing Costs	60	56.1
System Costs	2	1.8
Other Costs (General administration, support and Christmas relief)	3	7.3

6.84 Transport costs in this context represent about a third of logistics cost i.e. less than 2% of final sales and are reported as falling due to more efficient use of truck fleets. IT costs are also falling due to lower operating costs after a wave of start-up costs for IT projects. In general, stock levels have been falling (reflecting efficiency) and warehouses are larger, reflecting wider ranges of non-food items in many chain stores. These data do not include the trip from original producer, for instance a farmer, to a product manufacturer. This may explain why the logistics cost is relatively small compared to other sectors

6.85 A slightly different perspective is made in another report[100] which suggests unit loads used by manufacturers. retailers and service providers are key cost drivers. They estimate the logistics cost (defined as transport, storage, handling and packaging in the supply chain) represents 12-15% of retail sales price. A more efficient approach to unit loads (pallets, roll cages etc) is estimated to save 1.2% of retail sales price. Such an efficiency improvement can only be achieved, it is argued through supply chain integration and harmonisation of the physical aspects of the supply chain. Only a small proportion of the potential savings would accrue to the transport element.

6.86 SULOGTRA (2 and 3) also reports some shares of transport in final sales price[101] for the case study companies though the relevant sector of each is not revealed (only one company appears in both sets of data) in the ranges of

Logistics costs	2-3%,	3%,	6,	7%-	10%:
and for transport	0.5%	1%	4%	4.5%	5%

6.87 The relevant sector for each cost is not given. This issue of commercial confidentiality is a perpetual problem in obtaining an overall view but all the relevant studies reviewed note very large variations between sectors and even within sectors.

6.88 The share of transport costs for a particular product stems from a number of different factors. Its density, market location and delivery profile all influence the final transport cost share. Those with a high weight density (t/€) may be expected to consume more transport resources. A large market area implies a long average haul There are wide variations between products in the length of trip and whether it is an urban delivery or long distance haulage or by size of consignment. Frequent and small

[100] 'Efficient Unit Loads', by A.T. Kearney, Report to ECR Euro

[101] SULOGTRA, op.cit. D2b+3b Table 15. Logistics or Transport costs as a percentage of Sales Price

deliveries will incur higher unit transport costs. For instance SOFTICE[102] examined variability by country for all freight trips (pallets, part loads and Full Load Truck (FLT)) and for FLT alone. The data is shown again, in tabular form below.

TABLE 6.9 MEDIAN AND AVERAGE HAULAGE COSTS €/VEHICLE KILOMETRE

All				FTL only			
Median		Average		Median		Average	
Germany	1.609	Germany	2.836	Germany	1.609	France	1.792
Switzerland	1.479	Switzerland	1.877	France	1.105	Italy	1.605
Italy	1.168	Italy	1.724	Italy	1.07	Germany	1.571
France	1.067	France	1.5	Sweden	0.948	Sweden	1.212
Sweden	0.894	Sweden	1.061	Portugal	0.796	Switzerland	0.822
Portugal	0.471	Portugal	0.645	Switzerland	0.709	Portugal	0.74

6.89 Such substantial differences between countries and between products make it difficult to estimate precisely what impact new product developments in manufacturing are likely to have at a national level. At the micro/firm level, decisions on product development are unlikely to be influenced by transport cost, although location decisions could well be influenced by this cost in amongst other factors. It is deep within specific trade and commodity sectors and their supply chain networks that the implications would be revealed. In any event, the type of vehicle, value and density of load and length of haul will all have an influence on cost per tonne kilometre and transport intensity.

6.90 SOFTICE also reports much lower prices in Acceding countries for a range of distances than western European prices, although prices for full load truck segments are closer to average in both cases. The reasons for this is given in part to differences in labour rates but also[103] the lower levels of various taxes. As harmonisation takes place Acceding countries will face higher taxes on the road freight industry in addition to other tax adjustments.

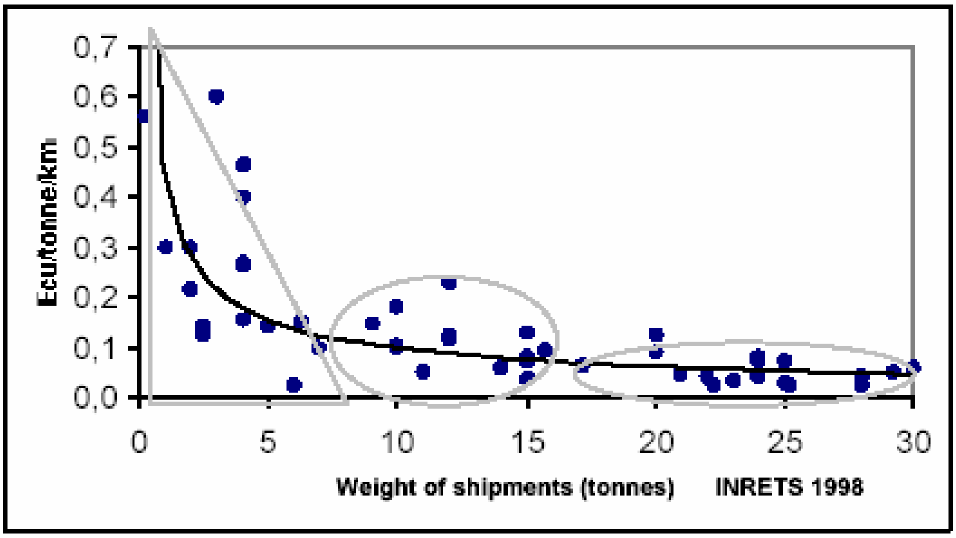
6.91 Another of the factors explored by SOFTICE was the variability of unit costs of haulage with size of shipment (Figure 6.4) [104]. This information is consistent with the RECORDIT data where values of cost per tonne km for intermodal freight would be towards the right hand side of the X-axis. The reasons for this are well developed in the SOFTICE report.

[102] Extracted from SOFTICE Final Report op. cit.

[103] RECORDIT, Final Report, op. cit.

[104] SOFTICE Report, op. cit. Figure 13

FIGURE 6.4 RESULTS FROM SOFTICE SHIPPER SURVEY



6.92 Once again detailed data is not available but it can be expected that consignment sizes (and hence costs) vary by manufacturing product. The differences between smallest and largest costs are in excess of a factor of 10.

External costs of transport

6.93 The European Commission White Paper[105] on fair payment for infrastructure use proposed a phased approach to charging for the use of infrastructure. Internalisation of external costs of transport such as pollution, congestion, accidents and other environmental damage has been one of the aims of developing a new charging framework.

6.94 External costs of transport have been studied by INFRAS/IWW[106] and are found to be large (approximately total external costs amount to 8% of GDP) and predominantly uncertain. Table 6.10 gives the average external cost of road freight transport per tonne kilometres in the western European countries showing quite a wide variation between different countries. Increasing transport costs by internalising external costs is generally thought to result in modal shift away from road where appropriate which would tend to reduce freight intensity.

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[105] European Commission (1998) “White Paper – Fair payment for infrastructure use: a phased approach to a common transport infrastructure charging in the EU” (COM/98/466).

[106] INFRAS (2000) “External costs of transport (accidents, environmental and congestion costs) in western Europe”, Paris, Infras Zurich, IWW, University of Karlsruhe.

TABLE 6.10 AVERAGE EXTERNAL COST OF ROAD FREIGHT TRANSPORT PER TKM IN EUROPE BY COUNTRY

Country	(€/1000 tkm)
Austria	44
Belgium	99
Denmark	60
Finland	66
France	128
Germany	96
Greece	64
Ireland	53
Italy	84
Luxembourg	84
Netherlands	64
Norway	136
Portugal	79
Spain	93
Sweden	89
Switzerland	160
UK	81
EUR 17	88

Source: INFRAS/IWW reported in Steininger[107] (2003)

Transport costs and Value Density

6.95 Although considerable attention has been placed on reducing the role of road freight using instruments such as the full recovery of marginal costs, the change in freight charges are likely to be much smaller than the variations that already exists for other commercial, location and structural reasons. Another way of putting this into perspective is to consider the relative size of transport cost to overall costs and product value for a set of manufactured products[108] (Table 6.11). The general view is that (outward bound) transport costs of intermediate goods are a higher proportion of their value at this stage than finished goods.

[107] Steininger, K. W. (2003) "Environmental Regulation of Cross-Border and Transit Transport in a Small Open Economy: Theory and Empirical Evidence for the Case of Austria". Presented at the 12th Annual Conference of the European Association of Environmental and Resource Economists, Bilbao, June 2003.

[108] Based on Fowkes et al. (1989) as reported in SOFTICE Final Report op. cit.

TABLE 6.11 DOMESTIC UK TRANSPORT SPECIFICATIONS

Commodity	**Cement**	**Metal Tubes**	**Oil Products**	**Fertilisers**	**Paper**	**Domestic appliances**	**Chilled foodstuffs**	**Brewery traffic**
Transport Cost as % of Value	18.7%	2.0%	6.0%	6.4%	0.9%	0.8%	0.9%	1.6%
Transport cost ECU per tonne km	0.049	0.088	0.069	0.039	0.087	1.01	1.48	1.29
Value (ECU per tonne)	77	1098	500	177	2,470	36,800		23,300
Range (ECU)	58-91	151-2,273	126-1,212	151-182	1,088	15-76k	-	10-38k

6.96 A survey of shippers carried out in the UK in 1997 included five flows of international traffic. Three of these were the movement of finished goods, where the cost of the international transport as a percentage of the value of the goods varied from 0.3% to 5.6%. In the case of an inter-factory movement of components the transport cost was 11.2% of the value (at that stage) of the goods. The fifth flow was of international mail but it is not presented here.

6.97 A breakdown of the values and service specifications of these flows are given in Table 6.12 which is adapted from SOFTICE. The transport rate per kilometre varies from 0.82 ECU (example 3) to 1.52 ECU (example1) reflecting it is reported partly the balance of traffic on the routes concerned, and partly the value placed on quality of service. The operators providing a high degree of reliability and short transits obtain much higher rates per kilometre, whereas the lowest rate applies to a high volume flow of LoLo container traffic, thought to be a return load operation coupled with the large purchasing power of the shipper.

TABLE 6.12 SOFTICE INTERNATIONAL FLOWS TO UK

Cargo	Example 1 Reprographic materials	Example 2 Confectionery	Example 3 Cereals	Example 4 Ceramics
Distance (km)	1617	900	933	1680
Rate ECU	1625	725	503	1230
Value of load ECU	516,000	40,000	9,000	11,000
Weight (tonnes)	14-16	19.4	12	12.5
Value (ECU)/Tonne	34400	2062	750	880
ECU/Tonne km	0.067	0.042	0.045	0.058
Transport as % of value	0.3	1.8	5.6	11.2

6.98 The table exemplifies the wide variety of issues pertinent to the share of transport in final costs and the subsequent discussion in SOFTICE is so apposite that it needs to be quoted in full.

> *Example 1 is a regular flow of very high value goods for which the shipper is prepared to pay a high rate for a reliable and secure service using an accompanied road goods vehicle (ARGV). The high freight rate per kilometre partly reflects the service and that goods on the return leg do not stand high freight rates. Modal choice is unlikely to be influenced by changes in costs resulting from higher taxes, though transport costs will be increased in the long term.*
>
> *Examples 2 and 3 are non-perishable foodstuffs carried in LoLo containers. Some of the traffic to Frankfurt is carried by rail from Rotterdam. The rate per kilometre is much higher in the case of the Swedish traffic, which uses a long North Sea ferry route. The main reason the German flow gains a very low rate is because it is back loading containers, the volume is relatively high at one or two containers per working day, and the transit time required is modest. The main constraint is the booked arrival times. The flow in example 3 provides an attractive base load traffic for an international transport operator.*
>
> *The first three flows are of finished products being moved from a manufacturing or food processing facility to a major distribution point in another European country, one of which is not a member of the EU. The costs of this international movement form only a small percentage of the value of the goods, between 0.3% and 5.6%. Further transport and distribution costs are subsequently incurred in the delivery of the products to the consumer in the destination countries. They have been supplied to the distribution hub based on the cost of production and transport to that point and additional delivery costs are likely to be similar to goods produced within the respective countries. A significant increase in international road transport costs may affect the sourcing of some products rather than have a major impact on choice of mode, depending on the costs and quality of service offered by alternative modes.*
>
> *Example 4 is different from the other international flows in a number of ways. It represents the movement of goods within the supply chain (though not on a just in time basis). The vehicles are in fact hired by an associate company in Italy for a round trip loaded both ways, the two companies splitting the charges. The UK company is in fact paying above the market rate because of competition for Anglo-Italian traffic to fill southbound lorries, and is being given a fairly slow and unreliable service.*

6.99 There is no similar data about freight haulage costs from this source for the Acceding countries but a somewhat different insight in freight intensity can be seen in terms of differences in value density between the EU and Eastern Europe generally[109].

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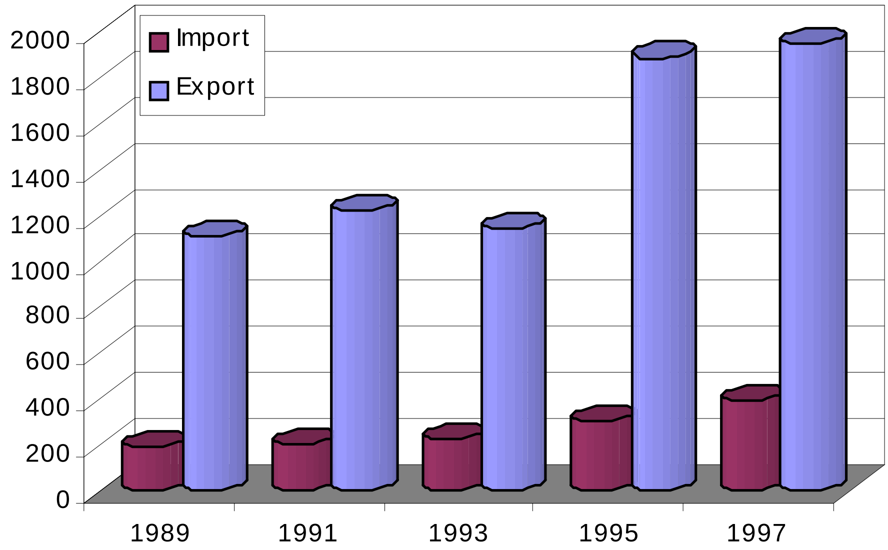
109 TRILOG op. cit. Figure 1.5

FIGURE 6.5 TOTAL VALUE FOR WEIGHT DEVELOPMENT IN ECU PER TONNE: EU IMPORT AND EXPORT FROM AND TO EASTERN EUROPE



6.100 The situation is characterised, not unexpectedly, by low value flows from Eastern Europe and high value flows to those countries. This reflects the flows of raw materials and intermediate goods into the EU and finished goods into Eastern Europe. The interesting trend noted elsewhere is the relocation of some types of manufacturing to Eastern Europe (closer to some raw materials and cheaper labour markets) and more and more transnational supply networks.

Policy Impact

6.101 Although a number of studies have investigated the likely response of manufacturing to increases in road transport costs through perception studies or attempts at elasticity analysis, it is worth placing the likely increase in the context of manufacturing and freight transport intensity.

6.102 Assuming that the base transport prices in the market are represented by transport internal costs (€1.05/vkm for road) the cost per tonne km for an articulated vehicle operating at its weight limit for half its time is €0.06 per tonne km (See table below). These values are, allowing for differences in the reference date of the information, very close to the values used in SOFTICE.

TABLE 6.13 ASSUMED LOADING UNITS WEIGHT

	Maximum	Average
20' container/Class C SB		
load (tons)	16	12
tare (tons)		2,3
40' container/Class A SB		
load (tons)	24	18
tare (tons)		4,2
Semitrailer/all road		
load (tons)	24	18
tare (tons)		

Source: RECORDIT partners' internal studies.

6.103 Two possible charging policies reflecting external costs are:

- The full recovery of external costs of road freight, gives on average an increase of €0.21 per articulated vehicle kilometre and €0.25 per rigid vehicle kilometre
- The balanced recovery of external costs (between road and rail), €0.12 per artic vehicle kilometre and €16 per rigid vehicle kilometre

So the additional amount per vehicle kilometre for Policy 1 is 20% and for Policy 2 from 11% (artic) to 15% (rigid).

6.104 This can be compared to other, earlier estimates, quoted in SOFTICE which differentiate between rural and urban.

> *"Transport costs for road freight transport can be expected to increase by 18 % in rural areas and 30 % in urban areas (ECMT, 1998), for rail freight by about 80 %, if full cost coverage for infrastructure costs is included. This, however, is not a likely scenario, as this would imply practically the end of rail freight service."*

6.105 Some simple examples show the relatively small effect that marginal cost pricing might have on final consumer prices.

Example 1

6.106 Electrical goods are typical of relatively high value density with a retail interface. Contrary to common perceptions few goods are actually delivered from shops, but from a warehouse. In the UK there might be from 7 to 14 of these for a particular retail chain.

Television set say (modestly) 80 per articulated vehicle.

Sale price	€500	
Distance trunking	1000km	
Old Transport cost at €1.05/vehicle km	€1050	
Policy 1 Cost at €1.26	€1260	
Policy 2 Cost at €1.17	€1170	
Policy 1 Additional cost per television	€2.62	0.5% of value
Policy 2 Additional cost per television	€1.50	0.3% of value

6.107 To this must be added the change in delivery costs from warehouses or shops. The current charge in the UK is typically €14 for any part of the catchment area of a large town, reflecting the high unit costs of small vehicles and low load factors. It is not at all clear that this charge is for actual delivery costs – it is often a trade-off with profit and not all retailers apply it. A change of 20% gives an extra cost of home delivery of €1.4 and 11% €0.8 per television. In total the total respective changes are €4.02 and €2.25, 0.8% and 0.4%.

6.108 Using this example it is also possible to see the impact of changing value-density. In this example the transport cost is quite high (with a long trunking distance and modest vehicle load factor) at €13.1 - 2.6% of final price. Any change in volume (which is the constraint on vehicle loading for this product) will lead to a *pro rata* increase in vehicle transport costs due to its impact on vehicle loading.

Example 2

6.109 Ceramic Tiles are relatively dense and may reach weight limits on vehicles before volume limits. The example here uses a scenario where the tiles are collected from a showroom. The information from REDEFINE and, anecdotally from the UK, is that intermediate warehousing is decreasing and the number of links in the supply chain is thus reduced. The distance used in the example is from the table above and the value of tiles based on a recent typical transaction by a UK builder working on small domestic projects.

Tiles pack of 16

Pack size	32 x 22 x 16 cm (0.011264 cu m)
Weight	10 kg
Value	€12 per pack
Sale price per tonne	€1200
Distance trunking	1650km
Old Transport cost at €0.06 per tonne km	€99

Policy 1 Cost at €.072	€119	
Policy 2 Cost at €.067	€111	
Policy 1 Additional cost per pack	€0.2	1.7% of value
Policy 2 Additional cost per pack	€0.12	1.0% of value

6.110 The impact on the final consumer is hardly perceptible.. The cost of tiles for a small room = 20 packs= €240 and the increase €4 or €2.4. The standard trade discount from such outlets is 10%. Transport considerations will be of low priority in product designers decisions.

Example 3

6.111 Potatoes are, for some obscure reason, much used as a logistics example of a fresh product in the food chain. An interesting feature is the variety of potatoes available to consumers appears to be increasing. Market prices are somewhat volatile depending on weather and crop yield but €1 per kg would be a top price for a specialist potato. The price on the wholesale market, from the field is perhaps 20-40% of retail price. The haul from farm to market is not likely to exceed 100 km, using a small rigid vehicle. Market (or more likely farm) to processing and the supply chain account for another, maximum, 200 km, but often a great deal less. Final distribution to supermarkets will be as part of a mixed load on an articulated truck and to specialist greengrocers by medium size rigid.

Sale price per tonne	€1000
Distance to market	100 km
Market transport cost per tonne for 5 tonnes at €1.05 km	€21
Distribution distance	200 km
Transport cost at €0.06 per tonne km	€12
Policy 1 Cost/tonne of market transport at €.1.30 vehicle km	€26
Policy 2 Cost/tonne of market transport at €.1.21 vehicle km	€24.2
Policy 1 Cost/tonne of Distribution transport €0.072 tonne km	€14.4
Policy 2 Cost/tonne of Distribution transport €0.067 tonne km	€13.4
Policy 1 Additional cost per tonne	€7.4 0.74% of value
Policy 2 Additional cost per kg	€4.6 0.46% of value

Conclusions

6.112 These three simple examples provide some understanding of how transport costs vary in their share of final sales price. They confirm the fairly modest component of transport costs in the final price. Manufacturers involved in new product development understandably pay little attention to these costs. In considering changes to existing products or the introduction of new products the impact on a *change* in transport costs is even more modest. However the examples also show that identifying the impact is fairly straightforward. Changes in density generally have a *pro rata* effect on costs, and its impact on final costs is fairly easy to predict.

6.113 Where new product development involves a change in market size, scale of production or sourcing the effect on transport costs is also fairly easy to predict. In practice purchasers (of final or intermediate products) do take account of transport costs in their choices about different suppliers in different locations. Where there are proposals for rationalisation in the supply chain (greater concentration of production, processing or inventory holding) decision makers do generally take account of the transport-operations cost trade-offs. Logistics management texts provide both the framework for analysis and practical examples indicating the scale of changes and optimum configuration that is desirable in particular contexts. These possible consequences of new designs that influence average haul and intensity, therefore can be handled fairly easily.

6.114 New product developments may also be associated with a change in the delivery pattern. Customisation, a move towards more precise delivery times or even direct delivery to the customer may all have implications for transport costs. These trends in delivery profile will tend to increase costs if smaller vehicles are used or if consignment sizes are smaller. These implications may be more difficult to assess as there is often uncertainty in the precise loading factors that can be achieved when the service pattern is subject to severe change.

6.115 Finally the new product may change the route it follows over its life. There may, for instance, be a greater tendency for the product to return for reprocessing or its final disposal may involve more transport resources. Conventional Life Cycle Analysis (LCA) already involves consideration of such possibilities and includes impacts on operating costs and environmental impacts as well as transport costs.

6.116 It appears therefore that if new product designers do want to consider the implications of their options and choices on transport costs there are no great conceptual difficulties to overcome. Textbooks and examples exist to guide such analysis in most cases.

Relevance to policy makers

6.117 Two distinct parties can be identified. First is the set of governmental organisations responsible for transport policy (the EU and national governments). And secondly, the set of decision makers responsible for guiding developments in manufacturing processes and strategy. Both of these parties make decisions that directly affect freight intensity, even though this is not the specific target of their decisions. Government institutions regard some form of intervention (by regulatory measures and taxation) in the freight transport sector as desirable. The main thrust of policy in recent years has been driven by a recognition of the external costs of freight transport (accidents, noise and air pollution, global warming, congestion) especially movement by road. Therefore there has been a tendency towards increases in charges (to reflect marginal cost pricing) on road freight and pollution reducing regulations (such as EUROIV standards). This tendency has been apparent throughout the EU and is beginning to emerge in the Acceding countries as well. There is general agreement that the optimum level of charges has not yet been reached[110]. Future policy initiatives can be expected that lead to higher charges on road freight movement.

6.118 The design and analysis of transport policy is well developed and is carried out within a framework closely related to economic cost-benefit that places monetary values on external costs. The governmental approach to policy initiatives is to use the framework in which costs impacts are balanced against benefits. The impact of these policies directed against reducing external costs is often to reduce transport intensity. But intensity is not a performance metric which would be part of the list of costs and benefits used to evaluate the policy. A great deal of effort (by both National and EU institutions) has been expended in generating and evaluating policy options in the freight sector. The long list described earlier in the chapter provides effectively a synthesis of the current policy options. Almost all of these are under active investigation and many are being actively pursued towards implementation. As far as government institutions are concerned the stance of policy appears appropriate with options identified and instruments identified for future implementation. Social welfare will be improved (through reduction of externalities) and by implication road freight intensity should be reduced by these initiatives

6.119 The other major set of decision makers influencing freight intensity are those responsible for guiding developments in manufacturing processes and strategy. In their choice of product design, sourcing, market area and delivery profile they influence the consumption of transport resources and hence freight intensity. The general impression is that companies attach little, if any, weight to transport when looking at product design, due to their perception of its small share in final sales price. In the case of sourcing and market area transport costs may receive greater consideration. This general lack of consideration also seems to apply to the area of logistics as a whole[111]. The implication of this is that because insufficient consideration in the development of products is given to transport, more resources will be consumed and freight intensity will be higher. If full consideration is given to transport costs and associated trade-offs with design issues then freight intensity should be reduced and policy initiatives such as charging for external costs will have their appropriate influence on design considerations.

Is consideration for transport realistic?

6.120 The business rational suggests companies give little or no consideration to transport in the design of products. Issues of functionality and aesthetics are those most critical to the success of new products. Some trends of course such as the use of lighter materials and miniaturisation can contribute to a decrease in transport intensity. Transport or logistics management need have little input into product design where the impact of

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[110] RECORDIT, op. cit. Final Report, 2003.

[111] SULOGTRA, op. cit., WP3.

change is small. The exceptions to this are where some attribute of the new product has a large impact on weight, volume or fragility. Packaging can be an important component in the design of new products, or redesign of existing ones.

6.121 It can be generally agreed that greater consideration should be given to the transport implications of product development. However compelling companies to do this when there is no awareness of the "social good" this may bring is a challenging prospect. To be realistic, this consideration should be seen as a two phase process. The first is a quick scan to see if the impact on transport is likely to be worth greater effort, followed if it is considered desirable, by a more detailed analysis of the quantitative effects.

6.122 Ideally this should be incorporated into the existing processes used for new product development (though these may be poorly defined in many companies). A wider perspective, which takes account of related aspects concerning sourcing, market area and delivery profile, should also be adopted. This perspective of a more holistic approach is consistent with current trends to greater supply chain integration which aims for greater harmonisation between the different actors in the chain and optimisation of all aspects that contribute to final product value.

6.123 The suggestion that companies take fuller account of logistics related implications in product development goes well beyond the subject of road freight intensity. Product design in its impact on weight can have a direct effect on intensity, and external costs. Average haul and hence intensity will be affected by more remote sourcing and larger market areas. However changes in design associated with volume or delivery profile may have a negligible impact on intensity but a large (undesirable) effect on the unit cost of transport and external costs. Additionally it seems logical that if transport impacts are to be given fuller consideration then a supply chain logistics perspective that integrates movement along the supply chain should be adopted. How extensive the 'supply chain' can be depends on issues of data availability and confidentiality.

6.124 How can designers be persuaded to take a more active consideration of their design options for transport costs leading, possibly, to a change in design? There appears to be a number of continuously evolving methods used in the process of generating and evaluating new designs. In recent years, due in part to pressures from government, the process now pays much greater attention to environmental considerations (Ecodesign and Environmental Product Declarations are two examples). Consumer awareness and their expectations of due environmental considerations, coupled with accredited product labelling, induces product designers and manufacturers to embrace such practices by choice to their competitive advantage over rival products and processes. The focus on freight transport intensity can be seen as another component of this wider concern for the environment and sustainability.

6.125 Influencing all the different processes and procedures used in new product development will probably have to be achieved by persuasion rather than legislative requirements. One immediate possibility is to incorporate transport considerations (or its derivative – environmental considerations) into the Integrated Product Policy (IPP) package.

6.126 The "Life-Cycle Thinking" approach in product development in the way suggested by the IPP package will probably be achievable by persuasion rather than legislative requirement. But the role of the industry and governments ought to be in developing appropriate Life-Cycle information and interpretative tools to inform in particular SMEs in adopting new design practices.

7. CONCLUSIONS

7.1 This section brings together elements of the study from preceding sections to present the main conclusions collectively together. The study reviewed existing data and research into factors affecting freight transport intensity.

7.2 Freight intensity is defined as the ratio of freight moved (tonne km) in an economy to the output (measured by GDP) of that economy. Using this definition it is possible to break down the determinants of freight intensity into 4 components using the following identity

$$\frac{roadtonnekm}{GDP€} \equiv \frac{roadtonnekm}{totaltonnekm} \times \frac{totaltonnekm}{totaltonnelifted} \times \frac{totaltonnelifted}{totaltonnegenerated} \times \frac{totaltonnegenerated}{GDP€}$$

intensity ≡ modal share x average haul x supplychain structure x product value density

7.3 The identity shows that freight intensity is the product of four factors:

- the modal share of road transport;
- the average haul;
- the number of times a product is handled to final consumption in the supply chain; and
- the average value density (defined as t/€) of final products.

7.4 All changes in freight intensity must logically derive from changes in one or more of these components. The analysis of past trends can use this framework and forecasts can similarly identify the role of individual components contributing to an increase or decrease in intensity. The above equation can be transformed to give

$$\%\Delta roadtonnekm \approx \%\Delta GDP + \%\Delta modal\ share + \%\Delta averagehaul + \%\Delta structure$$

7.5 Data on freight is not always available for all European countries over an extended period on a consistent basis. Sometimes data has not been collected, different methods are used between countries and countries sometimes change the method that is used.

7.6 An examination of available data series show a wide dispersion for road freight intensity between countries, with the three highest recorded for countries in Eastern Europe – Bulgaria, Estonia and the Czech Republic. Within the European Union there is also a wide dispersion. Italy records a figure over 250 tkm/GDP whereas Austria and Ireland are below 100 tkm/GDP.

7.7 The reasons for such a wide dispersion are unclear. Some of the variation is undoubtedly due to different methods of data collection and the errors inherent in this process. It is not possible to be precise about the scale of these effects but it could be as high as 50%. The error is likely to be particularly large where data on the total vehicle fleet is poor and hence the grossing factor for sample surveys is poorly estimated.

7.8 Trends in road freight intensity show the countries within the European Union have generally experienced an increase in intensity over the period 1970 to 2000. The increase for the EU as a whole is equivalent to an average annual growth rate of 1% per year, varying between countries from a low of -3.6% in Ireland to 2.4% in Italy. Two countries (Germany and Greece) record a figure of over 3% per annum for the period 1990-2000. France records a figure of just over 2% for the same period. Over the period 1970 to 2000, 5 countries in the European Union (Finland, Ireland, Portugal, Sweden and the United Kingdom) have experienced a reduction in intensity. In 1970 all these countries were higher than the EU average. By 2000 only Finland was above the average. Four of the countries also experienced a reduction in intensity during the 1990s and Sweden showed no change.

7.9 Five countries are looked at in greater level of detail (Germany, Sweden, Italy, France and the United Kingdom). The increase in average haul in these countries has contributed to the general increase in intensity in the 1980s and 90s. Again there are differences between countries but the figures suggest an average contribution of perhaps 2% a year. Without this increase therefore intensity would have fallen. Part of the trend (less than 1%) may be attributable to the changing mix of commodities over the period, which has seen a move towards commodities with longer average hauls.

7.10 Another important trend is that tonnes lifted have grown more slowly on average than freight moved. Again differences between countries exist but an average difference of 2% appears plausible. Two reasons behind this is the changing mix of production in the economies. The move towards services can explain perhaps 0.5%, and there is another element due to the changing mix within production industries (moving towards lower density products) though it seems this is unlikely to explain more than 0.5%.

7.11 The general conclusion is twofold. Firstly the growth in average haul (~2% per annum for the sample countries) has tended to make an important positive contribution to the increase in road freight intensity. The second conclusion is that factors grouped under the headings of Supply Chain Structure and Product Density have tended to decrease road freight intensity (~-2% per annum for the sample countries). Modal shift to road has by-and-large made a positive contribution to increase in road freight intensity.

7.12 Although the main focus of this Study is on intensity of road freight movement, the concern with the growth in road freight stems mainly from its impact on the environment. Damage (environmental and ecological) of trucks is the real output of interest for policy – not tonne km *per se*. The main components of environmental costs include fuel consumption which has an impact on global warming, air pollution and noise pollution. In these areas, however, there has been a significant improvement in the environmental load of a truck km throughout Europe. In the case of noise and air pollution there is the likelihood of further significant improvements.

7.13 The main drivers influencing the transport requirements over time can be summarised as follows:

- Mix of products and services
- Configuration and design of commodities
- Manufacturing processes

- Warehousing and handling technology
- Information technology
- Logistics management
- Technology of transport systems
- Regulation

7.14 The mix of consumption has moved away from commodities towards services, which have a lesser demand on transport resources. At the same time the balance of commodities consumed has moved towards those (such as electrical and electronic goods) that have a higher value to weight ratio. Both these tendencies have contributed to a reduction in the level of freight intensity.

7.15 The major driving force behind the growth of GDP has been the adoption of new technology, which involves not only new, more efficient processes, but also the development of new products. New products often tend to be more sophisticated and are often accompanied by different packaging requirements.

7.16 Allied with changes in the form of products, there has been a tendency for a particular product to be offered in many different forms (variety) and sometimes with the ability for customers to define the configuration that they require (mass customisation). All these factors surrounding new products can therefore be expected to result in different transport requirements.

7.17 Turning to manufacturing processes, technological developments have changed the methods of production. For instance new materials and changes such as the move towards modularisation in certain industries have led to the emergence of new processes. Of particular importance to transport is the possibility that new technology has meant greater economies of scale in production, leading to larger plants and longer distances for products to move (both to the new larger plants and from them to the marketplace).

7.18 The analysis has identified a long list of drivers influencing freight transport requirements over time. Evidence on the direction of their effect on the components of intensity can usually be deduced from the nature of the driver itself. Quantifying the effect however is far more difficult. Little or no evidence exists on many of the drivers. Often the evidence where it does exist refers to one type of supply chain in one country. Table 1.2 provides a summary of the conclusions concerning the importance of the various drivers.

7.19 Examining the components of road freight intensity in turn, average product value density has decreased partly due to the change in the mix of commodities and partly due to the change in design of individual products. Both of these effects can be regarded as important in contributing to a reduction in intensity. Given the steady growth in GDP in European countries and the consequent change in product and service mix this impact will have occurred in all countries.

7.20 Three areas are investigated for the evidence on product and value density (food, automotive and construction sectors). In these three areas, the evidence points towards a general increase in value density over the past 20 years. This has been partly due to the general increase in sophistication of individual products implying greater value per unit weight. This has occurred throughout the range of products – more processed foods, better performing cars, etc. At the same time new materials and manufacturing processes have led in many cases to lighter products. This tendency towards lower weight was widespread but not necessarily universal as the example of passenger cars showed. In total the sum of these changes in value density should have made a substantial contribution to a decrease in intensity. European countries have followed a similar path in their adoption of new products and manufacturing processes and therefore this effect should have been common over all countries.

7.21 The decrease in rail's share of the freight market has increased road freight intensity by 0.5% or more in some countries. The reason behind this is partly the relative decline in rail's traditional product market and its deterioration in competitiveness compared to road.

7.22 Evidence on supply chain structure and the handling factor (the number of times a product is lifted) suggests that there has been a steady trend towards fewer warehouses (or consolidation sites) in many logistics systems. The evidence for this is strong in the link between manufacturers and retailers particularly in the grocery trade. The trend has also probably been present in other parts of the supply. Different countries have moved towards greater concentration at different rates, but the trend has probably been present to some degree in all countries. With its implications for higher tonnekm this has been an important factor in increasing intensity.

7.23 Regarding the possible breakdown of the process of value creation into more production sites the evidence is very weak and there is no indication that this has been an important factor leading to an increase in tonnes lifted. A small effect on tonnes lifted may have occurred due to the greater requirements for recycling.

7.24 The increase in average haul is the major component behind the growth in road freight intensity, contributing perhaps 2% per annum to its growth. Again part of this is explained by the change in the mix of commodities. Other contributors are the realisation of a single market through the reduction of trade barriers and increased concentration of production. The scale of the latter is difficult to estimate – a number of commentators suggest it is a strong effect but this is not supported by evidence. The driver that is not usually given much prominence in the explanation of the rapid increase of average haul is the decline in the real cost of freight haulage. This must have been an important contributor to increases in market area and more remote sourcing. Firm evidence of its effect is lacking but, in the absence of other clear reasons for these two trends, it is rated as a very important determinant of the average haul trend. Examination of the growth in average haul for different commodities shows that it has been strong in all parts of the supply chain, in all supply chains and in all countries.

7.25 Taking the sum of these previous four components of intensity, the overall conclusion is that the major driver leading to a reduction in intensity has been the change in average value density. A number of other drivers have led to an increase in road freight intensity. A critical driver has been the change in road freight's relative cost. Increasing economies of scale (leading to greater concentration of production), improvements in warehouse technology (leading to logistical restructuring) and the realisation of the single market have all contributed to the growth in intensity.

7.26 Road freight intensity is not the only determinant of road freight's impact on the social costs associated with the environment and safety. Vehicle efficiency can mitigate the effects of increasing intensity. The limited evidence that does exist suggests that overall efficiency in terms of vehicle km per tonnekm has improved. A large part of this is due to the general increase in vehicle size and improvements in the lading factor and vehicle utilisation may also have contributed. The various factors identified as driving the growth in intensity also often have effects on efficiency.

7.27 The trend towards more variety in products and increasing demands for more frequent and precise delivery times is likely to have had a deleterious effect on both lading efficiency and vehicle utilisation. A counterbalancing force has been the greater use of ICT systems which have led to an improvement in the efficiency of vehicle operations.

7.28 The environmental and accident cost per freight vehiclekm has been falling over the period. Whilst intensity may have been increasing modest improvements in vehicle efficiency and significantly more environmentally friendly vehicles have meant the damage cost of road freight movement has grown more slowly than GDP.

7.29 In examining the role the drivers play in influencing the growth of intensity over the next thirty years, it is assumed that GDP will continue to grow steadily in the countries of Europe and that the driving force behind this (as in the past) is the emergence of new technology and its gradual dispersion throughout the industries of the countries. However, the future growth of knowledge (new technology, new management practices) cannot be predicted, and therefore predictions of the future tend to fall back on an assumption that past trends will continue uninterrupted. The approach adopted has been to examine the past trends of the drivers and to consider whether these will continue or whether there are reasons to expect them to change.

7.30 Table 1.3 provides a summary of the conclusions concerning future importance of the various drivers of intensity. A shaded box shows where a trend is predicted to change in the future compared to the past. These trends do not distinguish between sectors, countries or, indeed, periods in the future. Such refinements are too demanding but some impressions are included below.

7.31 The mix of products in the economies of Europe will continue to change towards services and products with longer average hauls. This trend may be stronger in Acceding Countries leading to a greater contribution to increasing freight intensity. This effect can be expected to reduce over time as the manufacturing sector's share in an economy falls.

7.32 Trends increasing product value density stemming from development of products and manufacturing processes will continue in most product areas. The effect will be to reduce intensity. The trend is likely to be strongest in sectors where the opportunities for technological innovation (which may increase value and reduce weight) are greatest. Experience from the past suggests that there will be a common development of products throughout Europe, and therefore any benefits from its impact on freight intensity will be experienced in all countries.

7.33 The most significant change arises from the prediction that road transport unit costs will increase in the future (due partly to a slowdown in technology improvements, deteriorating road speeds and policy initiatives). This will be experienced to a varying degree by all countries and all supply chains. Eventually it should lead to a halt in the relentless rise in average haul seen in the last 50 years. Its exact timing is impossible to judge as decision makers only react slowly concerning location of facilities or sourcing. The impact of falling freight costs is probably not yet fully exhausted. The effect should start to emerge within 10 years.

7.34 At the same time the increasing competitive advantage of road compared rail experienced in the last 40 years will not continue, and with assistance from policy it may actually be reversed. Precise estimates are impossible but there seems every prospect that this change will stabilise the share of rail in the freight market.

7.35 Taking all these considerations into account it seems highly likely that the gradual increase in road freight intensity experienced in EU15 as a whole will eventually change to a situation of relative stability in the index with the possibility of decline in the longer term. The balance of the arguments presented here suggest that road freight intensity will be significantly lower (perhaps 20%) in 2030 than now. There are uncertainties behind this of which the assumption that average haul will not experience the rapid growth of the past is crucial. Countries will not follow precisely the same paths and the future path of individual countries is likely to be erratic (partly due to the vagaries of the data collection process) and it will take some years for the long term trends to emerge.

7.36 The prospect for a reduction in freight intensity in the Acceding States is even stronger given the likelihood that they will move towards a larger share of services in their economies.

7.37 In the area of vehicle efficiency there are a number of trends working in different direction. There is no evidence to suggest that the balance of these effects is likely to lead to greater or less efficiency.

7.38 There are two important dimensions to policy initiatives that may influence freight intensity. These are closely associated with the two elements in the evolution of road freight intensity which emerge as relatively influential - the increase in average length of haul and the increase in value density.

7.39 The first dimension of policy is intimately linked to average haul, which has been influenced by changes in transport costs together with logistics and sourcing strategies, the latter often driven by enhanced customer needs. There are many factors including EU and government policies which are aimed at, or effectively impact upon transport costs and hence lead to changes in average haul. Few, if any, policies have any great impact on tonnes lifted. In this context the aim of policy is rather more complex than simply reducing intensity, and involves a balancing of factors such as environmental, safety and user costs of freight transport. The main thrust of policy is to ensure that road freight users pay the full marginal social costs of transport. Whilst these (and other) initiatives can be expected to have some effect on road freight intensity, their aim is not to reduce intensity per se.

7.40 The second dimension is potentially concerned with value density (€/tonne), which is driven apparently by increase in variety and sophistication of products, supported by emerging new technology. At the macro level there is clear evidence of the importance of the change in the commodity mix influencing intensity. At the individual product level there is evidence that value-density has changed to benefit road freight intensity. However there are no apparent formal policies aimed directly at changing value density.

7.41 The transport sector is already the target of EU and Government transport policies which will affect directly or indirectly road freight intensity. Policy analyses do not always make clear what component of road freight intensity will be influenced by policy initiatives, but the main influence can be expected to be changes in modal split and average haul. There may conceivably be an influence on the handling factor but this is not usually considered important. As far as value density is considered this is almost totally ignored by current transport policy. The main reason for this is that policy initiatives are mainly directed at the cost of freight transport and the purchasers of transport.

7.42 The impact of policy on road freight intensity is imperfectly understood. In particular knowledge about the elasticity of response (to price changes) is very limited. Where the impact falls is also uncertain. Modal split will certainly be affected by many measures. Of the other components to be affected average haul seems most important. The handling factor representing the number of times a product sold to the consumer has been lifted may change but is not likely to be very sensitive to changes in cost. At the same time there appears to be little evidence that value-density changes in response to transport costs. A major reason for this is that product designers responsible for determining that ratio take little or no account of it.

7.43 The main thrust of policy in recent years has been driven by a recognition of the external costs of freight transport (accidents, noise and air pollution, global warming, congestion) especially movement by road. Therefore there has been a tendency towards increases in charges (to reflect marginal cost pricing) on road freight and pollution reducing regulations (such as EUROIV standards). This tendency has been apparent throughout the EU and is beginning to emerge in the Acceding countries as well. There is general agreement that the optimum level of charges has not yet been reached and future policy initiatives can be expected that lead to higher charges on road freight movement.

7.44 The design and analysis of transport policy is well developed and is carried out within a framework closely related to economic cost-benefit that places monetary values on external costs. The governmental approach to policy initiatives is to use the framework in which cost impacts are balanced against benefits. The impact of these policies directed against reducing external costs is often to reduce transport intensity. But intensity is not a performance metric which would be part of the list of costs and benefits used to evaluate the policy.

7.45 The other major set of decision makers influencing freight intensity are those responsible for guiding developments in manufacturing processes and strategy. In their choice of product design, sourcing, market area and delivery profile they influence the consumption of transport resources and hence freight intensity. The general impression is that companies attach little, if any, weight to transport when looking at product design, due to their perception of its small share in final sales price. In the case of sourcing and market area transport costs may receive greater consideration. This general lack of consideration also seems to apply to the area of logistics as a whole. The implication of this is that because insufficient consideration in the development of products is given to transport, more resources will be consumed and freight intensity will be higher. If full consideration is given to transport costs and associated trade-offs with design issues then freight intensity should be reduced and policy initiatives such as charging for external costs will have their appropriate influence on design considerations.

7.46 It can be argued that companies are being rational giving little or no consideration to transport in the design of products. Issues of functionality and aesthetics are critical to the success of new products. Some trends of course such as the use of lighter materials and miniaturisation can contribute to a decrease in transport intensity. Transport or logistics management need have little input into product design where the impact of change is small. The exceptions to this are where some attribute of the new product has a large impact on weight, volume or fragility. Packaging can be an important component in the design of new products, or redesign of existing ones.

7.47 The conclusion is that greater consideration should be given to the transport implications of product development. This consideration can be seen as a two phase process. The first is a quick scan to see if the impact on transport is likely to be worth greater effort, followed if it is considered desirable, by a more detailed analysis of the quantitative effects. Ideally this should be incorporated into the existing processes used for new product development (though these may be poorly defined in many companies). A wider perspective, which takes account of related aspects concerning sourcing, market area and delivery profile, should also be adopted. This perspective of a more holistic approach is consistent with current trends to greater supply chain integration which aims for greater harmonisation between the different actors in the chain and optimisation of all aspects that contribute to final product value.

7.48 The suggestion that companies take fuller account of logistics related implications in product development goes well beyond the subject of road freight intensity. Product design in its impact on weight can have a direct effect on intensity, and external costs. Average haul and hence intensity will be affected by more remote sourcing and larger market areas. However changes in design associated with volume or delivery profile may have a negligible impact on intensity but a large (undesirable) effect on the unit cost of transport and external costs. Additionally it seems logical that if transport impacts are to be given fuller consideration then a supply chain logistics perspective that integrates movement along the supply chain should be adopted. How extensive the 'supply chain' can be depends on issues of data availability and confidentiality.

7.49 Influencing all the different processes and procedures used in new product development will probably have to be achieved by persuasion rather than legislative requirements. One immediate possibility is to incorporate transport considerations (or its derivative – environmental considerations) into the Integrated Product Policy (IPP) package.

7.50 The "Life-Cycle Thinking" approach in product development in the way suggested by the IPP package will probably be achievable by persuasion rather than legislative requirement. But the role of the industry and governments ought to be in developing appropriate Life-Cycle information and interpretative tools to inform in particular SMEs in adopting new design practices.

7.51 There is general anticipation in the industry about the cost of road freight transport in the future. This is mainly due to the perceived impact of the implementation of the Working Time Directive and of the Directive on the charging of heavy goods vehicles for the use of certain infrastructures, together with the introduction of electronic tachographs.

7.52 Sectors that are expected to be critical with respect to future road freight transport trends include food, automotive and manufacturing where product variety is an attribute of the output of the system.

7.53 The integration of the Acceding countries into the European economic system is expected to re-define some of the economic geography of the continent and with it, redefine supply chain structures. There will be some period of adjustment during the transition period. Further research into how Acceding countries' integration process may affect location and transport activities for critical sectors will be required in order to prepare for the interim.

7.54 But fundamentally, more insight is required about consistency in national data sources. Consistency of series between countries over the past (or lack of it) makes it difficult to have confidence about the effects of policy and about predictions for the future.

TABLE 7.1 SUMMARY OF DRIVERS AND THEIR IMPACTS

Changes in	Product value density €/tonne	Key logistic impacts	Handling factor	Modal share road	Average haul	Intensity	Vehicle payload	Lading efficiency	Vehicle utilisation
Mix of products/services	↑			↑	↑↑	↑↑			
Configuration/design of commodities Packaging Variety/ customization Sophistication	↑	Smaller order size			↑	↓		↓	
Manufacturing processes Modularisation Materials Economies of scale	↑ ↑	Vertical disintegration of production Spatial concentration of production; either through reduction in plant numbers, or increased plant specialisation ('focused production')			↑	↑		↓	↓
Warehouse/handling technology Reduced costs		Spatial concentration of inventory Development of break-bulk / transhipment systems Centralisation of sorting operation in hub-satellite network	↑		↓	↑			
Information technology Increased use of ICT Increased use of e-commerce		More efficient transport operations						↑	↑↑
Logistics management Application of JIT principles, quick response and ECR in retail distribution Proliferation of booking-in / timed-delivery systems		Less efficient transport operations						↓	↓
Technology of transport systems Improvement in road's relative cost/performance *Management of transport systems*		Wider geographical sourcing of supplies Wider distribution of finished products Increased use of outside transport / distribution contractors		↑↑	↑↑	↑↑			
Government Regulation Changes in vehicle size regulations Taxation Recycling requirements Realisation of Single Market		More efficient transport operations More movement per product	↑		↑	↑	↑		

TABLE 7.2 SUMMARY OF FUTURE DRIVERS AND THEIR IMPACTS

Shaded cells represent change in future

Changes in	Product value density €/tonne	Key logistic impacts	Handling factor	Modal share road	Average haul	Intensity	Vehicle payload	Lading efficiency	Vehicle utilisation
Mix of products/services	↑			↑	↑				
Configuration/design of commodities Packaging Variety/ customization Sophistication	↑	Smaller order size			↑	↓		↓	
Manufacturing processes Modularisation Materials Economies of scale	↑ ↑	Vertical disintegration of production Spatial concentration of production; either through reduction in plant numbers, or focused production.			↑			↓	↓
Warehouse/handling technology Reduced costs		Spatial concentration of inventory Break-bulk / transhipment systems Centralisation of hub-satellite network	↑		↓	↑			
Information technology Increased use of ICT Increased use of e-commerce		More efficient transport operations						↑	↑
Logistics management Application of JIT principles, quick response and ECR in retail distribution Proliferation of booking-in / timed-delivery systems		Less efficient transport operations						↓	↓
Technology of transport systems Improvement in road's relative cost/performance *Management of transport systems*		Wider geographical sourcing of supplies Wider distribution of finished products Increased use of outside transport / distribution contractors			↑	↑			
Government Regulation Changes in vehicle size regulations Taxation Recycling requirements Realisation of Single Market		More efficient transport operations More movement per product	↑	↓	↑	↓			

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