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Working Group on Transport

Project on Decoupling Transport Impacts and Economic Growth

ANALYSIS OF THE LINKS BETWEEN TRANSPORT AND ECONOMIC GROWTH

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FOREWORD

The overall objective of the project is to examine the potential for decoupling transport impacts and economic growth with a view to encouraging more sustainable transport patterns. There is growing concern that environmental impacts of transport are significant and continue to increase despite great advances in curbing pollution through technological progress. The project is part of the implementation of the transport chapter of the OECD Environmental Strategy for the First Decade of the 21st Century, in particular objective two (decoupling environmental pressures from economic growth). Evaluation of economic instruments targeted on environmental externalities and transport demand management tools has been stressed in the strategy as priority issues for the work of the Working Group on Transport. The project also takes up the momentum and priority given to this important issue in several international high-level meetings on the integration of transport and environment.

This project addresses the issue of decoupling by examining primarily non-technological options, instruments and policies and the direct and indirect effects on demand for passenger and freight transport. The effects of these instruments and policies will be examined including by providing incentives for the more rapid development and uptake of environmentally friendly technology, for reducing externalities from noise, greenhouse gas emissions, and fuel use as well as land-take and habitat destruction. The second phase of the project will examine policy options both for passenger and freight transport, since both modes cause serious and growing impacts, but may need to be addressed by different policies and measures.

The project stages will also include a review of existing policies and approaches for decoupling, the examination of the decoupling factors and indicators, and the findings from case studies provided by countries regarding decoupling impacts from economic growth.

This report is the outcome of the first phase of the OECD project on decoupling transport impacts and economic growth. This work is carried out under the oversight of the EPOC Working Group on Transport. This report has been prepared by Nadia Caïd of the OECD Environment Directorate. Comments on drafts of this report from Jean-Philippe Barde, Nils Axel Braathen, Nick Johnstone, Robert Larson, Steven Perkins, Ken Ruffing and Peter Wiederkehr are gratefully acknowledged.

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SUMMARY AND CONCLUSIONS

The purpose of the project is to identify cost effective instruments and measures that can help governments to promote more sustainable transport patterns. The project involves three main stages: i) a review of the main economic factors responsible for transport growth, such as economic growth, changes of mobility pattern, modal share and other factors affecting demand, such as speed, information and communication technologies (ICT) etc. ii) analysis of decoupling measures and instruments based on country case studies addressing transport implications of dematerialization of the economy, spatial organisation of production and consumption, and optimisation of transport organisation; and iii) identification of policy options focusing on economic instruments, notably fees, charges and taxes that encourage more sustainable transport while minimising economic costs.

This report covers the first stage of the project involving a review of the factors and measures that influence the links and interactions between economic growth and transport activity. Transport generates a number of important externalities that are not reflected in current prices and thus lead to sub-optimal transport use. The consequences of market imperfections on transport demand are highlighted. The historic correlation between growth of GDP and transport activity has been reviewed for the European Union, the U.S and the Japan, analysing trends of passenger and freight movements as well as the modes that contribute most to transport growth. Several analytical tools and methods are reviewed like macroeconomic growth models, cost benefit analysis, measures of transport elasticities and output elasticities from infrastructure investment, and transportation satellite accounts. The results from the application of these methods and tools are detailed insights into these complex relationships. Finally, conclusions are drawn from this analysis on the interactions of transport and economic growth.

Market failures can be corrected by proper pricing

Freight transport is primarily derived demand from requirements of transport-using sectors rather than an activity desired in its own right. As the economy grows and production, sales and income rise it is generally correct to assume that demand for transport would increase. Another important conclusion is that there are a number of market failures due to unaccounted impacts of transport (externalities) that can be corrected by proper pricing and thus could help internalising externalities and reduce inefficiencies. Usually internalising the various external costs of transport would affect the level of transport activities and choice of modes as well, thus further reducing the levels of the externalities.

A tax or charge system could be also used to encourage important modal shifts and generate revenue for developing more environmentally friendly modes. A promising example in this regard is the recently introduced distance-dependent and emission-related heavy-duty vehicle fee in Switzerland; it ensures economic performance of transport by using the various modes efficiently, while reducing significantly harmful emissions (ODT, 2001). Even if emission taxes have not been generally introduced, introducing use-dependent and performance dependent taxes (e.g. a specific tax based on the distance driven and the environmental performance of vehicles) may help to internalise external costs while minimising economic costs. One of the advantages of regulation is that it is an instrument that is targeted in achieving emissions reduction. Combining taxes and regulations and appropriate policy mixes could combine effectiveness (regulation) and dynamic efficiency. Usually internalising the various external costs of transport would affect the level of transport activities, thus further reducing the levels of the externalities.

Transport elasticities

Regarding passenger travel, the various studies and models reviewed have found that income is by far the main factor driving vehicle ownership. This factor appears to be more important than fuel price, vehicle price, infrastructure, or population density. But the analysis also shows that the relationship of vehicle ownership to income in each country tended to be non-linear indicating saturation effects at high levels of income. Also the performance of different policies will have different effects on old vehicles versus new vehicles, the level of vehicle use, etc. To examine these effects, more detailed models that explicitly represent individual choices are needed.

Concerning the model that can be used to assess the importance of transport in the economy, it can be concluded that the different approaches are complementary. Microeconomic full cost benefit analysis (CBA) is adapted for assessing projects and should be used both to achieve an optimal capacity standard of a new investment and to compare the cost efficiency of different investment projects (ECMT, 2001a). Macroeconomic assessments should be used for complementary information on possible long term network effects which are not covered in CBA. But research on the economic impacts of transport has either focused on assessing the macroeconomic effects of changes in transport system and infrastructure or the implications of individual transport projects at the microeconomic level.

The analysis of the transport and economy interrelations shows that the interrelations are numerous and complex and that changes of economic factors and conditions generate a sequence of adjustment, restructuring and adaptation processes in the economy and the transport system. To be useful for policy analysis, models should take into account the complexity of the links and recognise the multi-dimensional nature of the links between transport, location, development, etc.

Analysis of transport trends in the EU, the U.S and Japan

A general conclusion drawn from the analysis of transport trends in the three regions that have been studied (the EU, Japan and the US) is that in the period there is a relative decoupling of GDP versus passenger and freight transport in the US and Japan but not in the EU. Two transport indicators, one for volumes/weight moved per GDP and one for tonne-km per GDP, need to be considered, as each gives different information on the development and performance of the sector. The interpretation of the measure of transport intensities has to be made with caution, as rising or falling transport intensities do not necessarily mean more or less transport activity but may be due to an important increase of GDP dominated by growth in services. Only when compared with total transport performance indicators can conclusions be drawn regarding rising or falling total activity and thus the related environmental health impacts.

In terms of environmental impacts: the analysis of the trends showed that given the fact that road passenger and road freight are the overwhelmingly dominant modes and as their environmental impacts and other externalities are highest, some environmental impacts are still increasing. Thus, in designing policies to decouple these impacts there is a need to focus on the high growth modes where the impacts from activity growth outpace the level of improvement made per unit of transportation service. More specifically, the need is to focus policy instruments on reducing further the impacts per vehicle km that are still too high or increasing (given the rapidly growing demand).

The analysis of the transport trends in the different regions reveals the main economic driving factors behind these trends. These include: i) the supply of infrastructure that boosted transport demand, in particular the expansion of the highway system through large investments during the past thirty years. This has facilitated movements, with increasing speed, improved access, market integration, longer distances traveled, while overall transport costs were decreasing; ii) the lack of attractive alternatives to individual motorized transport explains the difference between the US and Europe as well as the US and Japan, the latter having much higher provision of public transport than the US or Europe and thus a lower average level of motorization. Other constraints, in terms of disposable income, available parking space and tax structures, clearly influence the modal choice of individuals and businesses; iii) liberalization of road freight over and above the liberalization of rail freight in Europe that has lead to a strong boost for road transport. In the US rail freight market liberalization together with improving cost structure and efficiency has also considerably stimulated growth for this mode; iv) decreasing real fuel prices that favored road transport, while relative prices of vehicles also declined compared to increases of GDP per capita; v) the relative share of household expenditures for transport remained fairly constant in Europe (13%) and the US (13-14%) for the past three decades, while GDP per capita increased. Thus, overall purchasing power for motor vehicles and transport increased, being even higher in the US than in Europe and Japan.

Transportation satellite accounts- results for the U.S

In addition to national accounts, transport satellite accounts (TSA) that measure transport expenditures of the different sectors of the national accounts provide more detailed estimates of all transportation services by industries, and thus, give a more complete picture of a sector's transportation intensity at a moment in time. Thus, there is no simple answer to whether a certain amount of output change would result in a corresponding change in transport input or vice-versa. Generally, the magnitude will depend on the sector considered, its economic importance and performance and the overall structure of the economy and its stage of development.

One important finding is that sectors with a larger contribution to GDP in terms of value have a relatively smaller transport demand (e.g. services, some manufactured goods) and the sectors with a lower contribution to GDP have large transport demands (e.g. agriculture). One factor that can help decoupling could be further dematerialisation of the economy since decreasing the material intensity of production could help to decrease the demand of transport. This will be examined in the second stage of the project since more detailed analyses and comparisons among countries through notably case studies will be needed to help to better understand the link between transport and sector performance and the key factors influencing it.

Certain types of infrastructure (e.g. highway) may have greater economic effects than others. The direction of causality is not always clear in the sense that it is difficult to know if it is economic growth that is caused by infrastructure investment or a region of strong economic growth that can afford to build more infrastructures. Detailed reviews of the different studies on this issue have shown that the estimated results are largely dependent upon the econometric specifications. Simpler econometric specifications always give large estimates. An important variable is the level of development of a country: it is clear that all countries need a well-developed transport infrastructure to be competitive in global markets. The question would be in developed countries, where a well connected transport infrastructure network of high quality is already in place, by how much additional investment would boost economic growth and whether the welfare gains would exceed the increased environmental and social costs.

The conclusion that can be drawn from the analysis of the historic trend of the freight in the U.S. is that high value-added sectors are increasing their share in the total freight movements. An important element of reflection to be underlined is that these high value-added sectors are also contributing more and more to the growth of the economy. The analysis of this trend also shows that the highest value commodities derive from knowledge-intensive activities such as electronics and electrical equipment, motorized vehicles, machinery and textile products. The types of commodities which have a high demand in terms of ton-miles are low value raw material such as fossil fuels, basic chemicals, grains, etc. These low value-added commodities account for a little over 40% of the ton-miles and 10% of the value.

Change of freight transport demand in Europe - The REDEFINE project

The outlook from the REDEFINE model used in Europe to assess transport demand from changes in production in five countries indicated that for the next several years road freight activity (measured in tonne-kilometres) is expected to grow faster than production (measured in tonnes of four commodity groups). This trend is more accentuated for agricultural products where transport equipment and production weight are diverging substantially. In all but one country, road traffic is expected to grow faster than gross output. Only for Sweden do projections indicate that fewer and fewer vehicle-kilometres will be needed for the same production volume.

Various studies based on empirical evidence or/and practical experiences have tried to identify the main drivers of transport demand. Prices, speed, the quality of transport alternatives offered, spatial planning and regulation have been chosen as the main representative drivers and have a large effect on the volume and mode of travel (ECMT, 2003). These drivers are not directly subject to transport policy control because of their diverse nature but their environmental impacts could be better managed using a package of policy instruments. These packages of policy instruments could include policies that better target externalities and internalise them more completely taking into account technical and scientific development; logistical organisation of production and distribution; demographic and social trends, including ageing and household size; life-style patterns and individual preferences on housing.

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1. INTRODUCTION

Transport policy decisions affect the mobility of people and goods and thereby positively influence productivity, GDP growth and employment. On the other hand, economic growth usually generates increasing transport demand. Greater amounts of goods produced will be followed by greater transport distances travelled, enhanced division of labour (e.g. due to globalisation), new production technologies, e.g. just-in-time production (SACTRA, 1999), etc., generating increases in environmental pressures.

An efficient transport systems and a well equipped transport infrastructure are vital to a strong economy - locally, regionally and nationally - by providing high quality accessibility to jobs, manufacturers, suppliers and customers. Thus, there has been continuing pressure for additional investments to improve the existing transportation network, focusing mainly on road transport, but also on heavy rail, urban public transports, harbours and airports. Economic growth and development affect both the demand and the pattern of transport services. Higher incomes stimulate car ownership, growth of business sales activates the carriage of more freight, technological change allows new methods of communication, adjustments to the composition of economic activity, including de-industrialisation, lead to new traffic flows, etc..

The impacts of economic growth on the demand for transport can be demonstrated fairly clearly. However, studies of the macroeconomic effects of transport infrastructure on productivity and growth are more difficult to conduct and therefore much less common in OECD countries. One of the reasons is that the subject is taken up mainly in the literature of economic development of developing countries. The question of effects on employment which is relatively new to the debate on transport strategies and the macroeconomic effects of changes in transport costs have therefore received increasing attention in recent studies.

The discussion about transport and economic growth is not simply a question of whether there are net positive or negative economic impacts arising from transport improvements. The question of the size of the effects is also important. Some commentators query whether the journey time-savings generated, for example, by road improvements, provide anything more than marginal economic benefits. Others argue that transport improvement, help enable firms to reorganise their operations, yielding significant benefits beyond those conventionally identified in investment appraisal. Also an important prerequisite for an analysis of the links between transport and economic growth would be in a first stage to assess the state and level of economic development of the country concerned.

The debate about transport and the economy is frequently made even less clear by a confusion of terms. The relationship between the two is sometimes taken to embrace different things: transport investment, transport infrastructure, transport improvement, road traffic, etc. Most studies have examined the former, while the broader economic effects have rarely been assessed due to the inherent difficulty and lack of data for such an analysis.

The analysis of the economic effects of changes in the transport system is usually performed by looking at transport costs and prices. Changes in transport costs have economic effects through their influence on regional patterns of commerce, on incentives to invest and to innovate, on the location decisions of firms, on the commuting and migration decisions of households. These generally positive effects are, however, accompanied by a number of costs such as pollution and congestion; i.e., referred to as external costs, since they are not fully covered by the prices users of transport services pay.

Policy-makers who wish to intervene to internalise the environmental and social costs of transport ideally would like to know the impacts of their actions on future economic growth which may have the secondary effect of reducing freight transport or personal mobility. The policy issue of sustainable transport has thus to do with ensuring that current transport practices are moving towards greater sustainability and that additional transport will be environmentally sustainable.

Scope and purpose

The present report covers the first stage of the project on decoupling transport's environmental impacts from economic growth. The project examines the question of whether transport is an input causing economic growth or a necessary prerequisite; whether transport volumes and a growth in transport infrastructure trigger economic growth or whether economic growth leads to a higher demand for and supply of transport. The question of whether economic growth can be sustained without commensurate growth in transport activity and adverse impacts will be also examined. This first stage of the decoupling project involves a review of economic factors that drive transport demand, including relative prices and examines the correlation between transport and economic activity and analyses transport statistics, notably data from satellite accounts. The key drivers for transport growth (primarily road transport) have been analysed, i.e. which factors stimulate growth of certain modes of transport that contribute most to the growth of transport (passenger and freight, land, water and air).

In most OECD countries, a close relationship between road freight demand and economic growth, primarily road freight has been observed for several decades. The majority of road freight traffic forecasts have been based on the assumption that these variables will remain closely correlated for the foreseeable future, and thus raise concerns that total impacts on the environment increase with growth of activity. However, in some European countries and the United States, it appears that these trends have begun to diverge. Available aggregate transport statistics in Europe, the Japan and the U.S. provide only a crude outline of the historic developments in road freight demand for a broad set of commodity-flows, but in most cases these developments cannot be attributed to any single underlying economic, logistic, or other factor. Results from targeted research at both the macro and micro level and from comparative studies across countries will be reviewed in stage two of the project in an attempt to analyse the drivers that generate the growth in freight transport demand and policy instruments that help to decouple the adverse environmental and social impacts from that growth. To this end, a number of case studies will be carried out and analysed in the context of regional economic development and transport demand.

This report focuses on economic factors, but there are various other factors influencing transport decisions and development, notably the structure of the family and more generally demography, but also household behaviour, social policies, other non-transport policies, and the different institutional and policy orientations, the level of technology innovations and research, etc. All these influence policy development in the transport sector to a significant amount: some of these driving factors of transport demand are analysed but not others since this report is more focused on the economic and social drivers of demand for transport services.

Structure of the report

This report addresses the issues of the interrelations of transport and the economy by reviewing the relevant literature in the area of transport and the economy, econometric models and analytical tools, historic transport trends, as well as transportation satellite accounts and the effects of transport infrastructure and economic growth.

The report is divided into six parts: Chapter 1 introduces the subject and presents the main issues. Chapter 2 focuses on identifying the interrelations between economic growth and transport development, the implications for transport demand of market imperfections and measures to correct them. In chapter 3 the analysis of elasticities and historic correlation between growth of GDP and increases of transport of passengers and freight as well as trends in modal share are analysed, in Europe, Japan and the United States. Some of the main results from the analysis of national accounts and transport demand are presented in chapter 4. While chapter 5 reviews the impacts on economic growth of transport infrastructure investments. These provided the basis for drawing conclusions presented in chapter 6.

2. TRANSPORT AND THE ECONOMY

A) The Importance of Transport in the Economy

The relationships and interactions between transport and the economy have been extensively reviewed in various theoretical and empirical studies. On the basis of the hypothesis that transport "public-capital" would boost economic growth a number of studies of transport infrastructure investments were carried out in the US during the early 1990s (Aschauer, 1991). One criticism of this approach is that it fails to determine causality – i.e. does investment in transport trigger growth or is it rather that growth enables more spending on transport infrastructure. A number of more recent studies assessed employment effects of infrastructure investments for a specific region, as this has become a very important policy issue. Numerous studies have addressed the benefits of transport; a review of them has been published recently for Europe (ECMT, 2001*a*). A comprehensive assessment of the economic effects of transport infrastructure investments has been performed by the UK Standing Advisory Committee on Trunk Road Assessment that also considered the wider economic effects of these investments (SACTRA, 1999).

It is generally acknowledged that well-developed economies require an efficient transport system. The development of transport has itself strongly influenced economic development: e.g., road and rail networks have laid the basis for the concentration and specialisation of production processes. Improvements in transport infrastructure have facilitated the expansion of trade and intensified competition among countries and economic regions. Such developments usually occurred in parallel with growth in the economy, and increasingly the transport sector generated an increasing share of employment and income. One important objective of the study is also to identify the instances where transport expansion may not be required for economic growth.

Apart from these well-accepted effects of transport there is an increasing body of work that raises concern about the nature, size and implications of the marginal benefits, in particular the question about additional growth effects from further expanded transport networks. This chapter is an attempt to address the various links and interactions between transport and the economy and the complex dependencies in socio-economic systems.

Figure 1 provides a schematic overview of the main links and interrelations between the transport and the economy:

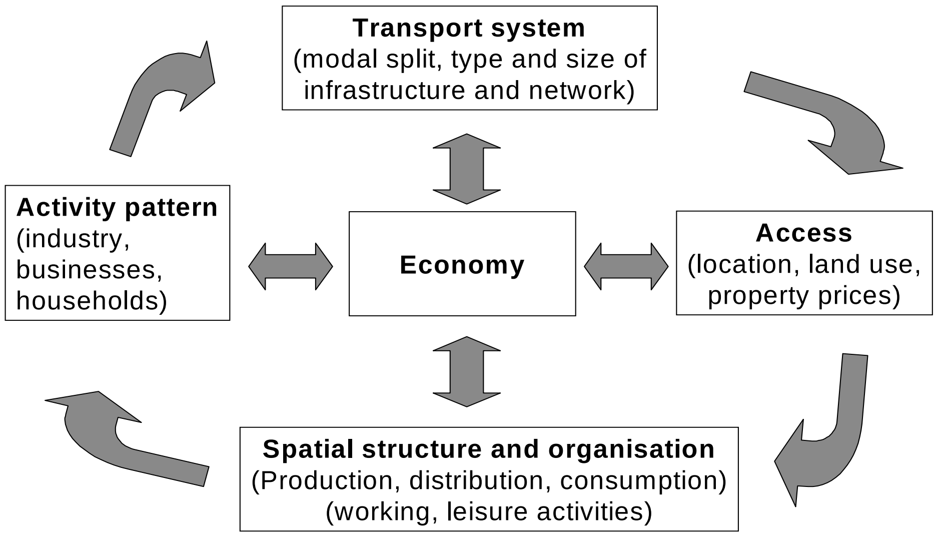
- In the centre is the economy that is influenced by various elements. Changes in access together with changes in the spatial structure and organisation affect property prices and thus assets of landowners that in turn affect the economy (e.g. higher consumption expenditures due to higher revenue from assets). Relevant for the economy of a region is also the activity pattern of households and firms. Their decisions (purchasing of consumer goods inside or outside a region, expansion of companies and attraction of new businesses) may have a considerable influence on the economic development of a region, as well as on employment and tax revenues.

- The transport system influences the accessibility of a region which affects the spatial structure and organisation, leading e.g. to a concentration of production facilities and services and a separation of workplace and home.

- The spatial structure, on the other hand, has a strong influence on the activity pattern of households (living, working, shopping and recreational activities). These activity patterns generate passenger and freight movements and influence the demand for transport.

- Policy interventions in the transport system (transport demand management, development and expansion of infrastructure, supply adjustments for public transport, etc.) change the local accessibility conditions of an area.

Figure 1. **Links of Transport and the Economy**



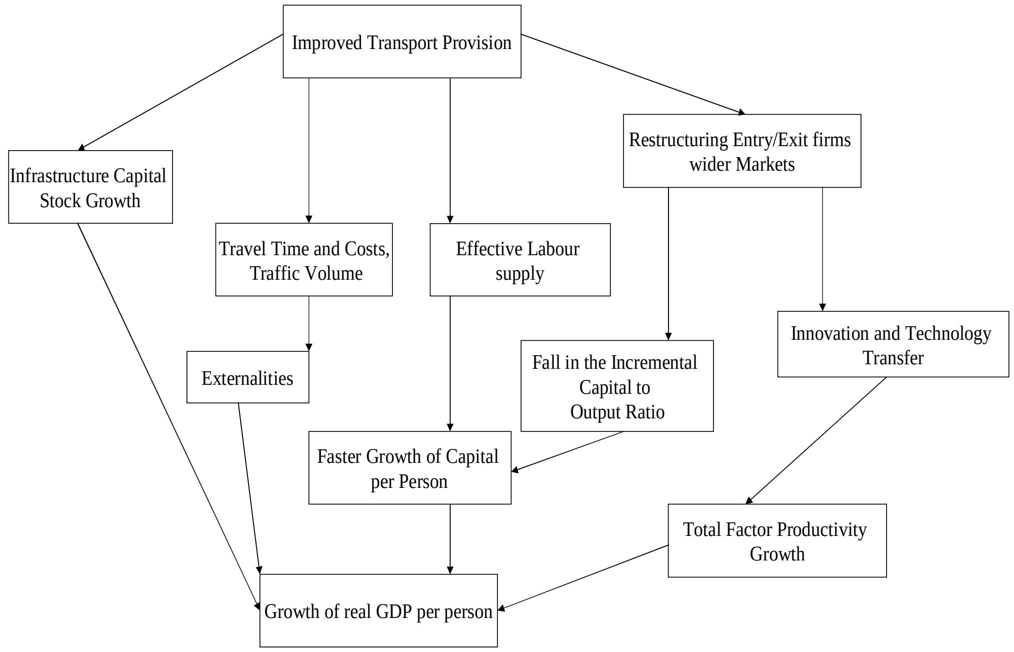
Source: adapted from Ecoplan, 2003.

There are numerous and complex interrelations between the transport activity patterns, the access system, and spatial structure and organisation. Figure 2 shows some of the components of the complex relations between the transport system and the economy.

Transport network expansions can generate positive spillovers (e.g. increased labour participation, reduced production and distribution costs, etc.) as well as negative externalities (e.g. increased congestion in other parts of the network, pollution, etc.). Figure 2 schematically shows the proposed relationships between transport provision improvement and economic growth. In the left of the diagram, the assumptions and theory of Aschauer (1989) are presented that infrastructure investments have a strong direct influence on economic growth.

The middle of the diagram presents the argument that transport improvements decrease the effective cost of labour to firms. This will lead the firms to raise their investments so that transport improvements have a positive effect on economic growth. These broad capital mechanisms relating transport improvement to faster growth may, in fact have transitory rather than permanent effects, if diminishing returns to investments are taken into account. It has to be underlined that the validity and importance of these hypothesised relationships has to be validated empirically and some of the effects presented could be very weak or even unproven. Other more complicated effects could also have been taken into account.

Figure 2. **Improvement of Transport Provision and Economic Growth**



Source: Adapted from the SACTRA (1999) report

The economic effects of transport are generally measured at national level using national accounts that present the changes of aggregates such as employment, national income, public expenditures, productivity and gross output. They are usually captured and presented in input/output tables. However, national accounts generally undercount the share of transport in the production costs of industries,

Measuring transport expenditures and contributions to the economy (e.g. GDP) can be provided by Satellite Accounts that include detailed data by individual sectors. Satellite Accounts are not very common and only very few countries (e.g. the United States) have actually implemented this new concept. It requires organising national accounts in rigorously controlled structures in order to enable the analysis of particular aspects of the economy as well as the collection of more detailed data by sector that are not included in conventional national accounts. A fully developed satellite account will provide data on the type and amount of transport services for the production of goods and services in the economy. A summary of the main features of Transportation Satellite Accounts is given in chapter 5 and some findings from Transportation Satellite Accounts in the U.S. are presented in chapter 6.

Summary

The interrelations between transport and the economy are numerous and complex and generate a sequence of adjustment and adaptation processes in the economy and the transport system. Models that are used have to take into account the complexity of the links and recognise the multi-dimensional nature of the links between transport, location, development, etc. Identifying the right measure to determine the links and assess the effects of changes of the transport system on the economy and vice-versa is a complicated task and usually involves sophisticated models. Research has either focused on assessing the macroeconomic effects (such as employment, gross production output, public expenditure) of changes in transport system and infrastructure or the implications of individual transport projects at the microeconomic level (time saving for individuals and lower transport costs for firms and thus lower prices and/or higher profits for marketed goods). The main issue for the analysis of the links between transport impacts and economic growth is to determine the appropriate level of aggregation and identify the right measure to assess the costs and benefits of these changes.

B) Reasons for Travelling and Goods Movement

In the last few decades, growth in income, improvements in technology and infrastructure, and increasing time available for leisure trips have allowed people to travel more and longer distances. The choice of modes of travel depends largely on the above factors. Numerous studies suggest that increasing levels of disposable income do have a strong effect on traffic growth, as car ownership increases up to a high level when saturation effects are observed. However, the amount of traffic is also influenced by prices, speed and quality of transport, and also by personal preferences and priorities. Answering questions regarding the principal motivations for personal traveling will be important for transport policy development.

Demand for passenger transport is caused by the following factors:

a) journeys that bring people to work, education and training, in economic terms supplying labour to production;

b) journeys that allow access for individuals to consumption opportunities, such as shopping, tourism;

c) journeys that allow access for individuals to other individuals (e.g. visiting friends and relatives); and

d) journeys that provide direct value to individuals (e.g. travelling on a preserved steam railway).

A survey in the UK identified shopping, commuting and personal business as the three most significant reasons for travelling; they accounted for 20%, 19% and 18% respectively of journeys per person per year (SACTRA, 1999). Surveys in Germany and the U.S confirm to a certain extent these results, although they are not entirely comparable as the methods used differ. In the UK, shopping, commuting and visiting friends make the majority of trips, while business travel in the US is the reason of majority of trips, but in Germany it is leisure which is the main reason for travelling.

Table 1. **Trips by Purpose in Great Britain, Germany and the USA**
(Percentage)

	Great Britain			**USA**	**Germany**
Trip purpose	**1975-76**	**1985-86**	**1994-96**	**1994**	**1994**
Work	22.0	19.3	18.6	21.6	21.3
Business	4.0	4.3	4.7	41.5	7.5
Shopping	17.6	21.7	19.7	24.8	26.9
Other personal business	10.4	12.8	18.4	12.1	
Social – Visiting friends	15.0	17.6	18.3		
Entertainment / Leisure	7.0	6.3	6.6		36.1
Holidays	8.0	7.4	3.9		0.2
Education, incl. escorts	10.0	10.6	8.0		8.0

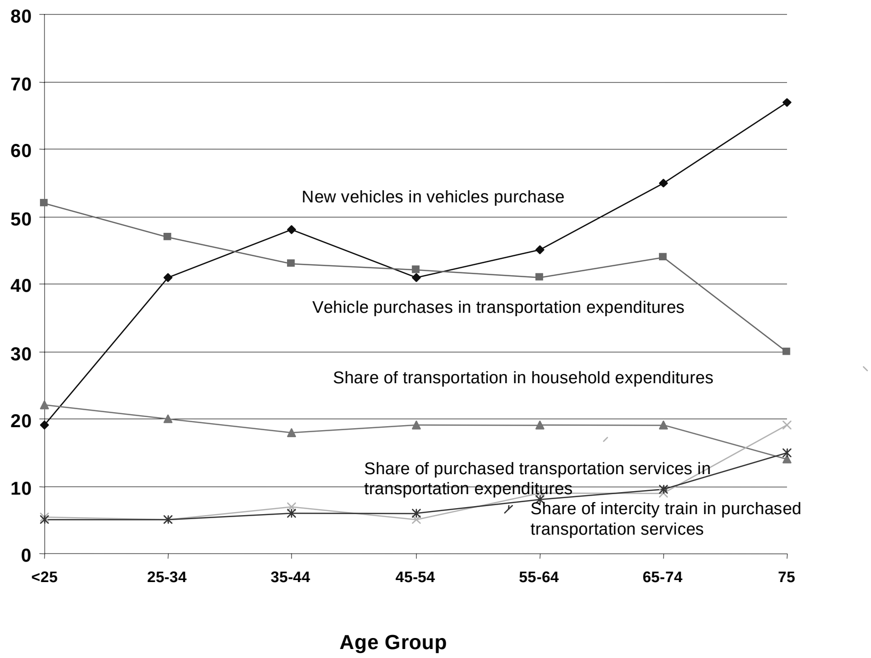
Notes: These figures are indicative only since definition in Great Britain, Germany and USA are not comparable

Sources: UK Department of Transport (1996); US Department of Transport (1996); German Enquête Commission "Mobility and Climate" (1994).

Growth in household transportation demand is also constrained by household time budgets. The time spent in travel by individuals has been shown to be approximately constant at one hour per day for the past forty years, while income, motorization and infrastructure increased substantially. The percentage of household expenditure also has not changed in the EU over the same period remained at 13% on average while GDP has increased very much (EU, 2001). U.S data also shows a constant percentage. Household expenditures also indicate the importance of transportation in the U.S. economy. In 1996, households spent, on average, $6400 on transportation, which is about 17 per cent of total expenditures. Vehicle purchases were the largest component of these expenditures. Southern and rural households in the U.S. have spent more than 50 percent of their transportation budget for purchasing new and used vehicles, more than other regions and urban households.

As figure 3 shows, age plays an important role in the distribution of household transportation expenditures. Indeed, household transportation expenditures, in absolute dollar amounts, rise as the age of the head of household increases, peaking at the 45 to 54 years of age category, and then decline. In 1996, households in the under 25 age category spent, on average, 22 percent of their total household expenditures on transportation. The percentage decreased gradually as age increased, reaching its lowest point, which is 13 percent in households in the 75, and over age category.

Figure 3. **Characteristics of Household Transportation Expenditures by Age Group in the U.S**



Source: U.S. Department of Labour, Bureau of Labour Statistics, "Consumer Expenditure Survey, "1996.

On the other hand, movements of goods or demand for freight transport are largely derived demands arising from other activities. The demand for freight transport arises from:

a) The supply of material to manufacture goods;

b) The distribution of products from the place of production to the final point of use via the point of sale; and

c) The purchase of goods and services by final users which requires the carriage of inputs to the place of production;

The main drivers of transport demand are also technical and scientific development; economic growth and rising incomes; demographic and social trends; life-style patterns and individual preferences on housing, work and other activities; pressures of competition in regulated and unregulated markets; logistical organisation of production and distribution (ECMT, 2003).

Some changes in the public policies related to trade and transport can promote interregional and global economic development processes (Lakshmanan, 2002). In the U.S, the implementation of free trade regimes (GATT, WTO, NAFTA, etc.) and liberalisation policies has expanded U.S. firms' international trade and capital flows in NAFTA, Europe, Asia and all over the world. Materials, products, services, and transportation have become more knowledge-intensive in developed economies (Chatterjee, 2000). To stay competitive in this environment, U.S. production and transportation firms have cut costs by broadening the sourcing of raw materials and intermediate products in increasingly interdependent regional and global markets. In the EU also, the effects of deregulation and liberalisation have increased the competition on the roads and have reduced bureaucratic and fiscal restrictions leading to a rapid and cost effective road transport.

Summary

It is generally accepted that demand for freight transport is derived demand from the transport-using sectors. As the economy grows and production, sales and income rise, it is generally assumed that demand for transport would increase, if past trends would continue. Others factors have strong impacts on road freight demand such as globalisation, integration of internal markets, liberalisation of road freight, new production concepts (e.g. just-in-time procurement), etc.

C) Market Imperfections and Consequences for Transport: the Externalities

Evaluating the links between transport markets and the economy in general is a complex exercise. This is due in part to the fact that there are a number of "deviations" in the market for transport services from the standard assumptions of a well-functioning market.

The market assumptions that should be fulfilled by the transport sector in a “perfect functioning market” include:

- the presence of a large number of buyers and sellers in the market; and,
- no barriers to entry.
- constant or increasing marginal costs

These assumptions are clearly not fulfilled in a number of cases in the area of transport. For instance, in some parts of the rail network, maritime ports or air travel, there may be very few sellers in the market. In addition, there may be significant barriers to entry due to high capital costs (e.g. transport infrastructure) or regulatory constraints.

Furthermore, many types of capital investment in transport infrastructure have decreasing marginal costs (i.e. rail networks, airports, and subway systems). In some sense, important parts of the transport infrastructure are (approximately) "natural monopolies". Even if there is competition in some of the services that use the infrastructure, free competition in the supply of the infrastructure will not tend to increase economic efficiency.

Part of transportation infrastructure is provided publicly, and in other cases it is provided privately, but subject to significant economic regulation. This is a significant problem when estimating the links between transport and economic growth since prevailing prices may not be a good guide to the marginal cost. The public sector may have complex and mixed objectives, both with respect to the transport-related goods and services which it provides directly, and which it regulates. As noted above, these characteristics of the "market" for transport-related goods and services make it difficult to know if the right amount of "transport" is being produced at the right price.

Individuals and firms make decisions concerning their travel arrangements and shipping orders on the grounds of market prices and market qualities, without accounting for the costs to others. The external social and environmental costs of transport are numerous, such as accidents, noise, congestion, air pollution (local, regional and global), solid waste generation, water pollution, severance of human and animal communities by infrastructure or traffic flows, altered land use, aesthetic impacts of infrastructure and traffic.

Various studies analyse issues related to the external costs of transport and how to take them into account. One concerns the marginal costs of transportation services provided by different modes: are services provided by different transportation modes properly priced in order that optimal level of transport is provided? To meet this efficiency objective, prices must equal the marginal social costs for each mode (RFF, 2003). The second important issue concerns the total costs of congestion; these types of costs do not concern only efficiency but cost recovery and fairness as well. Are the total social costs of transport fully paid by the users? Are transportation users unfairly subsidized? The third issue concerns the interaction between transportation markets and the other markets, in particular housing and land use but also the labour market. Government policies, including fees and subsidies, have been developed in transport, land use, housing, and other areas without taking these interactions fully into account.

Health and environmental impacts of transport externalities

Transport activity continues to cause large adverse impacts on environment, human health and the economy, despite considerable progress in reducing some traditional air pollutants from transport in OECD countries (OECD, 2001*b*). Major environmental impacts are due to greenhouse gas emissions, local air pollution, noise, congestion, in addition transport cause accident damages (see table 2). Transport activity also results in significant depletion of non-renewable resources mainly, fossil fuel, when may contribute to a more rapid shift to non fossil fuel energy sources in the transport sector.

External costs for road transport should be included in the costs of transport. If they are not taken into account by the individual motorist, demand for road travel will not change in relation to these real costs preventing the market from reacting properly. And the volume of traffic will exceed the optimum level that would pertain with internalisation of all relevant costs, resulting in important market inefficiencies. Many trips would be avoided or made by more environmentally friendly means of transport, if drivers were forced to pay the full social costs of their actions through policies that generate appropriate price signals.

In OECD countries, road transport is responsible for most of the transport sector’s impact on human health and the environment. It accounts for over 80% of all transport-related energy consumption, for most of the accidents and the majority of air pollutant emissions, noise and habitat degradation (OECD, 2001*b*). Maritime transport, although generally associated with lower environmental impacts, continuously raises concern due to oil pollution from major accidents and drain of residual fuels from reservoirs. More recently, there has been a growing concern over global environmental impacts from air traffic, which has been increasing particularly rapidly for tourism and leisure trips. Air transport currently represents about 11% of transport-related energy consumption.

a) Accidents

Road accidents are by far the main contributors to transport health effects as measured, for example, by disability-adjusted life years (DALYs) and related costs, including damage to vehicles and other property; police and emergency service expenditure; legal, insurance and funeral costs; medical treatment; compensation for pain, grief and suffering to those involved in accidents or to their relatives, and loss of output.

The methods used to estimate the cost of accidents generally involve cost estimation for fatalities, injured people and material damage. The value of material accidents is usually assumed to be equivalent to the monetary costs of the damage. As regards the costs for death and injuries, the estimates typically cover the direct costs (medical care, transportation costs, etc,); the indirect costs (production losses); and occasionally, an evaluation of the value of the life to the community.

b) Air pollution and climate change

The transport sector is a major source of air pollution at the local, regional and global level, and the dominant source in urban areas. CO_2 from transport are directly related to the consumption of fossil fuels, and represent a high proportion of overall man-made emissions in OECD countries (OECD, 2001*b*). Carbon monoxide (CO), carbon dioxide (CO_2), nitrogen oxides (NO_x), particulate matter (PM), lead (Pb) and volatile organic compounds (VOC) are the main pollutants emitted from transport. In the late 1990s, motor vehicles contributed 89% of CO emissions, 52% of NO_x emissions and 44% of emissions of VOCs, and thus contributing to poor air quality, but also to water and soil pollution (OECD, 1999*a*).

Local pollution from transport involves a wide range of pollutants emitted by vehicles with combustion engines. These include exhaust gases and particles, evaporative emissions, and dust (particles produced by wear on tyres, break linings, etc.). Although emissions per vehicle-kilometre are expected to continue to fall due to strict emission standards in OECD countries, there remain considerable external costs of pollution, mainly due to NO_x, VOCs and particulates. Exposure to air pollution can cause adverse health effects, most acute in children, asthmatics, and the elderly, and can damage vegetation and structures. Within the transport sector, road traffic is the most important contributor to urban air pollution. The substances emitted are harmful to health, with proven impacts ranging from minor irritation to carcinogenic qualities.

Global CO_2 emissions from transport, mainly from motor vehicles are projected to increase by approximately 83% from 1995 to 2020, and almost double from 1990 levels (OECD, 2001*b* and IEA, 2003). In OECD countries, CO_2 emissions from motor vehicles are projected to increase by approximately 44% from 1995 to 2020 (59% from 1990). The contribution of the transport sector to total CO_2 emissions in OECD countries is projected to increase from approximately 20% in 1995 to 30% in 2020. Anthropogenic greenhouse gas emissions are expected to lead to climatic changes in the 21st century and beyond. These changes will potentially have wide-ranging effects on the natural environment as well as on human societies and economies. Scientists have made estimates of the potential direct impacts on various socio-economic sectors, but the full consequences would be more complicated because impacts on one sector can also affect other sectors indirectly. To assess potential impacts, it is necessary to estimate the extent and magnitude of climate change, especially at the national and local levels.

c) Noise

Transport noise, particularly from road traffic and aircraft movements, is the major source of external acoustic nuisance in urban areas. Excessive noise levels of 65dB(A) and above are still being recorded in many countries, seriously affecting welfare and health by contributing to sleep disturbance, high blood pressure and cardiovascular diseases. In OECD Europe, about 30% of the population are exposed to road traffic noise levels above 55 dB(A), and some 13% above 65 dB(A) (EEA, 2000). Low-noise technologies for vehicles and road surfaces together with noise protection measures could reduce current levels significantly.

Traffic noise remains a major environmental problem as transport activity continues to grow. The value of the noise impacts across a country in monetary terms will depend upon the degree of urbanisation and the geographical structure of the country.

d) Nature, landscape and urban effects

Land use for transport is both a factor in generating transport activity (infrastructure induced mobility) and a contributor to environmental stress. Transport infrastructure, mainly in terms of roads, consumes about 25-30% of land in urban areas, and just under 10% in rural areas in OECD countries. The road network occupies 93% of the total land area used for transport in the EU. Rail is responsible for 4% of land take, and airports for less than 1%. The development and extension of transport infrastructure entails numerous effects on soils like compaction and soil sealing, and landscape separation effects leading to habitat fragmentation and destruction with negative effects on biodiversity. (EEA, 2000).

e) Indirect effect from upstream and downstream processes

Upstream processes represent the indirect effects of transport which might cause additional external effects due to air pollution and greenhouse gas emissions. They are the consequence of the whole production cycle as the energy production cycle, vehicle production and maintenance cycle and infrastructure construction and maintenance cycle. Regarding vehicle production and maintenance, the production of vehicles and rolling stock is important in the longer run, considering the life cycles of different transport means.

Thus, indirect effects relate to the production of all type of energy is causing additional nuisances due to extraction, transport, distribution of energy and fuels. They depend directly on the amount of energy used. These effects are relevant for all transport means.

F) Congestion

Total congestion costs are defined as the costs arising from an inefficient use of existing infrastructure. These costs affect primarily the transport users but also add to the cost of goods and services which affect the general public. These costs could be considered as the welfare loss by individual users due to lack of capacity or misallocation of existing volumes. Thus, there is a market failure since a road space is a scarce resource and is not priced in any market. The principal problem arising from congestion costs is the time lost by transport users. A consequence of traffic congestion is also an increase of air pollution causing damage to human health. The former externality affects other transport users, while the latter affects both travellers and the general public.

Analysis on congestion has estimated that 70% to 80% of total congestion costs in passenger transport are due to agglomeration traffic while the remaining share of costs is occurring in long distance travel. The external costs of road traffic congestion are estimated by approximately 33.3 billion euro in 1995, which corresponds to about 0.5% of Europe GDP.

Evaluation of externalities

In order to correct the market failures of external costs of transport and to maximise policy decisions, it is essential first, to translate the effects of transport activities on the environment into monetary terms and, secondly, to internalise external costs, i.e. that polluters pay the full marginal social costs of their activities (OECD, 2001). Quantification of the external costs of road transport is difficult, especially for congestion. The study of INFRAS/IWW (2000) has estimated external costs of transport at nearly 8% of the GDP in Europe excluding congestion.

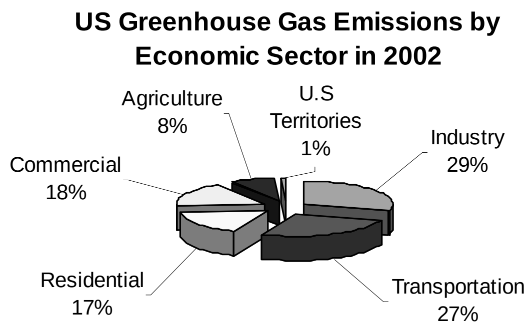
Despite these uncertainties, many journeys have a marginal social cost in excess of marginal benefits. These might include trips made by single motorists in congested urban areas at peak times. For other journeys (for example, many rural trips by car) marginal benefits exceed marginal social cost (SACTRA, 1999). Table 2 shows the total and average external costs of road for the year 2000 in EU 17

(Switzerland and Norway included). The data are expressed in million Euros per year for the total passenger and freight and in Euro per 1000 pkm or tkm for the average cost passenger and freight. Examining the total costs of road passenger, the important financial part of the accidents is well underlined since they represent 41% of the total external cost of road passenger. Air pollution costs take the second place in importance sharing 20% of the total external cost. Concerning freight transport, air pollution costs represent 40% of the total external costs followed by climate change costs that represent 22% of the total external costs.

Table 2. **External Costs of Road Transport 2000 in the EU-17 and US Greenhouse Gas Emissions by Sector in 2002**

	Total Costs Road Passenger (million Euro/year)	**Total Costs of Road Freight** (million Euro/year)	**Total Costs Road Transport** (million Euro/year)	**Average Cost Road Passenger** (Euro/1000 pkm)	**Average Cost Road Freight** (Euro/1000 tkm)
Accidents	136000	19290	155290	35.1	11.5
Noise	20900	11200	32100	5.4	6.7
Air Pollution	67300	62600	129900	17.4	37.4
Climate Change	59000	35400	94400	15.3	16.2
Nature & Landscape	8940	5510	14440	2.3	3.3
Urban Effects	5250	3160	8410	1.4	1.9
Upstream Process	31600	18900	50500	8.5	11.4
Total	329000	156000	485040	85	88

Source: Infras/IWW, 2000.



Source: Bureau of Transportation Statistics, 2004.

One element that has also to be taken into account is that externalities change over time. For example, the forecast of traffic demand to 2010 shows a dramatic increase of total congestion costs of 142% to 80.2 billion Euro p.a. (INFRAS, 2000). On the other hand, improved engine design has had a substantial effect in reduced emissions (ECMT, 1998). Road transport carbon dioxide emissions are increasing but the on-going reduction of emissions of local air pollutants from vehicles (e.g. Sox, Nox, etc.) are forecast to be further reduced in the future (OECD, 2001*b*).

Table 3 provides a range of scope and variety of external costs of transport from U.S and European studies. These costs are expressed in cents per passenger or vehicle (or kilometre) mile travelled whether the cost category is truly a component that varies with distance or is a fixed-cost component that is averaged over some standard distance. The data and estimates are very different since different assumptions about the kind of trips and mileage are used.

Table 3. **Range of Reported External Costs in Cost-of-Driving Studies in the U.S**
(Cents per passenger/vehicle-mile)

	Low (1)	High
Climate change	0.3	1.1
Congestion	4	15
Air pollution	1	14
Noise	0.1	6
Accident (external)	1	10

Source: Gomez-Ibanez (1997)

Low and high are respectively the second lowest and the second highest estimates reported in the articles surveyed.

Measures to correct market failures - Internalising externalities

As has been explained above, the negative environmental impacts of transport are numerous. The assessment of the nature and magnitude of external costs of different transport modes is an important element for transport decision-making, as it can help identifying priorities for action. For reducing external costs two options are basically available: direct or regulatory measures that focus on reducing emissions, or other kinds of external impacts and pricing mechanisms (e.g. taxes, charges, subsidies) that give incentives to change users behaviour towards “cleaner” or less transport. Measures for internalising external costs vary in their effectiveness and specificities, therefore for internalising the external costs a set of these instruments has to be used.

For example, imposing regulatory standards, such as requirements to fit catalytic converters on cars, has helped to decrease emissions substantially. Regulation is effective if properly enforced. Taxes would minimise the costs of achieving a given reduction in emissions, provide incentives to find ways of reducing emissions further, raise revenue and make transparent to drivers the marginal social cost of air pollution. As taxes vary in their effectiveness and characteristics, the difficulty arises to estimate the optimal tax rate (the rate should equal marginal damage). Taxes must be properly targeted and linked to emissions. Getting the level and type of tax "right" to assure intended environmental impact without unintended externalities is difficult and can be costly. One of the advantages of regulation is that it is an instrument that is targeted in achieving emissions reduction. Combining taxes and regulations and appropriate policy mixes could combine effectiveness (regulation) and dynamic efficiency could be more effective than implementing just one instrument.

Emissions taxes could be viewed as a more equitable instrument than a fuel duty because it reflects the social costs of pollution. The former addresses the market failure directly and provides a direct incentive to curb emissions, whereas the latter address the negative impacts indirectly. Some studies have compared emissions taxes for motor vehicles with gasoline taxes using an econometric model (Sevigny, 1998). The main conclusion is that a well-targeted emissions tax can reduce emissions with a much smaller cost in terms of fewer miles driven and at lower costs to motorists in terms of taxes paid.

Switzerland has introduced a distance-related, vehicle weight and emission-related charge system for trucks. One year into implementation, the effects of the Swiss heavy vehicle fee (HVF) system indicate that it is a success. The kilometres travelled by heavy goods traffic on the roads have decreased by 3% (in comparison with increases of around 6% in preceding years) and there have been increased renewals of the vehicle fleet. It has also provided revenue for financing important investments into railroads. Austria has already implemented a similar charge, Germany, Liechtenstein and the United Kingdom plan to do the same, and several others are expected to follow. Satellite tracking and automatic vehicle recognition systems have the potential to make further improvements to transport charging systems.

Another example is a fuel tax levied in Germany on producers of fuel and oil products, where the tax rates are differentiated by fuel type and, as of autumn 2001, by sulphur content. The environmentally oriented tax element (”Ökosteuer”, eco-tax) was introduced in 1999. The aim was to increase fuel taxation over a period of six years by USD 0.03 per year. The eco-tax is not only applied to fuels but to energy-use in general, e.g. it is also levied on electricity etc. In 2000, revenues from the fuel tax in the transport sector amounted to about DM 64 billion (USD 28 billion). The fuel tax is the third most important tax which represents about 7 per cent of the national budget. The implementation of the eco-tax provided incentives to switch to more fuel-efficient driving patterns in the short-term – and to buy more fuel efficient cars in the medium - to long-term (INFRAS/ECMT, 2000).

New instruments to cope with congestion in urban areas have also been considered in many cities. In the United Kingdom, for example, a cordon charge or “congestion charge” to regulate traffic in the city centre was introduced in London in 2003. The introduction of the charge – a GBP 5 daily charge, applied to most vehicles entering the Inner Ring Road charging zone -- has significantly reduced the levels of congestion. Journey times to or across the charging zone have reduced by 13%, and journey time reliability has improved by an average of 30%. Most of the decrease in car use has reflected a switch to use of bus transport, with an extra 15 000 bus seats provided. In terms of revenues from the charge, some GBP 68 million is expected for the year 2003/2004 (INFRAS/ECMT, 2000).

THE HEAVY VEHICLE FEE IN SWITZERLAND

A distance-related heavy vehicle fee in Switzerland (HVF) has been levied since 1 January 2001 (Federal Office for spatial development, 2004). It replaces the previous flat-rate heavy vehicle fee. Changing the system to a distance-related fee should, in particular, contribute to:

- restricting the increase in heavy freight traffic on the roads
- promoting the transfer of goods traffic to rail
- relieving the strain on the environment by implementing the "polluter-pays-principle"
- catalising the bilateral treaties with the EU

The HVF applies to heavy goods vehicles with an admissible laden weight of more than 3.5 tonnes and is calculated according to three criteria:

- number of kilometres covered on Swiss territory
- admissible laden weight of the vehicle
- vehicle's emissions

The rate of the fee was defined at 1.68 Swiss cents per ton and kilometer (tkm) for vehicles with EURO I standard. Simultaneously the weight limit was raised from 28 to 34 tons. By 2005, the rate ot the fee will be increased to an average od 2.44 Cents/tkm, and the weight limit will raise to 40 tons. The rate is calculated according to uncovered costs caused by heavy vehicles and the total amount of tkm driven by heavy vehicles (the weight depends on the admissible, not on the loaden weight).

Use of revenue

- 1/3 goes to the cantons
- 2/3 go to the Federation

The cantons use their share primarily to balance their uncovered costs caused by heavy goods transport. The share of the Federation is mainly used to partially finance the following projects of public transport:

- Rail 2000
- New Rail links across the Alps
- Links to the European High Speed Network
- Noise remediation of Rail

The HVF corresponds to the transport policy formulated in the EU Commission's white paper of 12 September 2001 and is supported by international law in the overland transport agreement with the European Union. Three years after Switzerland, on January 1st 2004, Austria has introduced a fee for heavy goods vehicles successfully as well. As in Switzerland, the fee is due for vehicles with a total admissible weight of more than 3.5 tons, but for the use of highways (and some high quality trunk roads) only. The introduction of fees for heavy goods vehicles is also planned in Germany, Sweden, UK and the Czech Republic.

Implementation

The HVF was introduced without any major problems. It is delegated to the Swiss Customs Authority.

Monitoring

The effects of the HVF are being constantly monitored and evaluated. The most important results after the first three years are a clear change of the trend in kilometres travelled by heavy goods traffic on the roads (decrease of 4% in 2001 and 3% in 2002). Further important effects were a significant renovation of the lorry fleet and a concentration in the road hauler business.

Summary

Taxes based on the distance driven and the environmental performance of vehicles and charge system can encourage important modal shifts and generate revenue for developing more environmentally friendly modes. A promising example in this regard is the recently introduced distance-dependent and emission-related heavy-duty vehicle in Switzerland; it ensures economic performance of transport by using the various modes efficiently, while reducing significantly harmful emissions (ODT, 2001). In Germany, an emission-related motor vehicle tax was implemented in April 1994 for heavy goods vehicles with a maximum permissible weight of over 3.5 tonnes. An emission related vehicle tax has also been applied to passenger cars since 1st July 1997. Passenger cars that meet the future EURO III or IV emission *standards or have especially low fuel consumption (90 or 120 g CO_2/km) receive a limited tax exemption. The tax is structured in such a way that total tax revenue does not change but vehicles with advanced exhaust emission control systems have to pay much less taxes than vehicles without such systems (see also OECD Environmental Database on environment related taxes). One of the advantages of regulation is that it is an instrument that is targeted in achieving emissions reduction. Combining taxes and regulations and appropriate policy mixes could combine effectiveness (regulation) and dynamic efficiency. Usually internalising the various external costs of transport would affect the level of transport activities, thus further reducing the levels of the externalities.*

3. TRENDS AND DETERMINANTS OF PASSENGER AND FREIGHT TRANSPORT

Demand for transport derives from the perceived need for access to people, places, goods and services in developed economies. The perceived need for personal mobility, and thus demand for passenger transport, is closely related to income levels, location, and the distance from home to employment, location of educational services, shopping opportunities available, and recreational needs. The other main drivers of transport demand for passenger transport are relative prices that boost or constrain demand, the speed due to vehicle technology and infrastructure, more leisure time spent for travel and tourism, and the structure of the family with more and more single households.

Understanding income and price elasticities of demand for transport services can help in understanding the link between transport and economic growth and the scope for policies which internalise externalities to reduce potentially adverse environmental and social impacts of transport.

A) Response of Transport to Economic Changes: Transport Elasticities

The factors that could affect the sensitivity of changes to prices are 1) the type of price change, 2) the type of trip and traveller and 3) the quality and price of alternative routes, modes and destinations. These factors can have some impacts on the links between changes in prices and travel activity and are described below.

Type of price change

Different types of charges can have different impacts on travel behaviour. Parking charges and road tolls may affect travel routes and destinations. A time-variable fee may shift some trips to other times. Fuel price increases tend to affect the type of vehicles purchased more than vehicle mileage.

Type of trip and traveller

Trips for commuting tend to be less elastic than shopping or recreational trips. Weekday trips may have very different elasticities than weekend trips. Travellers with higher incomes tend to be less sensitive to price than lower-income travellers. Travellers on business tend to be less sensitive to price than people travelling for personal activities.

Quality and price of alternatives

Price sensitivity tends to increase if alternative routes, modes and destinations are of good quality and affordable. For example, highway tolls tend to be more price-sensitive if there is a parallel free roadway. Also, driving is less price sensitive in the automobile-dependent areas where transport alternatives are very difficult to use.

Price sensitivities are usually measured using demand price elasticities, which are defined as the percentage change in demand of a good caused by a one-percent change in its price or other characteristics, such as service quality or road capacity. For example, an elasticity of -0.5 for vehicle use with respect to vehicle operating expenses means that a 10% increase in these expenses results in a 5% reduction in vehicle mileage or trips. If prices decline, travel usually increases as lower-value trips become more affordable, and if prices increase, travel usually declines, as consumers choose to abandon some lower-value trips, or shift to a cheaper mode or destination.

Table 4 summarises some results of empirical studies on transport elasticities. The numbers in parenthesis indicate the best indication of elasticity estimated by the authors. These results show that fuel price change have a significant negative effect on car fuel demand since a 10% increase in fuel price results in a 7% reduction in car fuel demand. Another significant result is the sensitivity of car fuel demand, car travel demand and car stock to income: the estimates show that an increase of 10% in income will lead respectively to a 12% increase in car fuel demand and travel demand, and a 10% increase in car ownership.

Table 4. **Estimated Long-term Transport Elasticities**

Estimated Component	**Fuel Price**	**Income**	**Taxation (other than fuel)**	**Population Density**
Car Stock (vehicle ownership)	-0.20 to 0.0 (-0.1)	0.75 to 1.25 **(1.0)**	-0.08 to - 0.04 (-0.06)	-0.7 to -0.2 (-0.4)
Mean Fuel Intensity (fuel efficiency)	-0.45 to - 0.35 (-0.4)	-0.6 to 0.0 (0.0)	-0.12 to - 0.10 (-0.11)	-0.3 to -0.1 (-0.2)
Mean Driving Distance (per car per year)	-0.35 to - 0.05 (-0.2)	-0.1 to 0.35 (0.2)	0.04 to 0.12 (0.06)	-0.75 to 0.0 (-0.4)
Car Fuel Demand	-1.0 to - 0.4 **(- 0.7)**	0.05 to 1.6 **(1.2)**	-0.16 to - 0.02 (- 0.11)	-1.75 to -0.3 **(-1.0)**
Car Travel Demand	-0.55 to - 0.05 (- 0.3)	0.65 to 1.25 **(1.2)**	-0.04 to 0.08 (0.0)	-1.45 to -0.2 **(-0.8)**

Source: Johansson and Schipper, 1997.

The scale of pricing is also an important variable since driving distance is actually quite elastic with respect to total costs. Other individual price components of driving (fuel, parking, and tolls) are considered inelastic because they each represent a small portion of user's total costs. For example, since fuel is only about 15% of transport user's total costs, a -0.2 elasticity of driving distance with respect to fuel price represents an elasticity of -1.3 with respect to transport user's total costs. This implies that if all user costs were converted into variable charges, each 1% increase in this charge would reduce driving by 1.3%.

The time period used to apply these instruments is also very important for determining the real transport elasticities. Indeed, transport elasticities tend to increase over time as consumers have more opportunities to take prices into effect when making long-term decisions. For example, if consumers anticipate low automobile use prices they are more likely to choose an automobile dependent suburban home, but if they anticipate significant increases in driving costs they might place a greater premium on having alternatives, such as access to transit and shops within convenient walking distance.

For this reason, it may take many years for the full effect of a price change to take place. Studies cited by Button (1993, p. 41) estimate that short-term elasticities that is generally estimated as two years, are typically one-third of long-term elasticities that is considered as 15 years or more. Dargay and Gately (1997) have concluded that about 30% of the response to a price change takes place within 1 year, and that virtually all takes place within less than 13 years. Dargay and Goodwin (1995) argued that the common practice of using static rather than dynamic elasticity values overestimate welfare losses from increased user prices and congestion, because it ignores society's ability to respond to changes over time.

Several types of aggregate models have been discussed in the context of fuel demand models studying also the effect of the decrease in fuel cost that lead to greater vehicle use: this mechanism is called the rebound effect. In all cases, the main dependent variable is gasoline demand. The dependent variables always include gasoline price and some measure of average household income.

- Static models. Usually based on non-cross-sectional data, these models estimate a single price and income elasticity parameters.

- Lagged endogenous models. Estimated on time series or panel data, these models contain a lagged dependent variable to distinguish between short- and long-run elasticities. The duration of the lag strongly affected the estimates, with short lags (one month or one quarter) producing very low elasticities, especially in the long run.

- Models with other lags. Other lag structures do not require the same rate of adjustment to price and to income changes.

- Models with vehicles and vehicle characteristics. These models included the number of vehicles or average vehicle characteristics, such as fuel economy.

Examination of the results of these studies suggests that gasoline demand is still moderately responsive to both price and income. However, summarized in the 1995 Dahl study, the elasticities have fallen substantially. This conclusion is illustrated in the Table 5, which compares elasticity estimates in the two time periods for simple static models and for lagged endogenous models. The decline in responsiveness extended to other related phenomena.

For example, Dahl (1995) reported that the mean price elasticity of average fuel economy (MPG) declined from about 0.4 to about 0.2. Several explanations have been suggested for the decline, including improved data, rising incomes in many countries in the world, and the much lower fuel prices in the 1980s, which made gasoline a smaller portion of the cost of driving. Moreover, the studies surveyed by Dahl (1995) used data from the 1980s, a period when energy prices declined substantially. At the same time, Gately (1992) found that the response of gasoline demand to both price and income is asymmetric, that is, sensitivity to price declines is much lower than to price increases.

Table 5**. Median Price and Income Elasticities of Gasoline Demand in 1991 and 1995**

	Price		**Income**	
Static models – fuel use				
Dahl and Sterner (1991a, 1991b)	-0.51		1.24	
Dahl (1995)	-0.18		0.39	
Lagged endogenous models	short-run	long-run	short-run	long-run
Dahl and Sterner	-0.26	-0.86	0.48	1.21
Dahl (1995)	-0.13	-0.65	0.19	0.72

Source: Dahl and Sterner (1991a, 1991b) and Dahl (1995)

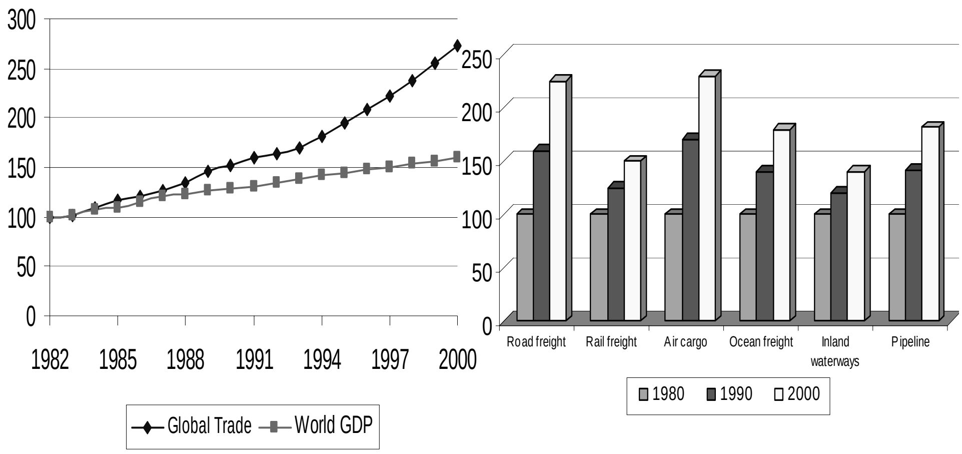
Summary

The various studies and models used indicate that income is by far the major factor driving vehicle ownership. This factor is much more important than fuel price, vehicle price, infrastructure, or population density. But the analysis also shows that the relationship of vehicle ownership to income in each country tends to be non linear. Between 1992 and 2015 the models used have found that the long-run ownership income elasticity falls from 0.24 to 0.04 in the US and from 1.92 to 0.4 in middle-income country like Korea, but increases from 1.34 to 2.16 in China. Also the performance of different policies will have different effects on old vehicles versus new vehicles, the level of vehicle use, etc. To examine these effects, more detailed models that explicitly represent individual choices are needed.

Main drivers of freight transport demand

The demand for freight transport is closely linked to economic growth and trade (see Figure 5). The global figures suggest that growth in global trade (in terms of value) has been higher than growth of global GDP and there is a continuous increase of trade stimulated by economic growth and related increasing movements of goods and often overall transport activity. The large majority of freight movements in terms of tonne kilometers are made by ocean freight, which is also the dominating mode for freight transport among the main economic regions of the OECD. In the past, ocean freight has experienced strong growth and still is the dominate mode in intercontinental freight movements. However, the highest growth rates of world freight volumes are observed for road freight and aviation.

Figure 5: **Growth in World Trade and GDP, 1980 to 2000**



Source: World Bank Data Base, 2002; Gilbert, 2001b.

The main drivers of freight transport demand are the production increases, the increase in average haul length, globalization, outsourcing of manufacturing, market integration (EU, NAFTA, APEC), changes of consumer preferences, efficiency improvements (load factor, vehicle size) induce a rebound effect, transport infrastructure investment.

When focusing on some regional trends of trade and the modes involved, the situation is similar to the global picture. Table 6 shows the trade-related transport activity in 1995 in the EU and how the different modes contribute to extra and intra-EU-15 trade in terms of value (billion Euros) and in terms of weight (million tonnes). In 1995 GDP was, with €7296 billion, some 37% higher than in 1980, slightly less than the overall growth of world GDP over the same period. Concerning exports to the extra-EU regions, the most important mode of transport used in terms of value of goods and weight is by large maritime transport with a share of 41% of the total value and 71% of the total tonnes transported. The second rank is held by air transport contributing 26.5% to the total of value (in billion Euros) of all imported and exported goods outside the EU-region; its value intensity (i.e., value per tonne) is highest among all the modes. The situation on modal share is the similar for imports, since transport by sea is with a share of 41.3% by far the largest contributor to the total value of goods traded. The data on volume provide a somewhat different picture, as aside of maritime transport, which dominates by imports and exports in terms of tonnes of goods transported (71%), transport by pipeline and by road maintain much lower shares, 11% and 8%, respectively. The situation for intra-EU15 movement of goods is different, as road freight performs by large the majority of movements, 61% in terms of value and 45% in terms of weight. Short-sea shipping holds the second place with 22% and 28%, respectively.

Table 6. **External Trade by Mode of Transport in the EU-15 in 1995**

	Value (billion Euros)				**Weight** (million tones)			
	Extra-EU 15			**Intra-EU15** Import	**Extra-EU 15**			**Intra-EU 15** Import
	Export	Import	Export + Import		Export	Import	Export + Import	
Sea	308	314	622	281	278	927	1205	295
Road	177	141	318	778	70	67	136	465
Rail	16	14	30	47	17	52	69	50
Inland waterway	3	4	7	11	11	28	39	122
Pipeline	2	21	22	11	4	187	191	94
Air	196	178	375	52	3	3	5	1
Other/unknown	40	88	128	87	6	58	64	17
Total	**742**	**760**	**1502**	**1266**	**388**	**1321**	**1709**	**1044**
% of GDP or volume	**10%**	**10%**	**21%**	**17%**	**14%**	**48%**	**62%**	**38%**

Source: European Commission, Transport Statistics, 2002.

B) Overview of Passenger and Freight Transport in the OECD Area

In most OECD countries, a close correlation between road freight demand and economic growth has been noted. The majority of road freight traffic forecasts have been based on the assumption that these variables will remain closely correlated for the foreseeable future. However, in some European countries and the United States, these trends have begun to diverge. Detailed analyses have been done for the freight services sector in the United States providing empirical evidence for the changes of the sector due to changes in infrastructure (physical, non-physical), technology, production and consumption as well as the institutional regulatory frameworks. However, national transport statistics can only provide a crude outline of the historic developments in passenger and road freight demand for a broad set of commodity-flows, and are insufficient to individually link these developments to a particular underlying economic, logistical, or other factor.

A similar, detailed analysis has not been performed in a European-wide context. Also the key economic factors that determine growth of road freight traffic demand have been less studied in a European context. Therefore, the following sections focus on the European situation.

Historically, there has been a strong correlation between economic growth in terms of GDP (gross domestic product) and the demand for passenger and freight transport in OECD countries. Freight transport has been growing faster than passenger transport, although total vehicle kilometers traveled is greater for passenger transport (OECD, 1999). Thus, growth of GDP has been accompanied by a similar growth in overall transport demand, particularly for road transport. While GDP in OECD countries has grown by 46 per cent from 1980 to 1995, the number of motor vehicles has increased by 55 per cent and vehicle kilometers traveled by 59 per cent. Also growth rates in air traffic have been much higher than GDP growth rates, typically around 9 per cent per annum for passenger traffic and 11 per cent for air cargo (OECD, 2001*b*). It is generally concluded from these results that transport and economic growth (in terms of GDP) are strongly correlated.

GDP is a convenient measure to compare economic performance among countries and has been used as the aggregate indicator for economic performance. The problem is that it does not incorporate a number of activities, which are not traded. A considerable amount of personal transport cannot be easily measured either by the value of goods and services for which that transport is undertaken (because of non-market values) or by the resources consumed in the production of the journey (because of environmental and social externalities). The most explicit example is travel for leisure or visiting friends and relatives. Nevertheless, the GDP indicator will be used for this analysis of trends in transport and economic activity.

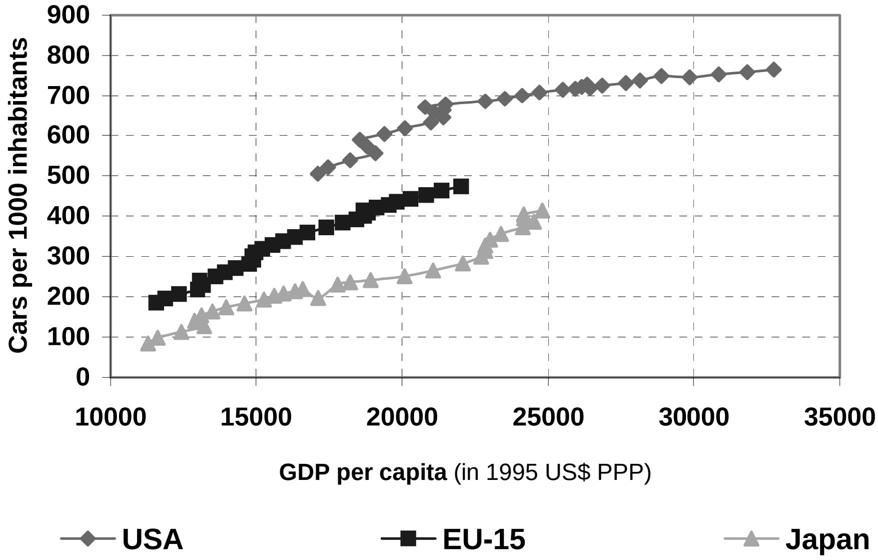
Passenger transport

Figure 6 shows the motorization level, i.e. the number of cars per 1000 inhabitants and GDP in OECD regions in the period of 1970 and 2000. It underlines the large difference of motorization levels between the three regions, the US, Japan and the EU. At the same level of GDP per inhabitant, the US has the highest number of cars per inhabitants, followed by the European region and finally Japan. This graph also shows that the trend followed by the EU and Japan is nearly the same but with a much lower level for Japan.

Transport per capita followed the trend of GDP per capita, except for Japan, which shows a different pattern (see table below). Trends for transport intensity (per GDP) were different from GDP per capita. The difference between the levels of GDP per capita through the different regions studied is also important because of its magnitude. GDP per capita in the U.S is 32% higher than that of the two other regions. The relative important place held by the cars in the US for passenger transport could be explained by several factors: the large areas of the country where no alternatives to car transport exist, at the same time transport infrastructure, particularly highways were expanding thus providing reliable and fast transport facilities for commuting, and finally the relative price of fuel is much lower than in the other two regions.

The trend suggest that: i) Transport elasticities to GDP per capita decreased from 1.0 to 0.25 in the U.S once a level of $22, 000 per capita has been reached; ii) Japan and EU trends point to an eventual convergence around 500 cars per inhabitant for another 30% increase in income.

Figure 6. **Motorization Level and Wealth in OECD Countries in 1970-2000**



Source: BTS, 2000; European Commission, Transport Statistics, 2002; MLIT Japan, 2002.

It is worth noting that the various intensity indicators that have been calculated for total passenger transport include all modes and thus provides a slightly different picture – notwithstanding the fact that growth of total passenger transport per capita followed the trend in GDP per capita (see adjacent table to Figure 6). In contrast, transport activity per GDP declined in the US and Japan by 16 percent and 24 percent respectively, while it still increased in Europe for the past three decades when GDP per capita almost doubled.

Total Passenger transport intensity in the OECD area

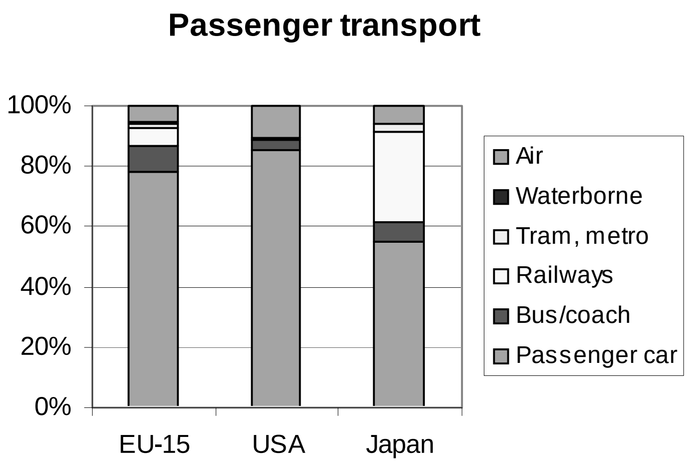
	1970	1980	1990	2000	1970 - 2000
GDP/capita (in 1995 US$, PPP)					Growth
US	17,117	21,112	26,324	32,742	91%
EU	11,571	14,912	18,447	22,029	90%
Japan	11,319	15,592	22,051	24,794	119%
Passenger transport per GDP (pkm/$US1000)					
US	1,054	1,008	970	886	-16%
EU	552	577	615	610	10%
Japan	593	488	476	451	-24%
Passenger transport per capita (pkm/capita)					
US	18,043	21,285	25,542	29,006	61%
EU	6,392	8,611	11,343	13,436	110%
Japan	6,714	7,612	10,487	11,185	67%

Source: BTS, 2000; European Commission, Transport Statistics, 2002; MLIT Japan, 2002.

Modal split for passenger transport

The comparison between three major economic areas, the US, the EU and Japan, reveals notable differences in terms of size, mode shares and overall trends suggesting different developments in these regions (see figure 7). Modal split for passenger transport is dominated by passenger cars in the US (86%) and the EU (78%) and (55%) for Japan, while the other modes have minor shares of less than 10 per cent, except for aviation in the US (11%) and railways in Japan that have a substantial share of 30% of total passenger-km travelled.

Figure 7. **Modal Split of Passenger Transport in the EU, the USA and Japan**

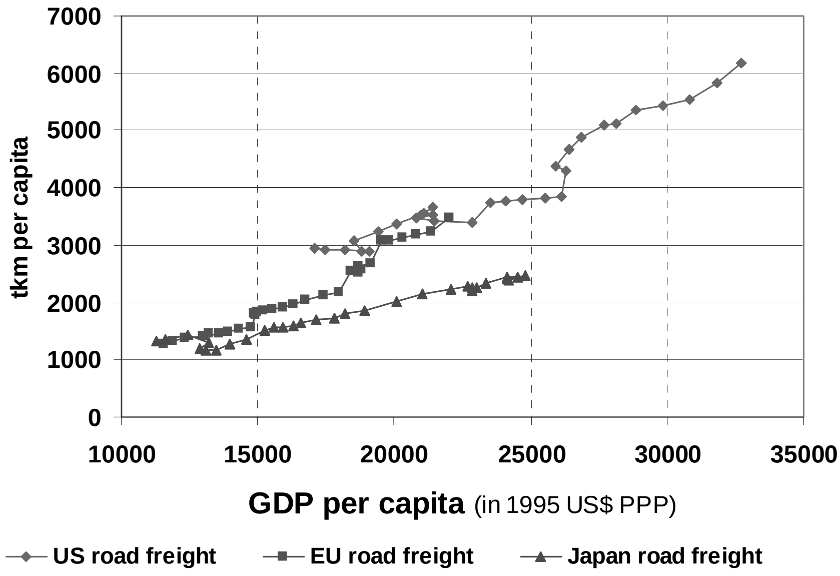


Source: European Commission, Transport Statistics, 2002.

Freight transport

Figure 8 shows the road freight intensity in terms of tkm per capita and GDP for the period of 1970 to 2000 of the three regions, the US, Japan and the EU. The data underline again the correlation between freight transport and economic growth and that, for a given level of GDP per capita, road freight intensity is comparable between the US and Europe. The latter follows very much the trend in the US, while Japan has a much lower freight transport demand for the same level of GDP per capita. The highest intensity for road freight has been observed for the US with 6100 tkm per capita in 2000, while in the EU it was 3500 tkm per capita and 2500 tkm per capita for Japan, albeit at a much lower level of GDP per capita. The trend for the US can be explained by the important size of the country or distance between sources and markets. The trend for Japan could be explained by the fact that the level of GDP per capita is not the only driving factor of the demand for road freight. Modal split of a country is an important factor to understand the difference in road freight intensity. In Japan, road transport is the dominating mode for freight with 58% of the total modal split, but short sea shipping is also very well developed with 40% of the total modal split.

Figure 8. **Trends of <u>Road</u> Freight Intensity and GDP per capita in the OECD area**



Source: BTS, 2000; European Commission, Transport Statistics, 2002; MLIT Japan, 2002.

If one considers the various intensity indicators that can be calculated for freight transport including all modes, a different picture among the regions emerges for transport activity per GDP. While growth of total freight transport per capita followed the trend in GDP per capita that almost doubled (see adjacent table to Figure 8), transport activity per GDP declined in the US and Japan by 31 percent and 38 percent, respectively, it still increased in Europe for the past three decades.

<u>Total</u> Freight transport intensity in the U.S., the EU and Japan

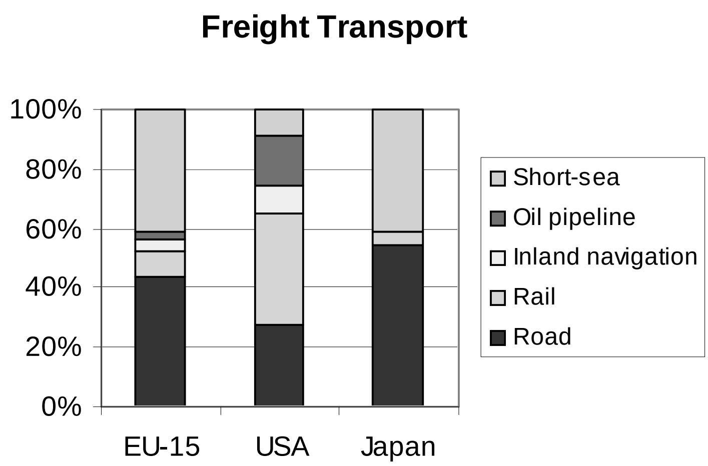
	1970	1980	1990	2000	1970 - 2000
GDP/capita (in 1995 US$, PPP)					Growth
US	17,117	21,112	26,324	32,742	91%
EU	11,571	14,912	18,447	22,029	90%
Japan	11,319	15,592	22,051	24,794	119%
Freight transport per GDP (tkm/$US1000)					
US	918	908	709	632	-31%
EU	328	340	329	361	10%
Japan	297	242	201	184	-38%
Freight transport per capita (tkm/capita)					
US	15,714	19,163	18,666	20,707	32%
EU	3,800	5,067	6,071	7,952	109%
Japan	3,360	3,775	4,423	4,554	36%

Source: BTS, 2000; European Commission, Transport Statistics, 2002; MLIT Japan, 2002.

Modal split of freight transport

The modal split for freight transport is similar for the EU and Japan with a high share of the two major modes, short-sea shipping (41%) for both countries and road freight, (44%) for the EU and (55%) for the Japan. The US economy has a more balanced modal share among the various freight modes, with rail freight taking the highest share of the total (37%), followed by road freight (30%) and pipelines, inland navigation and short-sea shipping having shares between 5% and 10%.

Figure 9. **Modal Split of Freight Transport in the EU, the USA and Japan**



Source: European Commission, Transport Statistics, 2002.

<u>Summary</u>

This overview and presentation of aggregate data underlines the statistical correlation between passenger and freight transport and GDP. Concerning passenger transport the other important driving factors of demand, apart household income are the price of transport facilities (fuel, car, etc), the price, speed quality and availability of the alternatives modes of transport, the spatial system of health, education and other services. Some other factors are also determining the demand for transport as for example the demographic and social trends including ageing and household size (ECMT, 2003). The driving factors of freight are the increase of production, the length of haul, globalisation, market integration, infrastructure investments, and the optimisation of transport organisation.

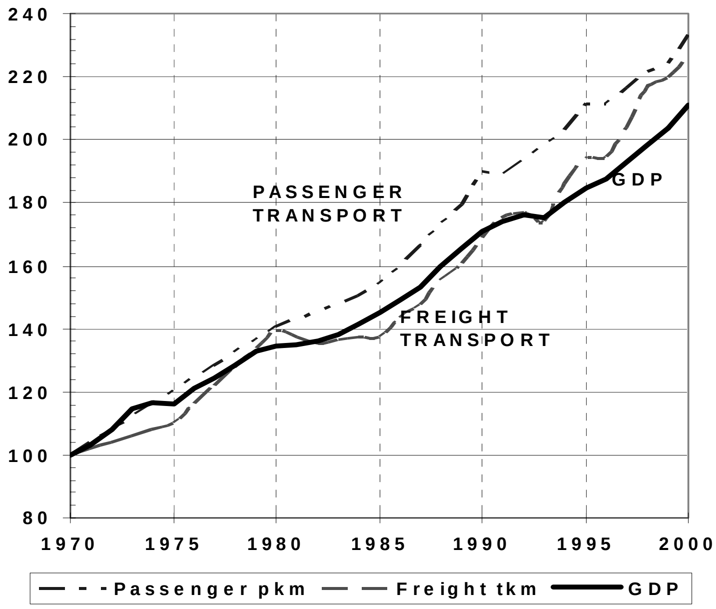
C) Trends in Europe

In the EU Member States, a close correlation between growth in passenger and goods traffic and economic growth has been observed over the past three decades. Figure 10 illustrates this fact by showing the past trends of passenger and freight transport and the strong correlation with GDP (yet with some variations over time). Total passenger transport (passenger-km) includes passenger cars, buses/coaches, rail, tram/metro and domestic aviation. Total freight transport (tonne-km) includes road, rail, inland waterways, short-sea shipping and oil pipelines. GDP trends are based on US dollars in constant 1995 prices. Growth of GDP in the EU was above 3% between 1970 and 1980 and remained fairly constant over the past twenty years, slightly higher between 1980 and 1990 increasing by some 27%, and by 24% from 1990 to 2000. Real GDP has increased by 2.1 per cent annually between 1991 and 2000 and by 2.4 per cent between 1980 and 1990; freight transport has increased between 1991 and 2000 by 3.7 and between 1980 and 1990 by 1.9 per cent (see also Table 7).

Passenger transport increased by some 35% between 1980 and 1990, and thus grew more than GDP, while over the following ten years it increased by 25%, still slightly higher than GDP over the same period. Total volume of freight transport in the EU grew slightly slower than GDP until the early 1990s. Since then, growth of freight transport exceeded that of GDP and total volume increased by some 40% over that past ten years. Thus, economic output (in terms of GDP) and transport demand both for passenger and freight remained strongly correlated, and continued economic growth boosted freight transport growth, in particular road freight and short sea shipping.

Regarding modal share, road transport clearly dominates total increase of passenger transport, while for freight it holds an equal share with short-sea shipping. The second most important freight transport mode, contributes the lion share of total volume of imported and exported goods in Western Europe. Thus, the statistic correlation between road passenger and road freight transport and GDP is high, as well as between short-sea shipping and GDP suggesting that the increase in production output resulted in growing transport activity. On the other hand, the share of rail, public transport, inland waterways and oil pipelines continued to decrease, and thus, the statistical correlation of these modes with GDP is quite low.

Figure 10. **Trends of GDP and Transport Activity in the EU, 1970 to 2000**



Growth per decade

	1970-1980	1980-1990	1990-2000
GDP (1995 US$ PPP)	35%	27%	24%
Passenger (pkm)	41%	35%	23%
Freight (tkm)	39%	21%	34%

Source: European Commission, Transport Statistics, 2002.

Figure 10 is on relative trends, indexed for 1970 and shows that growth of transport went very much along GDP growth. Passenger transport has shown a much stronger growth than GDP, notably since the 1980s and primarily due to strong growth in passenger car transport. Freight growth followed much along GDP until 1993 when it definitely separated from it and grew much stronger since, primarily due to the liberalisation of road freight, the integration of the internal market and the opening of the Eastern European market.

The interpretation of these aggregate trends and correlation is complicated since many factors are involved and influence each other, including globalisation of production, liberalisation of the internal market, the quality of transport infrastructure and investments made to maintain, expand and develop it that can boost certain modes at the expense of others. The critical role of transport infrastructure investment and its links to economic growth is examined in a separate chapter later on in this report.

Annual growth rates per decade of passenger and freight transport are shown in table 7. The comparison of the rate of growth in freight transport with the rate of growth in GDP shows that during the period of 1980-1990, growth in GDP was proportionately higher than growth in freight transport. For the past decade, the situation regarding GDP and freight transport was reversed. GDP rose by 2.1 per cent between 1990 and 2000, while freight transport increased by a 3.0 per cent p.a. Overall, the correlation between growth of freight transport and growth of industrial production and with GDP is not simple due to underlying factors and structural changes - variation in growth of production do not necessarily translate into similar variation of transport activity.

Table 7. **Average Annual Growth Rates of Transport in the EU-15**

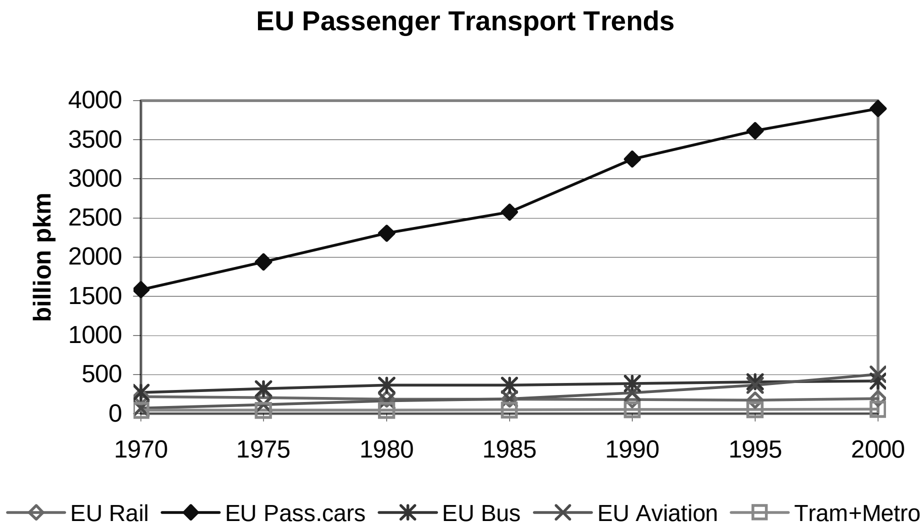
	1970-1980	1980-1990	1990-2000
GDP	3.0	2.4	2.1
Passenger transport (pkm)	3.5	3.0	2.1
Freight transport (tkm)	3.4	1.9	3.0
Passenger km per capita	3.0	2.8	1.7
Freight km per capita	2.9	1.8	2.7

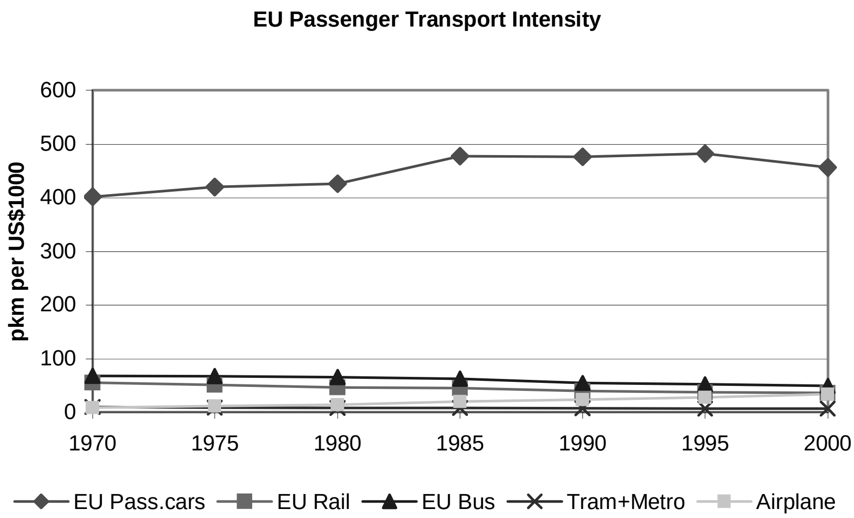
Source: European Commission, Transport Statistics, 2002.

Passenger transport trends by mode

Figure 11 shows the trends by modes and intensity (pkm per GDP) for the past three decades: travel by car dominates the overall growth. Passenger transport by car overwhelmingly dominates the modal share with 78.3 per cent in 2000, nearly constant over the past decade (Energy and transport in figures 2001, European Commission). The share of air transport in the modal split grew from 1.5 per cent in 1970 to 5.8 per cent in 2000. In the same period public transport has lost part of its share of the modal split. The share of rail transport fell from 10.1 per cent in 1970 to 6.3 per cent in 2000. Regarding growth of individual modes, the highest growth rates are observed for aviation and passenger car transport.

Figure 11**. Passenger transport trends by modes, 1970 to 2000**





Source: European Commission, Transport Statistics, 2002.

Changes of modal split of passenger transport in the EU

Passenger transport has experienced important increases during the past decades, mainly due to increases of income levels and overall expansion of the economy. Since 1980, the volume of passenger transport has increased by 80%. The highest growth in passenger transport in the European Union has been observed for air transport and for passenger cars. For passenger transport, rail and bus/coach transport have increased below the rates of growth of GDP since the mid-1980s, as these modes have lost market shares.

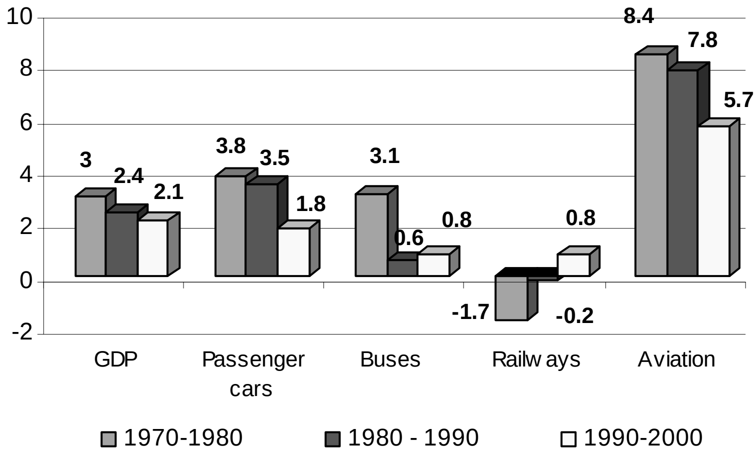
This trend towards more individual motorised transport is partly explained by a similar trend in family structure. Thus, increasing individual mobility and the growth of individuality in society are clearly related. This is reflected by the increasing number of single-person households; e.g., in 1970, there were

5.5 million single-person households in Germany, while in 1994, there were as many as 12.7 million such households.

There are various ways of calculating indicators of transport intensity: i.e., transport activity per capita or per GDP. To illustrate the correlation between transport volume (tonnes) or performance (tonne km) and economic output, the intensity per GDP is calculated (see Figure 11). For the past three decades trends of passenger transport activity per GDP in the EU are different for the various modes. During the period analysed, transport intensity has increased by 25% and slightly declined for the past five years. This increase is strongly dominated by developments of growth of passenger cars in parallel with growth of GDP, at a rate similar to overall transport activity in the EU. These data which represent the ratio of transport activity and GDP are complicated to analyse. An upward trend could mean that transport growth has been stronger than GDP or GDP growth slower than transport growth.

Figure 12 presents data on the average annual growth rates of passenger transport in EU-15 for the years 1970, 1980, 1990 and 2000. Aviation and passenger cars experienced the highest growth rates with annual growth rates of 5.7% and 1.8% respectively during the past decade. Growth rates of transport by railways and buses were significantly lower than those for GDP

Figure 12. **Average Annual Growth Rates of Passenger Transport, EU 15**
(% per year in passenger-km)

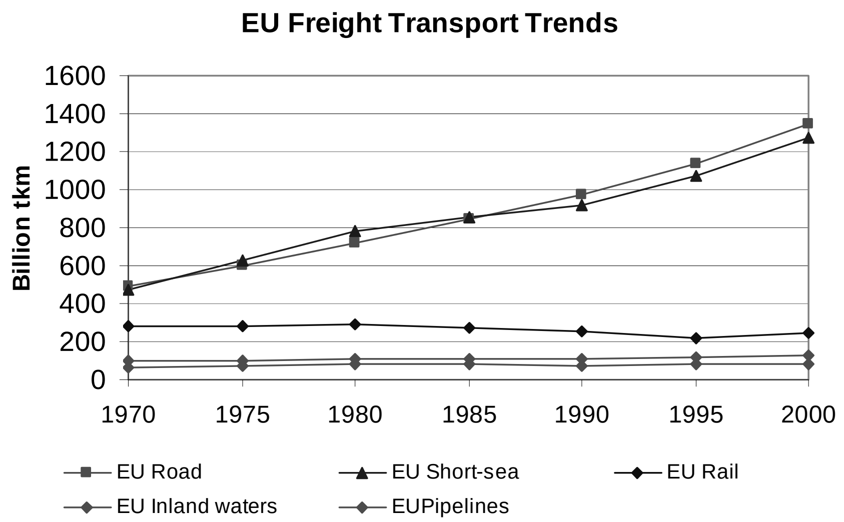


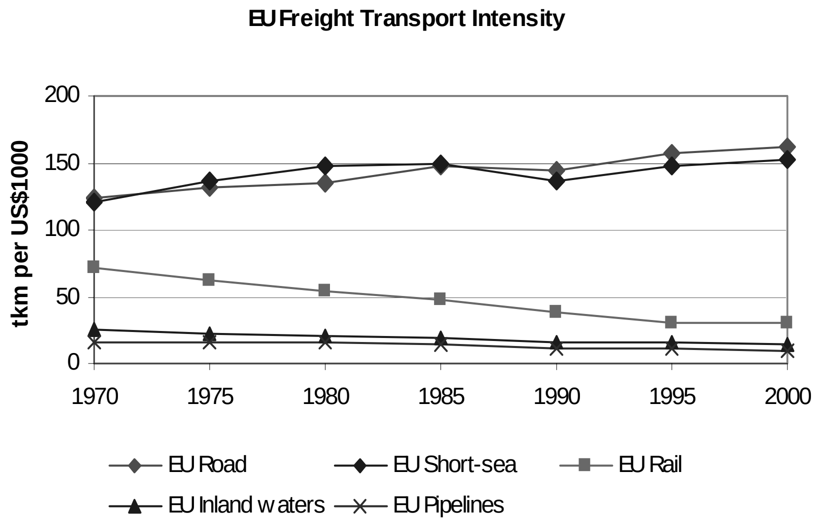
Source: European Commission, Transport Statistics, 2002.

Freight transport trends by mode

The transport of goods in Europe is performed mainly by road (80% in terms of tonnes transported), while the other modes contribute with much smaller shares between 3% (inland waterways) and 7% (railways). However, the picture looks more balanced in terms of tonne-km: short sea shipping contributes some 41%, while in terms of volume its share is only 6%; the part of the road share (in tkm) is 44% and that of railways is still low with some 8% of total tonne-km.

Figure 13. **Freight Transport Trends in the EU-15 for Different Modes.**





Source: European Commission, Transport Statistics, 2002.

Transport performance (measured in tonne-km) is the amount of the transport (measured in tonnes) for a given period multiplied by the average distance traveled of the goods transported (measured in km). For the period considered, transport performance has increased very much for road (41%) and for sea (30%), but has declined for rail (7%). While the amount of goods transported remained nearly stable, the average distance traveled by road has increased considerably.

Changes of modal split of freight transport

The EU data underline the fact that the strong growth of transport activity has not affected all modes of transport to the same extent (see Figure 13). The share of road transport increased between 1970 and 1999 from 31% to 45% in terms of total tkm, while short sea remained stable around 42% since 1980. During the same period the share of the rail in the modal split decreased by 22% to 8% which is the most substantial decrease in modal split. During the same period, the share of inland waterways has declined from 8% to 4% (European Commission, Energy and transport in figures 2001).

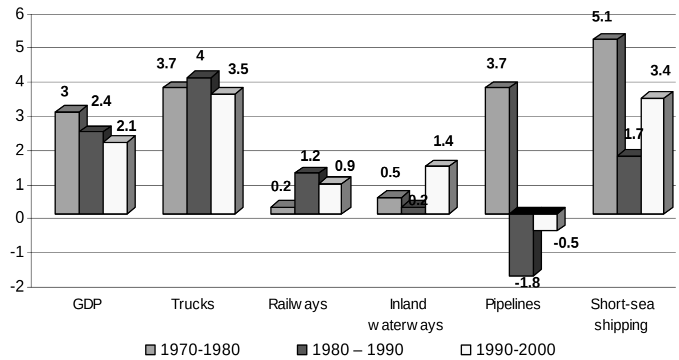
Freight transport intensity

Over the past three decades, freight transport intensity in the EU does not show a clear trend, while increasing overall over the past ten years. For the direction of the overall trends, the development of the major modes is the determining factor: short-sea shipping and road transport in the case of freight. Transport intensity of rail and pipeline has declined, while road freight intensity continued to increase since 1985 reflecting the already mentioned strong growth at a higher rate than GDP. The indicator of total weight of goods moved per GDP (in terms of tons per GDP) shows for all countries a decrease that confirms the on-going trend in highly industrialised economies towards more services and a lower material intensity.

During the period analysed, transport intensity (in terms of tonne km per GDP) was stable due to both strong growth of road freight and short sea shipping in parallel with growth of GDP, at a similar rate for overall transport activity in the EU.

Figure 14 presents data on the annual change of transport performance by mode of transport in EU-15 for the years 1970, 1980, 1990 and 2000. For freight transport, road freight and short-sea shipping experienced the highest growth rates with annual growth rates of 3.5% and 3.4% respectively for the past decade. Growth rates of transport by rail, inland waterways - and since the mid-1980’s, those of oil pipelines - were significantly lower than those for GDP.

Figure 14. **Average Annual Growth Rates of Freight Transport in the EU-15**
(% per year in tonne-km)



Source: Energy and transport in figures 2001, European Commission.

During the period 1980 to 1997, the data show the growing importance of the services sector that increases its share of GDP by (+9%) compared to the other sectors whose shares declined: the primary sector (-2%) or secondary sector (-7%) (OECD, 2000*a*).

This could have resulted in a slight impact on freight transport activity relative to economic growth. However, the analysis of aggregate transport data did not confirm this hypothesis, mainly due to the fact that goods are increasingly transported over longer distances (increases in tonne-km) without necessarily a corresponding increase in the volume of production.

A recent analysis for Germany however concluded that socio-economic developments might have resulted in a certain degree of “decoupling” of transport impacts and economic growth, since the economy has experienced structural changes towards smaller contributions to overall GDP of the primary sector and the secondary sector, but larger contributions of the tertiary sector (Pastowski, 1997). In fact, “decoupling” occurred due to the fact that freight transport intensity is significantly lower for services. The elasticity of transport intensity as related to the share of the tertiary sector has been calculated to amount to - 0.3. This means that an increase of the share in the tertiary sector by 1% results in a decrease in transport intensity by 0.3%.

The analysis of trends and changes in modal share in the EU over the past decades reveals significant changes in the volume and structure of economic activity that influences transport demand. The main factors stimulating growth in freight transport in the EU are primarily related to the integration of the European markets, the liberalisation of the internal market (for road but not yet for rail transport) and globalisation, while at the same time the cost of freight (including fuel prices) remained relatively low (TERM, 2001). These conditions facilitated the development of complex trading networks taking advantage of the removal of cross-border barriers and cost differentials among regions. This has resulted in increased distances between resource extraction, manufacturing and distribution of goods; in fact, the category of machinery and manufactured articles has experienced the strongest growth in total tonnes transported. Similarly, customer requirements for more tailored and specialised goods as well as changes in consumer preferences led to additional, more frequent movements and longer distances traveled of goods, and thus, overall more transport activity without necessarily a higher volume of goods produced (see chapter 5 for a more detailed discussion).

Summary

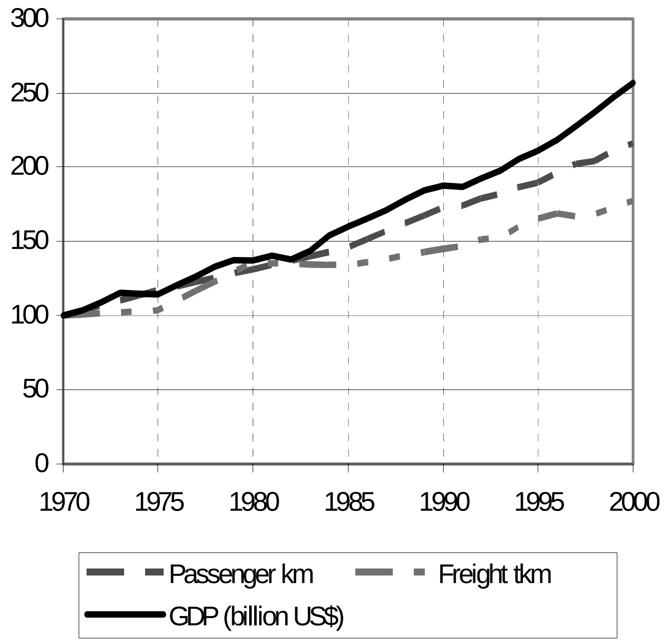
The linkage between freight transport (as a primarily derived demand like energy) and GDP is generally acknowledged to be strong. Freight transport activity is increasing even more rapidly than GDP, in particular for short-sea transport, aviation and road freight.

The analysis of the modal split showed further that the strong correlation is due to road passenger and road freight and maritime freight, respectively, as they are the dominating modes. The correlation with the other modes is therefore weak and has diminished in recent years. Data suggest that economic growth and transport demand increased in parallel. At the same time, technology improvement and infrastructure, especially road has been increased. Over the period analysed, the interrelations between growth of GDP and transport activity have been strong. Determining a causal link between transport and economic growth or vice-versa, would require much more detailed analyses based on more disaggregated data to show how much of productivity growth in different sectors is due to transport changes (investment and infrastructure) in different modes.

D) Trends in the U.S

Unlike the trend in Europe, US GDP has increased more than passenger transport and much more than freight movements. These trends reflect some important structural changes in the U.S economy (figure 15).

Figure 15. **Transport and GDP Trends in the U.S.**
(in terms of pkm, tkm)



Growth per decade

	1970-1980	1980-1990	1990-2000
GDP (1995 US$ PPP)	37%	37%	37%
Passenger (pkm)	31%	32%	25%
Freight (tkm)	35%	7%	22%

Source: US BTS, National Transportation Statistics, 2002

The U.S has experienced a relative decoupling of GDP versus passenger and freight transport over the past two decades. GDP has increased by 160% since 1970 until 2000 with a stronger growth period between 1978 and 1990, especially since 1995, reflecting some important changes in the economic structure. Passenger transport increased gradually, but slightly less than GDP, resulting in an overall increase of 120% over the past three decades. Freight transport increased by more than 100% over the past

30 years, less than GDP and passenger transport growth. There are several distinct periods for this trend: growth in freight transport was only slightly less than GDP until 1978, but from then onwards stagnating until 1985, strongly increasing afterwards with lower growth rates as for GDP from 1985 to 2000.

Overall, the correlation has decreased over this period, but in recent years some change has occurred towards higher growth rates due to the expansion of the US economy. Even if the trend of freight transport in the same period has also followed the trend of GDP, the relation was less close to GDP than the one of passenger transport (the income elasticity was 0.5). The growth of freight transport in terms of tonnage and ton/miles during the period 1970-95 varied substantially in relation of the different mode used. For example, intercity trucking ton/miles increased by 124%, while air freight ton/miles grew by 468%. Saturation for passenger transport can be expected resulting in a stabilization of passenger km traveled; various studies have shown that, on average, people travel one hour per day. Concerning freight transport a continuing shift from primary and secondary sectors to service sectors could, in the medium term, result in stabilization of freight transport in terms of t-km.

Table 8. **Average Annual Growth Rates of Transport in the US**

	1970-1980	1980-1990	1990-2000
GDP	3.2	3.2	3.2
Passenger transport (pkm)	2.7	2.8	2.3
Freight transport (t-km)	3.1	0.7	2.0
Passenger km per capita	1.7	1.8	1.3
Freight km per capita	2.0	-0.3	1.0

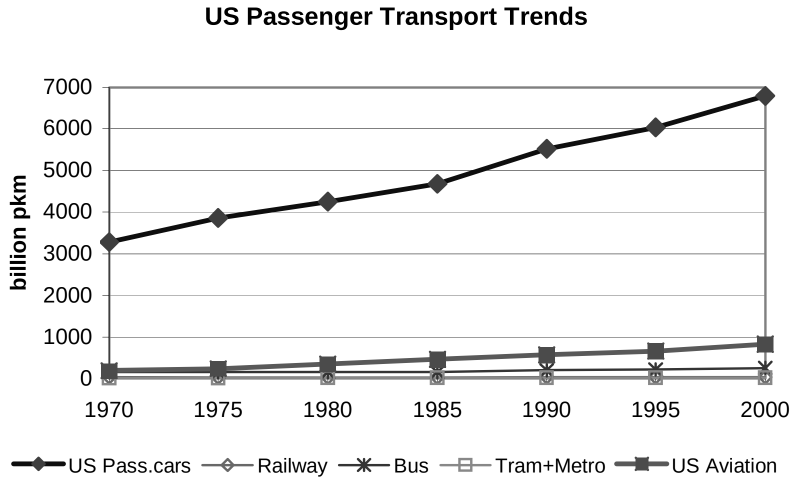
Source: European Commission, Transport Statistics, 2002.

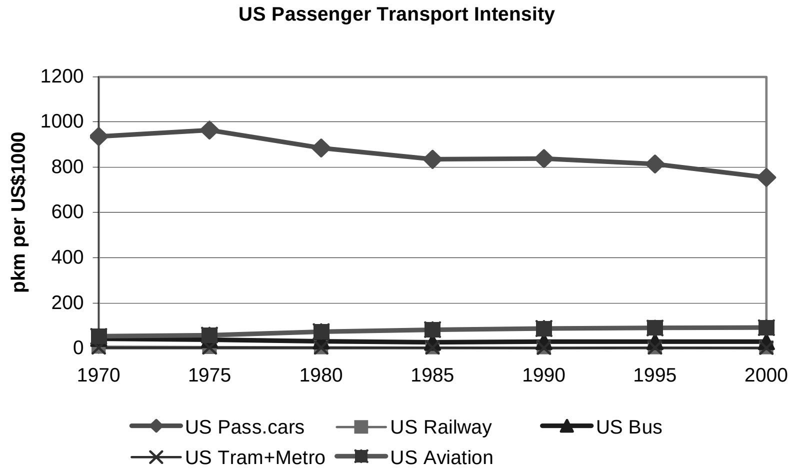
Overall, the difference in the growth rates between freight transport and industrial production and GDP can be explained by underlying factors of structural changes, such as changes in production patterns that moderate the growth of transport activity. The ratio of freight km per capita shows that the growth of freight intensity is more reduced due to the fact that population growth rate in the US is important.

Passenger transport trends by mode

Figure 16 shows passenger trends by mode. Regarding growth of individual modes, the highest growth rates of passenger transport are observed for aviation and passenger car transport. Passenger car use has increased by 116% from 1970 to 2000, while air transport has grown by 400% in the same period. However, in terms of billion pkm, passenger car is very much higher than air transport; while in terms of growth rate air transport is the fastest growing mode.

Figure 16. **Passenger transport trends by modes in the US, 1970 to 2000**





Source: US Bureau of Transportation Statistics, National Transportation Statistics 2002, Washington, D.C. 2003.

Changes of modal split of passenger transport

Transport by passenger cars overwhelmingly dominates the modal share with some 80% exhibiting little change over the past decade (US BTS, 2004).

The share of air transport in the modal split grew from 5 % in 1970 to 10 % in 2000. In the same period public transport has lost part of its share of the modal split.

Passenger transport intensity by mode

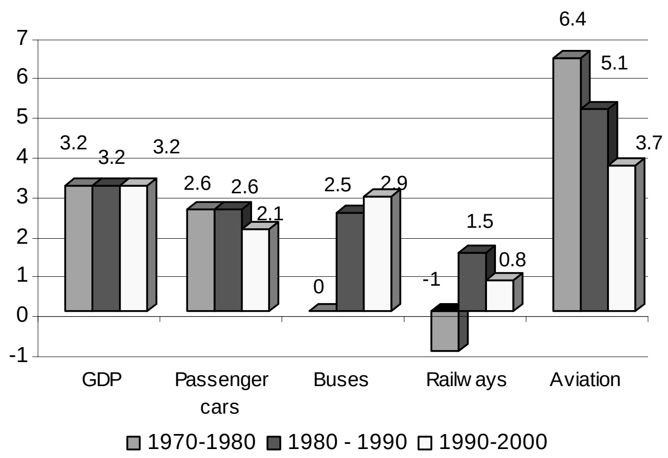
There are two ways of calculating indicators of transport intensity: transport activity per capita or per unit of GDP. To illustrate the correlation between transport volume (tonnes) or performance (tonne km) and economic output, the intensity per unit of GDP is calculated.

In the US, passenger transport intensity has been continuously decreasing over the past thirty years as GDP has grown faster than transport activity. The development of the major modes is the determining factor: passenger cars (in pkm), e.g. in the case of passenger transport.

Passenger transport has experienced important increases during the past decades, mainly due to increases of income levels and overall expansion of the economy. Since 1980, the volume of passenger transport has increased by 80%. The highest growth in passenger transport in the US has been observed for air transport and for passenger cars.

Regarding the growth of individual modes, figure 17 presents data on average annual growth rates of passenger transport in the US for the years 1970, 1980, 1990, 2000. Again, aviation and passenger cars have experienced the highest growth rates with annual growth rates of 3.7% and 2.1% respectively for the past decade. Growth rates of transport by rail and bus have increased below the rates of growth of GDP since the mid-1980s, as these modes have lost market shares

Figure 17. **Average Annual Growth Rates of Passenger Transport in the US**
(% per year in passenger-km)



Source: US BTS, National Transportation Statistics, 2002.

Freight transport of the U.S. - changing context and scope

Over the last four decades, U.S economic growth has influenced the growth of the freight transport services, which in turn, induced economic growth (Lakshmanan and Anderson, 2002). In parallel and during the same period, substantial structural changes towards a service economy which is less material intensive have been observed in the U.S economy. At the same time, however, national transportation networks markets have integrated Southern and Western regions into a nationally distributed production system.

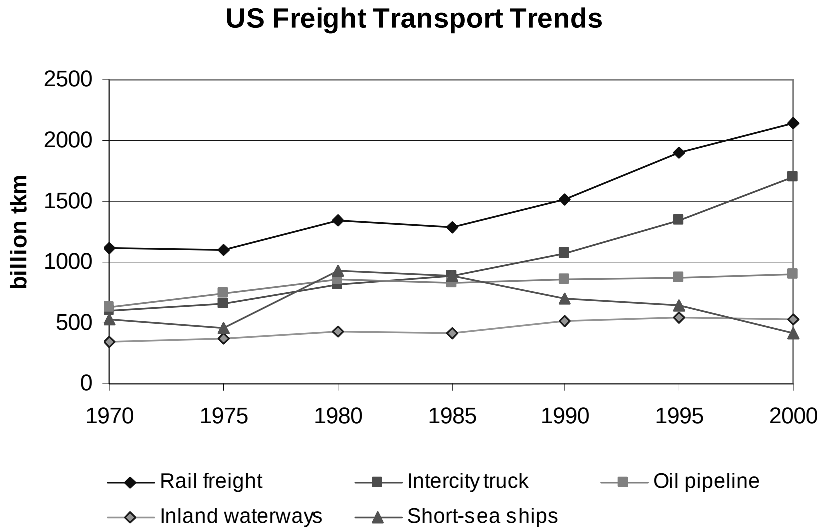
The freight services sector increased sharply during the last two decades led by driving forces such as technical change in transport and information technologies, transport infrastructure investments and the globalisation process. These changes have also induced considerable technical changes which have been made also possible by transport policy reforms, organisational innovations and restructuring of the logistical process of the freight services sector. As a consequence, the quality of the services offered to transport-using economic sectors have improved substantially with the level of innovation: for example, greater speed and reliability of the good transported at lower overall costs, time-definite global delivery of goods, sourcing and distribution functions, flexibility in destinations, etc. (Lakshmanan and Anderson, 2002).

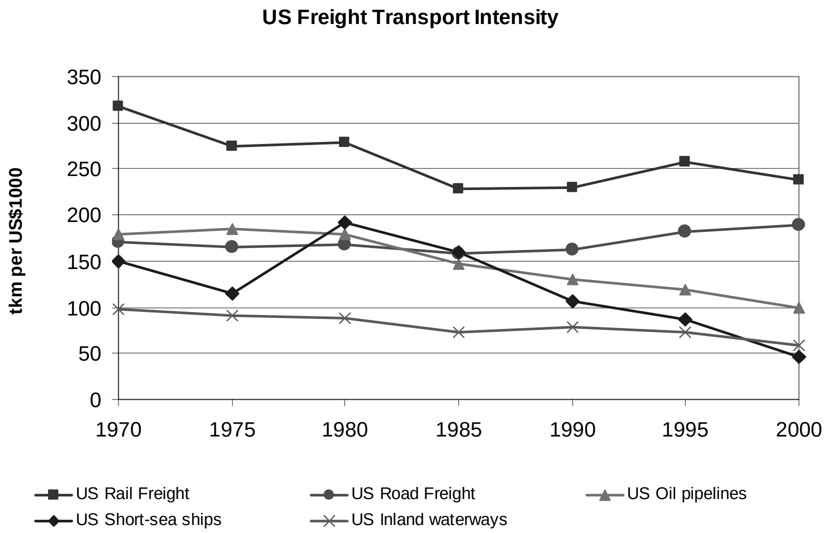
The analysis of the historic trends of the U.S. freight services shows that the volume of freight moved and the distance over which the goods have been moved has continuously increased at lower prices. The total tonnage transported in the U.S. increased from 4.54 billion tons to 6.21 billion tons (+37%) between 1965 and 1998, while ton-miles increased more sharply from 1854 billion ton-miles to 3710 billion ton-miles (+100%). Thus, goods are transported over longer distances, due to ease of travel and speed as a result of highly efficient road and rail systems. These changing trends could be explained by the interaction of multi-structural economic changes including technological and organisational changes in the economy. The spatial integration has increased in a context of an overall American economic growth with a trend toward less material-intensive service sectors, these two trends working in an opposite direction (Lakshmanan and Anderson, 2002).

The second important change of the last twenty years has been induced by technical innovations of the freight services which resulted in greater speed and reliability, time-definite global delivery of goods, flexibility in destinations, etc. These improvements in the quality of the services sectors reduced costs, but also added to the production value of firms.

Figure 18 shows that freight transport trends for the past three decades have been quite different between the various modes. Rail freight is the dominating mode and maintained its position against strongly increasing road transport, while transport by pipeline and inland navigation remained almost stable at lower levels. There has been a strong growth in rail as well as in road freight since 1985 due to the integration of the American markets, while during the 1970's and early 1980s (during the second oil crises) rail and road experienced lower growth rates. A striking feature of freight transport in the US is that rail keeps a high modal share (some 37%), followed by road freight with (28%).

Figure 18. **Freight Transport in the U.S. by Mode**





Source: US BTS, National Transportation Statistics, 2002.

Freight transport intensity

Freight intensity (i.e., in terms of ton-miles per GDP) indicates that the U.S. economy is moving towards a lower intensity of freight use (Table 9). The number of tons per US$1000 GDP has decreased from 1.58 to 0.73 tons (-54%) between 1965 and 1998. Similarly, but to a lesser extent, freight intensity decreased from 0.69 to 0.44 ton-miles per US$1000 GDP (some -30%) during the same period.

Table 9. **Trends in Freight Transport in the U.S. from 1960 to 1998**
(percentage change)

Indicator	1960-1980	1981-1998
Transport volume (tons)	11	23
Performance (ton-miles)	101	24
Tons/capita	-5.5	4
Ton-miles/capita	59	4
Tons/GDP (US$ 1000)	-31	-33
Ton-miles /GDP (US$)	-7	-31

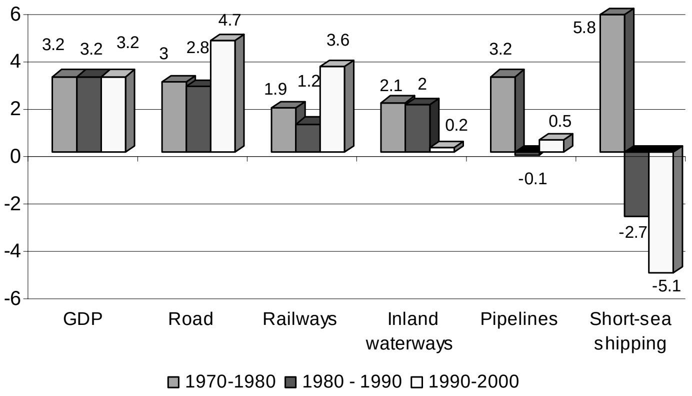
Source: US BTS, National Transportation Statistics, 2002.

The increase in ton-miles of freight moved per capita (1965-80) was remarkable (59%), while tons per capita of freight moved decreased by 5.5%, i.e. the total tonnage of goods remained fairly constant, while goods were transported over longer distances. This comparison reflects also the structure of the U.S. economy where the spatial integration of the national economy covers longer distances.

The analysis of the trend of freight intensity and GDP confirms that the U.S. economy is moving towards less intensive freight movements. However, this declining trend is less marked when distance is included: ton-miles per unit of GDP have decreased only by 36% over the same period, thus, confirming that average length of haul increased. This trend was more prominent for the main freight modes (rail and road) until the 1980’s, when the average length of haul increased most for road and rail freight. Since then, changes for the individual modes were less prominent and for short-sea shipping and air freight the average length of haul even decreased in the 1990s (BTS, 2001).

Regarding the growth of individual modes, figure 19 presents data of average annual changes of transport performance by mode of transport in the US for the years 1970, 1980, 1990 and 2000. For freight transport, road freight and rail freight experienced the highest growth rates with annual growth rates of 4.7% and 3.6% respectively for the past decade. Growth rates of transport by short-sea shipping, inland waterways - and since the mid-1980’s those of oil pipelines - were significantly lower than those of GDP. For passenger transport, rail and bus/coach transport have increased below the rates of growth of GDP since the mid-1980s, as these modes have lost market shares.

Figure 19. **Average Annual Growth Rates in Freight Transport in the US**
(% per year in tonne-km)



Source: US BTS, National Transportation Statistics, 2002.

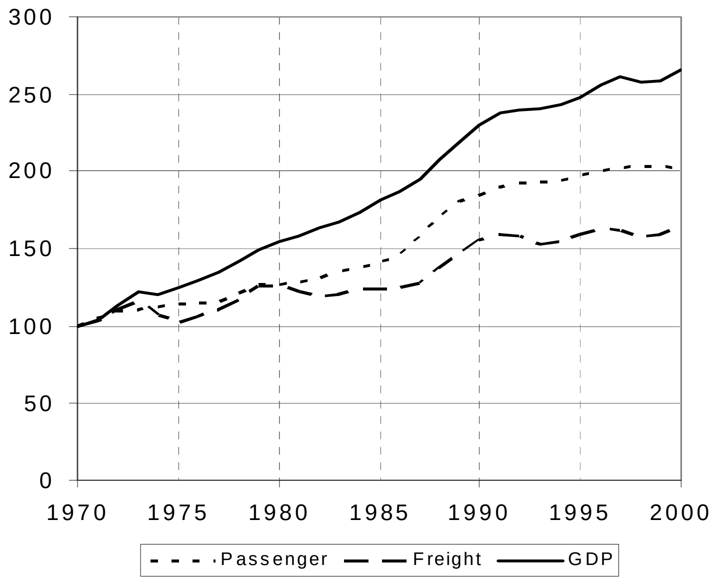
Summary

The changes in the trends of the freight indicators can be explained by various others changes of some driving forces that have impacted directly on the freight service industry. These latter changes have occurred in the area of the economy, with the emergence of new regulatory instruments, technological improvements and policy changes. These elements have enabled the freight services industry to undergo a complete restructuring and, as a consequence, to offer a whole array of new services at lower costs. The analysis of data and trends in the U.S. for the last four decades also points to the role that transport infrastructure investments play in the improvement of the freight industry and its contribution to economic productivity.

E) Trends in Japan

Japan has experienced a relative decoupling of GDP versus passenger and freight transport over the past two decades. Figure 20 shows the past trends of passenger and freight transport and the correlation with growth of GDP (in US dollars in constant 1995 prices). Total passenger transport (passenger-km) includes passenger cars, buses/coaches, rail, tram/metro and domestic aviation. Total freight transport (tonne-km) includes road, rail, and short-sea shipping. Growth of GDP in Japan was fairly constant over the past twenty years, slightly higher in the second half of the 1980s and slowing down in the 1990s, increasing by 15% from 1990 to 2000. Passenger transport increased by some 45 % between 1980 and 1990, and slightly less than GDP, the trend was nearly the same for the following ten years as passenger transport increased by 10%, still slightly less than GDP. Total volume of freight transport in Japan grew slightly slower than passenger and GDP until the early 1990s. Thus, economic output (in terms of GDP) and transport demand both for passenger and freight remained correlated, but less than in the US and Europe.

Figure 20. **Trends of GDP and Transport Activity in Japan, 1970 to 2000**
(in terms of tkm, pkm)



Growth per decade

	1970-1980	1980-1990	1990-2000
GDP (1995 US$ PPP)	54%	49%	15%
Passenger (pkm)	27%	45%	10%
Freight (tkm)	26%	24%	6%

Source: GDP: OECD data, traffic: National transportation statistics handbook, MLIT Japan, 2002.

Regarding changes in the modal share, road and rail transport clearly dominate total increase of passenger transport, while for freight it holds an equal share with short-sea shipping. Thus, the correlation between GDP and transport is mainly due to developments in the dominating modes like road passenger and road freight transport, as well as between short-sea shipping and GDP suggesting that increases in production output resulted in growing transport activity. On the other hand, the share of rail, public transport, and inland waterways continued to decrease, and thus, the statistical correlation of these modes with GDP is quite weak.

Growth of transport in Japan was somewhat slower than growth of GDP. Passenger transport growth was higher than freight transport since the 1980s, primarily due to strong growth in passenger car transport. Freight growth was continuously lower than GDP for the past three decades, except during the late 1980s where it grew stronger, primarily due to a boost from globalisation and strong demand from the rapidly developing Asian economies.

These trends and correlation are influenced by many factors that stimulate or hinder growth, including globalisation of production, liberalisation and integration of markets, the quality of transport infrastructure. In Japan, trade liberalisation and market access are key drivers of the production that is heavily relying on exports, while domestic demand has been relatively constant and population growth as well as immigration is limited.

Table 10. **Average Annual Growth Rates of GDP and Transport in Japan**

	1970 - 1980	1980 - 1990	1990 – 2000
GDP	4.4	4.1	1.4
Passenger transport (pkm)	2.4	3.8	0.9
Freight transport (tkm)	2.3	2.2	0.6
Passenger km per capita	1.3	3.3	0.6
Freight km per capita	1.2	1.6	0.3

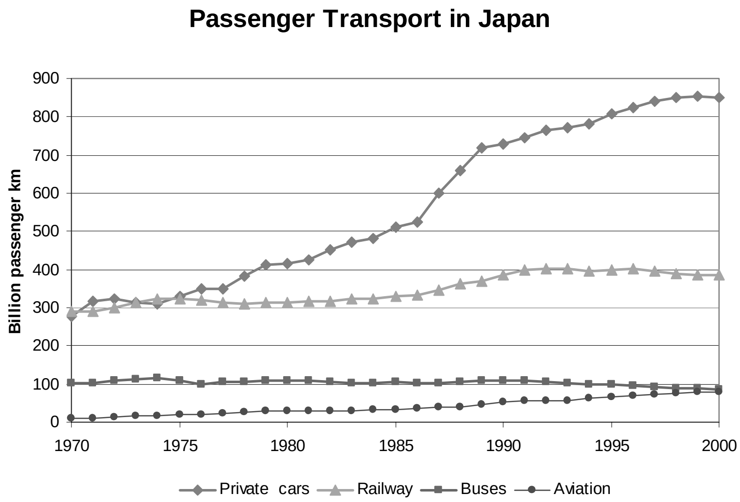
Source: GDP: OECD data, traffic: National transportation statistics handbook, MLIT Japan, 2002.

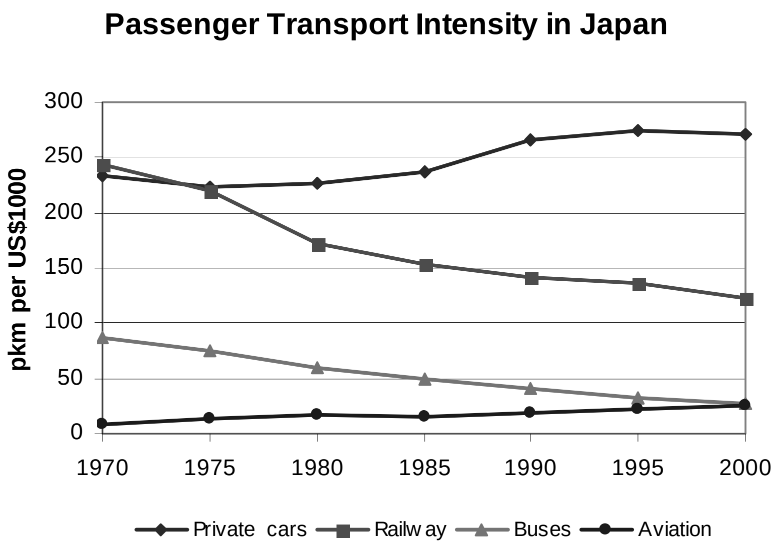
Passenger transport increased during these three decades but less than GDP. In the first decade (1970-1980) the annual average growth was 2.4% increasing to 3.8% in the 1980-1990 decade and finally slowed down its increase (0.9%) in the following decade. During the period of 1980-1990, growth in GDP was proportionately higher than growth in freight transport. For the past decade, the situation remained, with freight transport slowing down considerably. Overall, the correlation between growth of freight transport and GDP is not simple due to underlying factors and structural changes; a variation in growth of production does not necessarily translate into similar variation of transport activity.

Passenger transport trends by mode:

The highest growth rates of passenger transport were observed for aviation and passenger car transport (see Figure 21). Passenger transport by railways has been fairly constant, aside from the late 1980s when it experienced a period of short increase, while bus transport has remained constant over the entire period considered.

Figure 21**. Passenger transport trends by modes, 1970 to 2000**





Source: Compendium of statistics on energy economics, Japan (2002), OECD data.

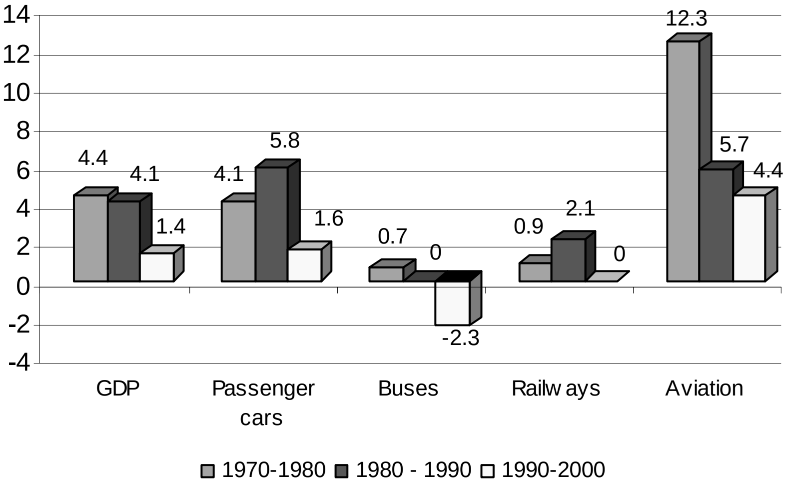
Changes of modal split of passenger transport

The share of air transport in the modal split grew from 1.3% in 1970 to 5.6% in 2000. During the same period public transport (rail, bus and shipping) lost part of its share of the modal split. The share of rail transport fell from 41% in 1970 to 27% in 2000. Transport by passenger car dominates the modal share with some 60% - increasing over the past decade - while rail still keeps a remarkably high share of almost 27%.

To illustrate the correlation between transport activity (expressed in tonne km) and economic output, the intensity per unit of GDP is calculated (see Figure 22). Over the past three decades trends of passenger transport activity per GDP in Japan varied for the different modes. Generally, transport intensity has decreased by 23%; overall, strongly dominated by developments of growth of passenger cars and railways at a rate lower than that of GDP. Thus, transport activity was increasing overall, but intensity decreased due to the fact that GDP growth was higher than domestic transport demand.

This trend towards more individual motorised transport is partly explained by changes in family and household structure since the late 1980s. Thus, increasing individual mobility and the growth of single-person households in society are related. There are an increasing number of single-person households in Japan. Passenger transport has experienced important changes during the past decades, mainly due to the increase in the income level and overall expansion of the economy, but to a much lesser extent than in Europe or the U.S. Figure 23 shows the average change of growth rates of different passenger transport modes in Japan. Since 1980, the volume of passenger transport increased by 80%.

Figure 22. **Average Annual Growth Rates of Passenger Transport in Japan**
(% change per year in passenger-km)

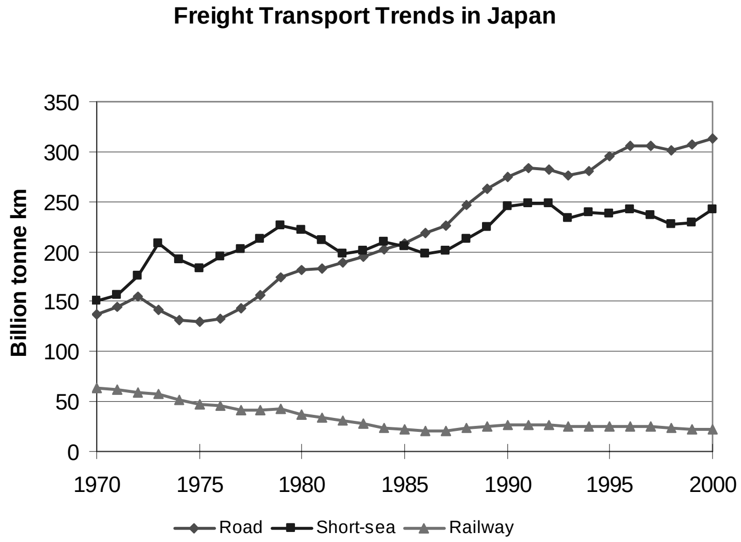


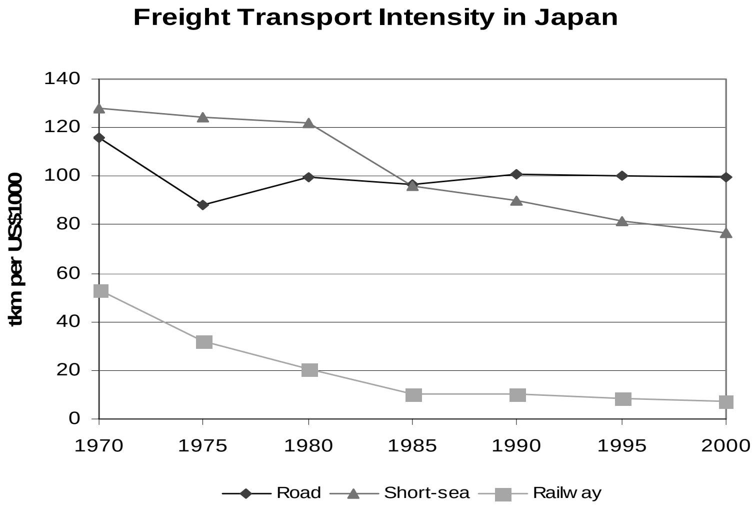
Source: GDP: OECD data, traffic: National transportation statistics handbook, Ministry of Land, Infrastructure and Transport, Japan.

Freight transport trends by mode

Figure 23 shows that the transport of goods in Japan is performed mainly by road (80% in terms of tonnes transported), while the other modes contribute with much smaller shares between 3% (inland waterways) and 7% (railways). However, the picture looks more balanced in terms of tonne-km performed transport: short sea shipping contributes some 41%, while in terms of volume its share is only 6%; the part of the road is 44% and that of railways is still low with some 8% of total tonne-km.

Figure 23. **Freight Transport Trends in Japan for Different Modes.**





Source: Compendium of statistics on energy economics, Japan (2002), OECD data.

During the period analysed, transport performance increased very much for road (128%) and for sea (60%), but declined for rail (-64%). While the amount of goods traveled remained nearly stable, the average distance traveled by road increased considerably.

Changes of modal split of freight transport

The analysis of transport trends for Japan underlines the fact that strong growth of transport activity has not affected all modes of transport to the same extent. The share of road transport in the total of freight transport (in terms of % of total tonne km) increased between 1970 and 2000 from 39% to 54%. During the same period the share of rail in the modal split decreased from 18% to 4% which is the strongest decrease in modal split, while short sea remained stable around 47% since 1985.

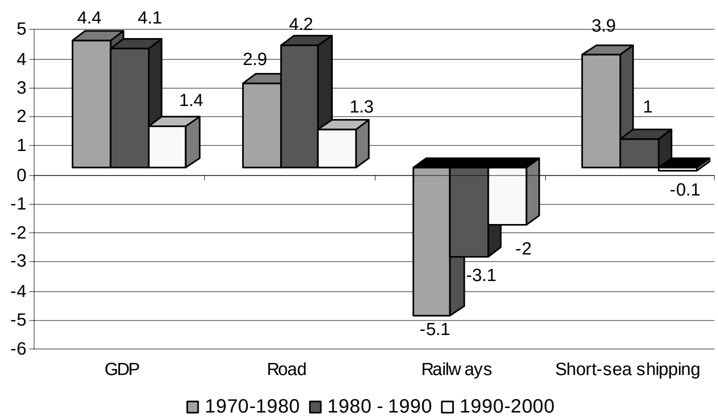
Freight transport intensity

Over the past three decades, freight transport intensity in Japan showed a declining trend in general, thus, economic growth has been faster than transport activity. However, the situation varied for the different modes: growth of activity for road freight was similar to that of GDP since 1980, and therefore, resulted in stabilisation of transport intensity for the past twenty years. Transport intensity of rail and pipeline declined significantly, as these modes lost market shares. Regarding the direction of the overall trends, the development of the major modes (road transport and short-sea shipping in the case of freight transport) is the determining factor.

While road freight intensity increased to the level in the late 1970s where it remained stable, transport intensity of short-sea shipping and rail freight continuously decreased, thus, contributing to an overall decreasing transport intensity. This trend is even more prominent when measuring transport activity in terms of tonnes per GDP (i.e., activity per tonnes) and, confirms the observation of an on-going trend in highly industrialised economies towards more service content and lower material intensity of products, notwithstanding the general trend of more frequent movements and increasing distances travelled.

Figure 24 presents data of the average annual change of transport performance by mode of transport in Japan for the years 1970, 1980, 1990 and 2000. For freight transport, road freight experienced the highest growth rates with annual growth rates of 1.3% for the past decade (see Figure 24). Growth rates of transport by road and rail freight were significantly lower than for GDP. For freight transport, rail and short-sea shipping increased below the rates of growth of GDP since the mid-1980s and rail lost market shares. Over this period the correlation decreased, but in recent years some change has occurred towards higher growth rates for road freight due to the higher demand in the Asian region.

Figure 24. **Average Annual Growth Rates for Freight Transport in Japan**
(% per year in tonne-km)



Source: GDP: OECD data, Traffic: National transportation statistics handbook, Ministry of land, Infrastructure and Transport, Japan.

The correlation between production output and transport activity is established in principle, but growth rates are not directly proportional. This is due to structural changes of the economy in Japan for the period 1980 to 2000 indicating the growing importance of the services sector reaching more than two-thirds GDP having increased its share by 12.3% compared to the other sectors that declined, the primary sector -11.2% or secondary sector -54%, (OECD, 2000*a*). Transport intensity (i.e., the ratio of transport activity and GDP) might have been influenced by this trend. This could have resulted in a slight impact on freight transport activity relative to economic growth. However, the analysis of aggregate transport data did not confirm this hypothesis, mainly due to the fact that goods are increasingly transported over longer distances (increases in tonne-km) without necessarily a corresponding increase in the volume of production.

Summary

The analysis of trends and changes in modal share in Japan over the past decades reveals significant changes in the volume and structure of the economy – both domestically and internationally - that influenced transport demand. The main factors stimulating growth in freight transport in Japan are primarily trade liberalization, globalisation in the Asian region, while at the same time the cost of freight (including fuel prices) remained relatively low or decreased in real terms. This has resulted in increased distances between the point of resource extraction, manufacturing and distribution of goods. Similarly, customer requirements for more tailored and specialised goods as well as changes in consumer preferences led to additional, more frequent movements and longer distances traveled of goods, and thus, overall more transport activity without necessarily a higher volume of goods produced.

F) Summary and Conclusions

Trends in the three areas examined are quite different, similar in Europe and the US, but different for Japan both for passenger and freight. In all the three regions passenger cars and road freight are the dominating modes apart rail freight transport for the US which is the dominating mode, while passenger rail in Japan still keeps a high share, and short-sea shipping in the EU, Japan and the US. Growth of aviation in the three regions is very strong.

In terms of intensities, (activity per GDP or per capita) there are noticeable differences: transport intensity on a per GDP basis has been declining in the US and Japan both for passenger and freight, while in Europe it has been slightly increasing for passenger transport or remained fairly constant in the case of freight. Basically, the level of transport intensity for passenger transport in the US is about 20 per cent higher than in the EU and more than 50% than in Japan.

Intensities on a per capita basis have been increasing for both passenger and freight in all countries examined, except for freight transport in Japan where it remained almost constant. In the EU it has more than doubled over the past thirty years, and in the US almost doubled, but from a much higher level. However, the rate of increase in these intensities has been falling in both the EU and US (except for freight in the EU).

The analysis of the transport trends in the different regions revealed the main economic driving factors behind these trends; these include:

1) The supply of infrastructure that boosted transport, in particular the expansion of the highway system the main investments taking place during the past thirty years. This has facilitated movements, by increasing speed, easiness of access, market integration with longer distances traveled, while overall transport costs were decreasing.

2) The lack of attractive alternatives to individual motorized transport explains the difference between the US and Europe as well as the US and Japan trends, the latter having much higher public transport performance than the US or Europe and thus a lower average level of motorization. Other constraints in terms of disposable income, available parking space and tax structures also influence the modal choice by individuals and businesses.

3) Liberalization of road freight over and above the liberalization of rail freight together with increased market integration lead to a strong boost of road transport (rail freight market liberalization in the US together with improving cost structure and efficiency also stimulated considerable growth for this mode).

4) Decreasing real fuel prices that favored road transport, while relative prices of vehicles also declined compared to increases of GDP per capita.

5) While, GDP per capita and disposable income increased, the relative share of household expenditures for transport remained constant in the OECD (Europe: 13%, US: 13-14% of the past three decades). Thus, overall purchasing power for transport increased, being even higher in the US than in Europe and Japan.

A general conclusion is that both indicators for freight (volumes/weight moved per GDP and tonne-km per GDP) need to be considered, as each gives different information on the development and performance of the sector. Measure of transport intensities must be interpreted with caution, as rising or falling transport intensities do not necessarily mean more or less transport activity. Only when compared with total transport performance indicators conclusions, can be drawn regarding rising or falling total activity and thus related total impacts.

Given the fact that road passenger and road freight are the overwhelmingly dominating modes and as their environmental impacts and generation of externalities are highest, some environmental and health impacts are still increasing (mainly CO2 emission, accidents, noise, land take, congestion and resource use). Thus, decoupling is very much related to the high growth modes where the impacts due to increased activity outpace the level of improvement made per vehicle-km.

The analysis of transport trend data in relation to GDP trends has been based on available statistics at an aggregate level. It confirms the historic strong correlation between increasing transport activity of passenger and freight and GDP growth. However, the US and Japan have experienced a relative decoupling of GDP versus passenger and freight transport over the past two decades. The analysis of the modal split shows further that the strong correlation is due to road passenger and road freight and maritime freight, respectively, as dominating modes. The correlation with the other modes is therefore weak and diminished in recent years. Data suggest that with an expanding economy, transport demand increased in parallel, as also technology improvement and infrastructure, especially road has been expanded. Economic growth and increased production generated more transport activity, while the supply and expansion of transport infrastructure may have led also to additional economic growth.

4. ANALYSIS OF NATIONAL ACCOUNTS AND TRANSPORT DEMAND

A) Measuring Transport Input to GDP - The US Transportation Satellite Accounts

An important issue of measuring the link between transport and economy is to find a measure of the importance of transport in the economy which can be used easily both by economic actors and the public. The economic importance of transport should reflect how many economic resources are devoted to supporting nation's transport needs. It is generally admitted that transport's importance in the economy should be measured by its share in GDP.

However, numerous analyses have been made on the exact role and importance of transport in the economy because various different concepts of transport are used in the economic literature. For example, transport could be assimilated strictly to those activities directly involved in transporting people and freight from one place to another. In some literature, transport is assimilated with transport industries. Other models take transport as a social function that includes all economic activities that support people's transport needs, directly or indirectly. Accordingly, the importance of transport in the economy must be measured from these different perspectives.

The National Income and Product Accounts that include satellite accounts are very few, because these are relatively new concepts. Transport satellite accounts measure transport expenditures by the sectors of the economy. The purpose of satellite accounts is to organise the national accounts framework in rigorously controlled structures, in order to better understand and analyse special aspects of the economy that may not appear in the traditional notion of industries (Han, 2000). Satellite accounts are considered an effective tool in such crosscutting areas as information, environment, energy, tourism and of course, transportation. Data on transport expenditures have been compiled for the U.S. in the Transportation Satellite Accounts produced by the U.S. Bureau of Transportation Statistics (BTS) for 1992 and 1996.

In various countries, national accounts under estimate in general the share of transportation production costs of every industry. Therefore, productivity studies based on these statistics are not accurate since the contribution of transportation infrastructure investment to the productivity growth of the economy is not well taken into account. A fully developed satellite account for the transport sector would show the range and the importance of transport services for production of goods and services in the economy. It takes into account the own-transport services, which are produced inside the firms and included but not identified separately in the official accounts.

This new accounting framework includes the portion of economic activity traditionally recognised as transportation, e.g., the services of for-hire transportation firms such as railroads, airlines and trucking firms, and, in addition, measures those transportation activities operated in-house within firms in the agriculture, mining, manufacturing, retailing and service sectors; i.e., more generally, operating private trucks by firms to move their own raw materials, products and employees.

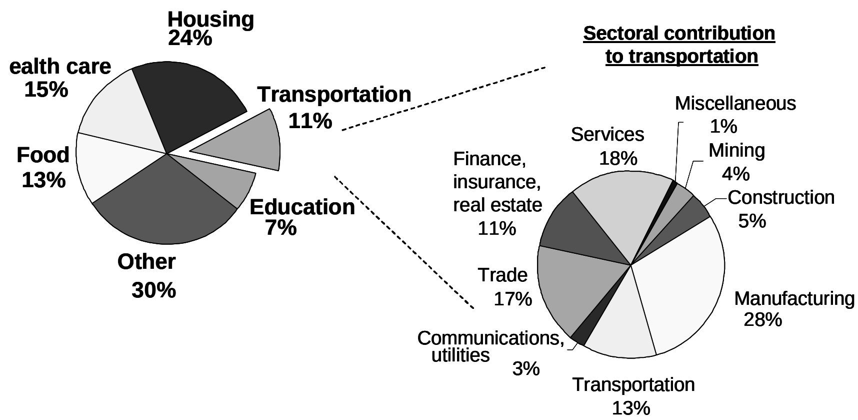
B) Transportation Satellite Accounts in the U.S.

Measuring the importance of transportation in the US economy is a good example for understanding the link between transport and economy, since transportation has a very important role in the US economy. This implies knowing the level of transportation-related production and consumption of goods and services, household spending, wages and salaries, and government revenues and expenditures.

Transportation Satellite Accounts also allow to calculate the contribution of transportation services to GDP provided by non-transportation industries (in-house transportation). In-house transportation services consist primarily in private trucking fleets, which have followed the sharp expansion of the importance of the highway/trucking system of the U.S economy. According to the BTS report (1999), in-house transportation services contributed $121 billions to GDP in 1992 (see Table 11). For-hire and in-house transportation industries contributed $313 billions to GDP in 1992, i.e., about 5 per cent of U.S. GDP. The contribution of transportation to GDP is larger than that of the agriculture, mining, or computer industries and comparable to that of the wholesale/retail trade and health industries.

In 1997, transportation-related goods and services contributed $905 billion, or about 11 per cent, to U.S. GDP. This is the broadest measure of transportation’s contribution to GDP. Transportation continued to rank fourth, after housing, health care, and food, in terms of societal demand for goods and services (Figure 25). Between 1992 and 1997, transportation's final demand grew faster than the overall GDP. Its share of GDP in the U.S. increased to 11.2 per cent. This means that the importance of transportation final demand increased as a driving force in the economy.

Figure 25. **Major Sectoral Contributions to Gross Domestic Product in U.S. (1997)**



Source: Lakshmanan and Anderson, 2002.

In-house transportations of firms can be seen as a significant industry since in 1992 the value-added by in-house transportation was larger than that of education ($119.8 billion), computers ($8.9 billion), agriculture ($86.3 billion), and mining ($74.7 billion) industries.

Table 11. **Transportation Services Contribution to GDP in U.S. in 1992**

Part of transport	Value added (Billion US$)	% GDP
for-hire service	191.6	3.1
Own-service	121.5	1.9
Total	313.1	5

Source: American Association of State Highway and Transportation Officials,1998.

Table 12 summarises industry uses of transportation services. The manufacturing sector is the highest user of for-hire services with $80 billions of dollars; this corresponds to 53% of the total gross output by industry. In the second position, but with a much lower amount, the share of use of for-hire services finance accounts for $21 billions, corresponding to 14.1% of total gross industry output. Concerning the use of own-account services which is slightly higher than the use of for-hire services in terms of total use of services, the share of wholesale and retail and services are the highest accounting for nearly 25.9% and 25.5% of total gross output.

Table 12. **Industry Uses of Own-Account and For-Hire Transportation Services**

Sector	Use of for-hire transport services (US$ billion)	Use of own-account transport services (US$ billion)	Total use of Transport services (US$ billion)	Sector share of total services used
Agriculture	5.720	13.177	18.897	6%
Mining	2.810	3.870	6.680	2%
Construction	13.286	38.950	52.236	17%
Manufacturing	80.248	21.806	102.054	32%
Communications/Utilities	8.803	1.187	9.990	3%
Wholesale/Retail	8.963	42.817	51.782	16%
Services	10.523	42.035	52.558	17%
Finance/Insurance	21.482	0.899	22.381	7%
Total Gross Output	151.835	164.743	316.578	

Source: American Association of State Highway and Transportation Officials, 1998.

In terms of employment, the for-hire transportation industry’s share of total employment changed little from 1990 to 1997, hovering around 3 percent of the total U.S. civilian labour force. The largest portion of for-hire transportation industry employment in 1997 was in the trucking and warehousing group (41 percent), but the group’s annual growth rate was not as large as that of other modes such as transit.

Also, trucking and warehousing had the largest share of the for-hire transportation industry’s total wages and salaries in 1997, but the air transportation industry’s share increased more sharply. Similarly, truck drivers accounted for the largest percentage of transportation jobs in 1997 (67.8%), which was a slightly lower share than throughout the 1980s and 1990s. Jobs in aviation experienced the fastest growth (12.4% gains) in 1997. Based on limited data on transportation occupational wages and salaries, airline pilots and navigators were paid the most in 1997 (although earnings declined from the past year), while bus and taxi drivers were paid the least.

Labour productivity (i.e., the ratio between ton-miles or passenger-miles to the number of employees or employee-hours) varied by transportation modes. In the railroad industry, labour productivity (measured by an index of passenger-miles, freight ton-miles, revenue, and other factors) increased between 1990 and 1996 by a total of 44.5%, which was faster than the petroleum pipeline industry (36.1%), the air transportation industry (both passenger and freight 19.5%), and the trucking industry (17.7%).

Highway transportation generated $66.74 billion (current dollars) or 71% of the total of transportation in 1995. Fuels taxes are an important source of highway revenue, accounting for 85.8% of the Highway Trust Fund and 60% of state highway revenues in 1995. All levels of government spent a total of $129.3 billion on all modes of transportation in 1995. State and local governments spent about 69% of total government transportation expenditures.

As in past years, more government funds were spent on highways than on all other transportation modes combined. In 1995, highway spending was $79.2 billion, about 61% of total government transport expenditures, while transit received about 20%. State and local governments continued to spend most on highways, transit, and pipelines, while the federal government spent more on air, water, and rail. In 1999, transportation infrastructure capital stock in highways and streets was worth $1.3 trillion, nearly all owned by state and local governments.

Table 13 shows that the value of freight moved in 1993 and 1997 grew more than three times as fast as GDP in this period. The value of freight moved per dollar of GDP increased by 6.6% between 1993 and 1997, i.e., more than twice the rate of GDP growth. This suggests that high value-added sectors are increasingly contributing to freight movements and economic growth.

Table 13. **Value of Goods Moved in 1993 and 1997 in the US**

Indicator	1993	1997	Increase
GDP (billion US$ in 1992 prices)	7054	7270	3%
Freight (value)	6335	6944	9.6%
Freight intensity (value / GDP)	0.90	0.96	6.6%
Freight (in tkm)	4375	5138	17.3%
Freight intensity (in tkm/capita)	16965	19168	13%

Source: BTS Commodity Flow Survey, 1993-1997,

The value of freight and its contribution to GDP in the United States

The usual indicators of the value of the freight sector using tons and tons-miles are not by themselves appropriate to reveal its real value to the U.S. economy, since its major characterization is the predominance of the knowledge intensive sectors and this could not be taken into account. For this reason the Commodity Flow Survey has been conducted by the US Department of Transportation Bureau of Transportation Statistics (BTS) in 1993 and 1997 to provide data of freight and value added.

Table 14 presents the transport ranking of commodities by value of the freight transported and ton-miles. The most important five sectors in terms of value are commodities with high value added such as electronics and electrical equipment, motorized vehicles, machinery and textile and leather products. These types of commodities have generally a lower demand of transport in terms of ton-miles (in this survey less than 7%), while they represent more than 38% of the total value transported. On the other hand, products that have a high demand of transports in terms of ton-miles are low value raw materials such as fossil fuels (coal, liquid fuels), basic chemicals, cereals and food products, etc. representing more than 42% of total ton-miles. The usual statistics do not measure the value of the goods transported and thus, cannot reveal the changing trends. There has been a general trend for the last twenty years which showed that a general increase in the high value adding sectors will have a direct impact on the freight services.

Table 14. **Transport Ranking of Top Five Freight Sectors by Value per Ton and Ton-miles For the Year 1993 and 1997 in the U.S.**

Top 5 Sectors by Value/Ton				**Top 5 Sectors by Ton-Miles**			
1993		**1997**		**1993**		**1997**	
Sector	Value/ Ton	Sector	Value/ Ton	Sector	Value/ Ton	Sector	Value/ Ton
Electronic, Electrical and Office Equipment	$19,915	**Electronic, Electrical and Office Equipment**	$21,955	**Coal**	$21	**Coal**	$22
Motorized and Other Vehicles	$6,216	**Motorized and Other Vehicles**	$5,822	**Cereal, Grains**	$122	**Cereal, Grains**	$110
Miscellaneous Manufacturers	$9,727	**Textiles, Leather, etc.**	$11,591	**Basic Chemicals**	$539	**Other Prepared Foods, Fats & Oils**	$1,008
Machinery	$8,356	**Machinery**	$9,926	**Gasoline & Aviation Fuel**	$225	**Coal & Petroleum Products, n.e.c.**	$158
Textiles, Leather, Etc.	$8,266	**Other Prepared Foods, Fats, & Oils**	$1,008	**Other Prepared Foods, Fats & Oils**	$873	**Basic Chemicals**	$446
Total Value of the top 5 Sectors (%)	37.6		38.3		10.4		10.6
Total ton-miles	6.1		6.5		42.8		42.7

Source: BTS Commodity Flow Survey Data 1993, 1997.

Table 15 shows that the value of transportation used by each sector to produce a dollar of output declined slightly between 1992 and 1996; on average it amounts to about 3% for the sectors considered.

Table 15. **Transport inputs and industry sector outputs in U.S. (Billion dollars at producers' prices)**

	Agriculture, forestry, and fisheries	Mining	Construction	Manufacturing	Communications and utilities	Wholesale and retail trade	Finance, insurance, and real estate	Services	Other	Total
Industry output 1992	237.7	156.7	679.3	2951.3	520.7	1091.5	1654.7	2227.6	914.4	10433.9
Industry output 1996 (% of total)	290.3 2.2%	173.3 1.3%	867.7 6.5%	3666 27.6%	660.7 5.0%	1453.5 10.9%	2148.2 16.1%	2961.6 22.3%	1085.1 8.1%	13306.4 100%
Change (%)	22%	11%	28%	24%	27%	33%	30%	33%	19%	28%
Transport input 1996 (% of total)	22.2 5.7%	6.5 1.7%	64.5 16.5%	116.6 29.7%	11.9 3.0%	67.7 17.3%	13.4 3.4%	80.7 20.6%	8.6 2.2%	392.1 100%
Transport input (%) to total industry output 1992	8.0	4.3	7.7	3.5	1.9	4.7	0.7	2.9	0.6	3.1
Transport input (%) to total industry output 1996	7.6	3.8	7.4	3.2	1.8	4.7	0.6	2.7	0.8	2.9

Sources: Bureau of Transportation Statistics 1999, Han et all. From Gilbert 2001 *b*.

Agriculture, forestry, and fisheries followed by the construction sector have the highest relative shares of transportation compared to their output, although in absolute terms manufacturing and services have the largest contributions. This shows that the sectors that contribute most to GDP (i.e., manufacturing and services) have a relatively small share in transport services (some 3%); in absolute terms, however, they contribute more than 50%, followed by wholesale and construction adding together another 33% of transport activity.

Summary

In addition to national accounts, transport satellite accounts (TSA) that measure transport expenditures by the sector provide more detailed estimates of all transportation services by industries, and thus, give a more complete, picture of a sector's transportation intensity. TSA could also provide a basis for evaluating transportation investment needs and estimating the contribution of transportation infrastructure investments to productivity growth. The problem is that the analysis of data from transportation satellite accounts showed a detailed, but complex picture of the links between sector-specific economic output and transport use (input to the sector). There is no simple answer to whether a certain amount of output change would result in a corresponding change in transport input or vice-versa. Generally, the magnitude will depend on the sector considered, its economic importance and performance and the overall structure of the economy and its stage of development. One important finding is that sectors with a larger contribution to GDP in terms of value have a relatively smaller transport demand (e.g. manufactured goods) and the sectors with a lower contribution to GDP have a large transport demands (e.g. agriculture). One indirect driver of decoupling could be dematerialisation of the economy

since decreasing the material intensity of a product could help to decrease the demand of transport. This will be examined carefully in the second part of the project since more detailed analyses and comparisons among countries will be needed to help to better understand the link between transport and economy and the key factors influencing it.

C) Sectoral Demand for Freight Transport in Europe – the REDEFINE Project

In most OECD countries, a close correlation between road freight demand and economic growth has been noted in many studies for much of the past thirty years. The majority of road freight traffic forecasts have been based on the assumption that these variables will remain closely correlated for the foreseeable future. However, in some European countries and the United States, it appears that these trends have begun to diverge. Detailed analyses have been carried out for the freight services sector in the United States providing empirical evidence for the changes of the sector due to changes in infrastructure (physical, non-physical), technology, production and consumption as well as the institutional regulatory frameworks. However, national transport statistics can only provide a broad overview of the historic developments of road freight demand for a broad set of commodity-flows, but do not allow to individually attributing these developments to a particular underlying economic, logistical, or other factor.

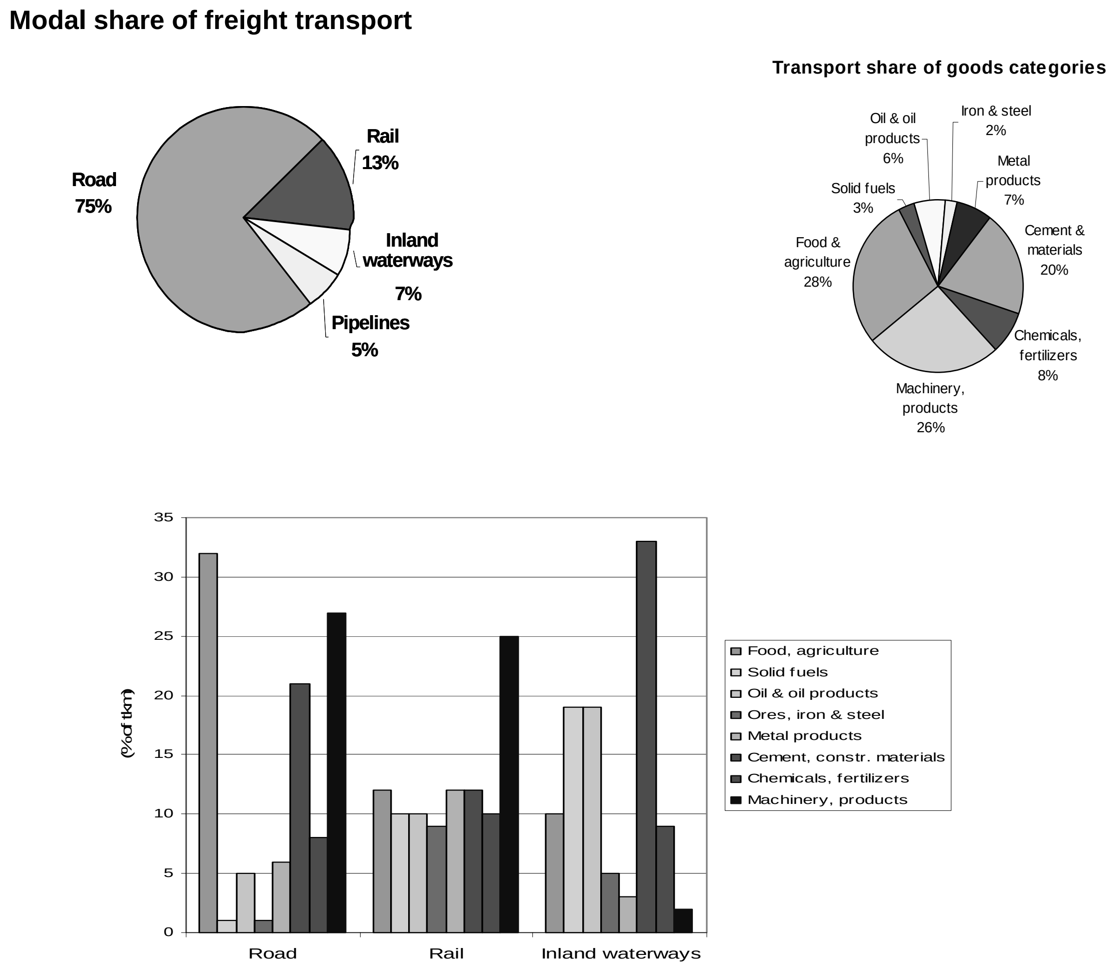
A similar, detailed analysis has not been performed in a European-wide context. Also the key economic factors that determine growth of road freight traffic demand have been studied only recently in a European-wide context. Therefore, the following sections focus on the European situation.

The pattern of freight transport varies strongly among different modes when considering individual goods categories. This data analysis includes only intra-European transport and excludes imported and exported goods transported by short-sea shipping, by large the dominating mode in terms of tonnes moved (see Figure 27). Cement and building materials is the largest category contributing 45% of all tonnes nationally transported. While the part of rail has been increasing for this category over the last decade, road transport assumed a large share of 45%. The most important category in international transport is machinery and manufactured goods that contributed 26% of all goods and has experienced strong growth over the past decade in Europe; again road transport contributes a significant share with 17% of the total volume (TERM, 2001).

The modal share is different, if total freight transport performance (in terms of tonne kilometres) is considered (Figure 26). Agricultural products and food are the categories of goods with the highest share of 28%, mainly transported by road (almost one third of the goods transported by road). The second most important category is machinery and manufactured articles, contributing 26% to the total amount; road holds highest share (more than a quarter of its total performance, while for rail it is the largest category). Cement and building materials contribute to some 20% of the total performance, again with a high share of road. Of all transport performed by inland waterways, 34% contributes for building materials, while for road transport this category represents some 21% of total tonne kilometres transported. For machinery and manufactured articles two modes contribute largely to the total amount of freight movements – road freight with 27% and rail freight with 24% of all their respective movements. Considerable amounts of both solid and liquid fuels are transported by inland waterways, equally shared and adding up to 38% of all goods transported by inland waterways.

The comparison of total freight activity in terms of tonnes and tonne-kilometres provides some interesting insights: e.g. for road freight the share in the category of cement and building materials is about 21% in terms of tonne-km, while in terms of tonnes its contribution was 45%, thus, suggesting that these goods are transported over shorter distances. For other categories like agricultural products and food, machinery and manufactured articles transported in containers, the analysis suggests that these goods are transported over longer distances, as their respective shares in tonne-km are higher than in tonnes.

Figure 26. **Modal Share of Types of Goods Transported in the EU-15 in the mid-1990s**
(excluding short-sea shipping)



Source: EU Transport Statistics, 2002.

The analysis of trends and changes in modal share in the EU over the past decades reveals significant changes in the volume and structure of economic activity that influence transport demand. The main factors stimulating growth in freight transport in the EU are primarily the integration of the European markets, the liberalisation of the transport market (for road but not yet for rail transport) and globalisation, while at the same time the cost of freight (including fuel prices) remained relatively low (TERM, 2001). These conditions facilitated the development of complex trading networks taking advantage of the removal of cross-border barriers and different labour costs among regions. This has resulted in increased distances between resource extraction, manufacturing and distribution of goods; in fact, the category of machinery and manufactured articles has experienced the strongest growth in total tonnes transported. Similarly, customer requirements for more tailored and specialised goods as well as changes in consumer preferences led to additional, more frequent movements and longer distances traveled of goods, and thus, overall more transport activity without necessarily a higher volume of goods produced.

As has been shown above, road transport has increased tremendously over the past decades in Europe, while the share of modal split of rail and inland waterways has declined substantially. This could be explained by the fact that the structure of industry and type of goods produced in the various sectors has changed, since mass commodities, suitable for rail and inland waterway transport, have become less important (Baum and Kurte, 2000). In Germany, the amount of coal transported declined from 135 million tonnes in 1960 to 102 million tonnes in 1990, and the amount of fertilisers from 19 million tonnes in 1960 to 17 million tonnes in 1990. These groups of goods are commodities that generate a large amount of rail and inland waterway traffic. With the decline in the volume of such goods transported, their share in the modal split is also reduced, while food, machinery and container goods have considerably increased their part. Their volume increased by more than 50 per cent between 1970 to 1990, while primary materials, stone, sands, minerals and solid fuels (coal, wood) declined (Pastowski, 1997). Another explanation is that some new production concepts, which are, generalised nowadays, as for instance the just-in-time procurement in industry and trade is highly demanding in terms of flexibility and speed. Compared to road traffic, rail and waterway traffic are much slower and require multi-modal solutions, and therefore, are less used.

In the late 1990's the European Commission launched a project on the Relationship between Freight-transport and Industrial Effects (the REDEFINE project), to examine the link between transport and economy using economic, trade and freight transport data of five countries: France, Germany, the Netherlands, Sweden and the United Kingdom. Research has been carried out both at the macro and micro-economic levels in order to understand how the negative impacts of transport can be minimised through the adoption of new policy initiatives to rationalise demand. The objectives of the REDEFINE project were to: 1) model the factors affecting the demand for road freight and relationship between these factors and changes in industrial and logistic structures; 2) develop strategies to manage and improve road freight transport and logistics in order to reduce the negative externalities caused by transport; and 3) forecast the effectiveness of alternative policies.

The project took a demand-side position as representative of the link between production and transportation. This means that the production of one variable generated a demand for that variable. Data of the model were aggregated into 14 groups representing important areas of economic activity: agricultural products; beverages and food; wood and paper; building materials; textiles and clothes; other crude minerals; chemicals and fertilisers; petrol and petroleum products; coal and coke; metals; machinery; transport equipment; other manufactured articles; and miscellaneous articles.

These data showed that the sectors with the highest relative growth of transport demand were express parcel services, transport of waste, building materials, manufactured products and agricultural products. A surprising fact is that for the pulp and paper case study, and food and drink products, the growth in tonne-km was much lower than the total production increase, thus, suggesting major organisational adjustments to improve productivity.

The study examined the relationship between the value of goods produced and road freight traffic demand and calculated as a series of key ratios (Table 16). Seven factors were identified that affected the relationship between output of goods and vehicle-kilometres of freight traffic: a) value density (weight of production and import); b) modal split that is affected by price and reliability factors; c) handling factor or the number of links in a supply chain; d) average length of haul; e) vehicle carrying capacity; f) load factor; g) empty running or efficiency of fleet management. If each of these ratios remained stable, as well as relative prices, road freight traffic would be perfectly correlated with changes in the value of goods produced (at constant prices). It was assumed that by estimating changes in each of the key ratios over time, it should be possible to determine how much of the growth of lorry traffic was a function of economic growth and how much would be attributable to changes in logistics.

Table 16 summarises the determinants of change in road freight traffic for the period 1985-1995 in terms of vehicle kilometres travelled broken down into the seven key ratios. It shows that the overall growth in tonne-kilometres is of similar order of magnitude in these five countries, but the reasons of that growth are very different for each case.

Table 16. **Main driving factors of road freight transport in Europe: 1985-1995**
(percentage of increase of total tkm)

	U.K.	France	Germany	Sweden	Netherlands
Value of production and imports	-4	28	14	82	17
Value density	-32	23	-2	51	-3
Weight of production and imports	-7	4	16	21	21
Modal split	1	10	20	11	0
Weight transported by road	1	14	33	34	21
Handling factor	18	2	-2	-20	3
Road tonnes-lifted	18	16	31	8	25
Average length of haul	24	36	4	37	29
Tonne-km	46	57	33	48	60
Vehicle carrying capacity	9	15	N.A	28	24
Load factor	-4	7	N.A	-4	-3
Average payload	4	23	N.A	22	20
Empty running	-5	-21	N.A	-7	-7
Vehicle-km	37	28	N.A	18	30

Source: EU REDEFINE project summary report, 1999; italics are ratios, others are aggregates.

The results for these countries indicate that an increase in the average length of haul is the most important contributor to increased road freight demand. This has resulted in a 50% increase in road tonne-kilometres, at least double the growth in the weight of goods produced or imported. In some countries, this has been accompanied by a significant rise in the share of road traffic. Although in all countries except Germany, an increase in the average length of haul was the single most important determinant of the increase in traffic, the secondary factors differed. In the UK, there was an 18% increase in the handling factor. In the Netherlands, there was a large increase in the total volume of goods handled, but increases in vehicle carrying capacity and reduced empty running improved the impact on total traffic. In France, Germany and Sweden, there was a substantial increase in the modal share of road. In Germany, the main factor was the substantial increase in road's modal share, as well as an increase in average length of haul, but here the handling factor (average number of links in the supply chain) fell substantially.

A number of logistics trends were examined that summarise the links between the changes in the organisation of logistics and the supply chain: a) restructuring of logistical systems: e.g. spatial concentration of production or inventories; b) realignment of supply chains: e.g. vertical disintegration of production, changing patterns of sourcing, and changing markets; c) rescheduling of product flow, like the use of just-in-time, quick response and timed delivery systems; and d) management of transport resources: e.g. reducing road transport’s relative costs, changes in vehicle size, increasing efficiency of vehicle utilisation, handling systems, etc. These four main headings have been identified as the significant drivers behind these key ratios:

- Restructuring of logistic systems: spatial concentration/specialisation of plants and inventory has led to increasing the carrying capacity of vehicles (i.e., larger vehicles), but reductions of the average length of haul, while development of transhipment systems and centralising sorting operations increased the average length of road haulage, but improved the handling factor.

- Realignment of supply chains: vertical disintegration of production and concentration of supplier sourcing could have increased the average length of haul, but improved handling. Wider geographic sourcing of supplies and distribution of finished products, as well as increases in retailer's control over supply chains and concentration of international trade on hub ports had a positive impact on the average length of haul, vehicle carrying capacity and handling.

- Rescheduling of product flows: application of just-in-time, quick response in retail distribution, growth in daily deliveries and proliferation of booking-in or timed-delivery systems had reduced vehicle carrying capacity (smaller vehicles) and load factors, while eventually increased empty running.

- Changes in the management of transport resources: reducing road's relative costs, increasing outside transport contractors, changes in vehicle size regulations and handling systems, computerised routing and scheduling and return loading affected positively vehicle carrying capacity, improved load factors and avoided empty running.

The first two of these four main factors were the main drivers behind changes in handling and average lengths of haul. Changes in the latter two are the main factors affecting the carrying capacity and load factors of vehicles (i.e. the weight and size of vehicles). The use of full and heavier vehicles has attenuated the trend and consequently, led to an increase of 20% of the weight of the average payloads. This, together with a reduction of approximately 10% of empty running has limited the overall increase in vehicle kilometres. Additional demand, however, is still greater than the 20% increase that changes in the weight of goods produced or imported would account for.

The project also examined supply chains of a number of sectors and commodity groups in five European countries through a series of case studies. The sectors selected were subject to three selection criteria: substantial production quantity, high growth rates and strong logistic trends. Transport trends between 1985 and 1995 were examined in the following sectors that contributed 80% of total vehicle kilometres travelled: Agricultural products: potatoes (France), building materials: concrete and ceramic products (Netherlands), transport equipment: car seats, exhaust equipment, supply parts (Germany), and express parcel services (Netherlands); food and drink products: beer and diary products (France), wood and paper: newspaper, craft liner, fine paper (Sweden, and generation of household waste (UK). The first group of four sectors experienced higher growth in vehicle kilometres driven than growth of production, while for the latter group growth of production was higher than that of transport demand. The highest growth of vehicle driven was noted for transporting building materials, household waste and express parcels.

For the period 1985-1995 the analysis of the case studies showed changes of the main logistic trends in the sectors examined. The results are summarised in Table 17.

Table 17. **Major logistics trends from sector case studies in five EU countries**

Key logistics trend and driver	**Agriculture** France	**Food & Drink** France	**Wood & paper** Sweden	**Building materia** Netherlands	**Transport equipn** Germany	**Mischellaneous** UK, Netherlands
Restructuring logistics	+	+++	++	++++	+	+++
Realignement of supply chains	++	+++	++	+	++	++
Rescheduling of product flow	+	++	+	+	+	
Management of transport resources	+++	+++++	++++	+	+	+++
Product design, and complexity		+	+	+	+	+

Note: '+' indicates a significant driver or determining factor in the sector
Source: EU REDEFINE project, 2000.

The conclusions drawn from the case studies were as follows. The use of outside transport services, changes in vehicle size, handling systems, computerised vehicle routing and scheduling, and an overall increase in return loading were identified as the main factor influencing transport demand. The second strongest factor was restructuring logistics including spatial concentration of production and inventory (i.e. reduction in numbers and specialisation) and realignment of supply chains with the main influencing factor being vertical disintegration of production and wider distribution of finished products. Of less importance for influencing transport demand were product design and complexity, and rescheduling product flows, except for just-in-time practices being of considerable influence for growth of transport demand.

The growth in road transport for some important sectors suggest substantial increases of some external effects, including accidents, congestion, fuel use (and CO_2) and some pollutants. The increase of congestion and CO_2 emissions was of the order of 20% to 25%, while the emissions of NO_x were expected to decrease by at least 40% due to stringent emission standards that have been introduced.

An outlook for the period 1995 to 2005 was also produced on the basis of projected changes of production volumes and key ratios (e.g. value density, modal split, length of haul, vehicle carrying capacity, handling and load factors). The results of these projections indicated that road freight activity measured in tonne-kilometres is expected to grow faster than the growth of production until 2005 in terms of weight in a majority of the four groups of the model. The main driver of this trend is the considerable increase (some 20% to 30%) in the average length of haul. This trend is more accentuated for agricultural products where transport requirements (in terms of tonne-kilometres) and production weight are diverging substantially. In Sweden projected future trends suggest that less and less vehicle-kilometres are needed for the same production volume, in other words, economic activity is developing at a higher level than road traffic activity which is needed for the transportation of these produced goods. In the four other countries the opposite is true, since road traffic is growing faster than economic activity.

Summary:

The REDEFINE project of the European Union has underlined the fact that the relationship between economic activity and road freight transport demand is a complex one and conclusions from sectoral studies in a specific country cannot be necessarily translated to other sectors or the same sectors in other countries. While in some countries growth of production exceeds that of freight transport demand, the opposite is true in other countries and sector. Therefore, policies and measures should be designed and implemented taking into account the specific circumstances of the sectors targeted.

5. TRANSPORT INFRASTRUCTURE INVESTMENT AND ECONOMIC GROWTH

The benefits and importance of transportation infrastructure to economic growth have been generally recognised. Transport investments can be considered as a stimulus from the demand side to economic growth, and can contribute to the transformation of economic regions and urban areas. Investments in transportation systems (roads, railways, and canals) have stimulated economic development in various regions of the world particularly in the 19^{th} century. Investment in infrastructure is essential for reducing the costs of transport between regions, especially between those on the periphery and those in the centre. It plays an important role in reducing regional disparities and improving the competitiveness of regions by facilitating trade and the movement of labour. It has also increased the efficiency of the production and distribution processes, created opportunities for economies of scale and increased specialisation, changed logistic systems and reduced costs. This package of positive impacts and incentives can also lead to an increase of economic productivity and alter the comparative advantage of being located in different regions.

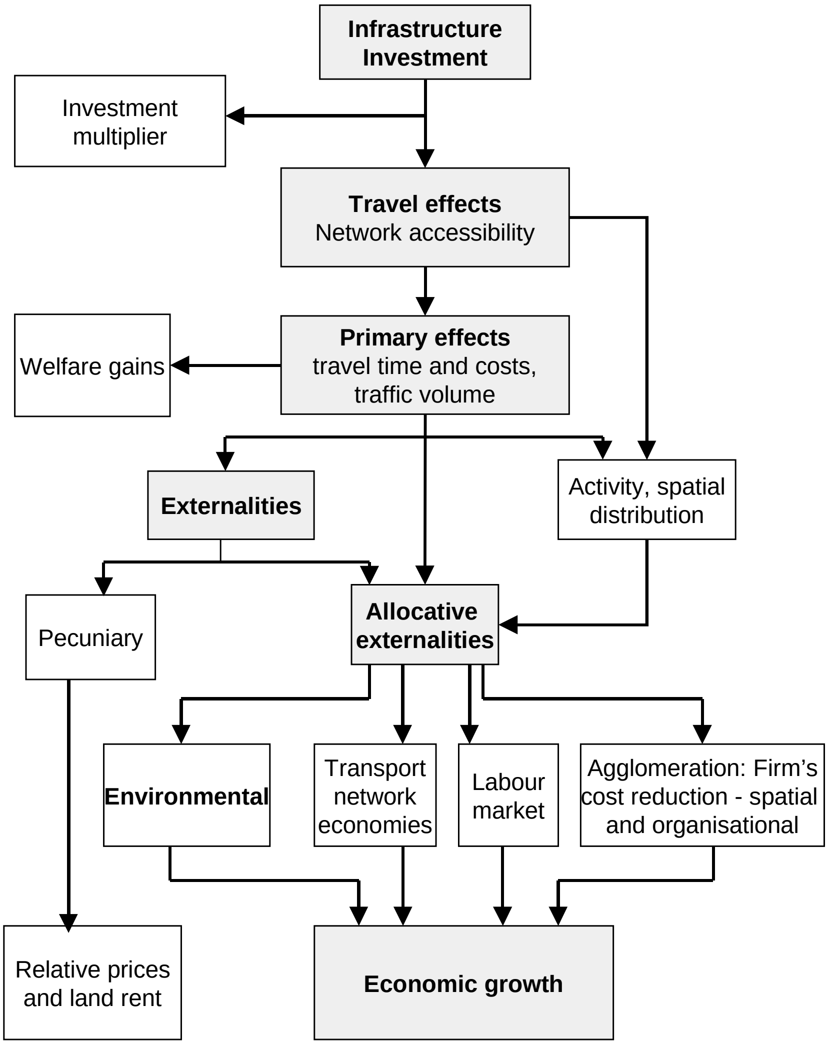
Infrastructure improvements could take the form of: i) investments with an improvement of the quality of the stock through for example new highways, airports, commuter rail lines, etc., repair and maintenance of existing infrastructure stock and/or ii) promoting efficient use using for example more capacity of existing infrastructure stock and optimisation of transport organisation using intelligent transportation systems, management of traffic flows, etc., changing user costs with fuel taxes, tolls, etc. These different types of changes in infrastructure stock and use patterns will influence the generalised costs of transport users and thus their economic impacts.

This issue has been extensively studied and the majority of the literature on the links between transport and the economy has actually tried to assess the economic effects of investments in transport infrastructure. A most recent and extensive analysis has been carried by the Standing Advisory Commission on Trunk Road Assessment in the UK (SACTRA, 1999). Earlier studies were undertaken in the late 1980s and early 1990s in the United States trying to assess the effects of the US highway system on economic growth and performance.

A) General Links between Transport Infrastructure Investment and Economic Growth

An important aspect in the analysis of the relationship of transport and the economy is the role and impact of transport infrastructure investment on economic growth; in other words, the potential contribution of increased capacity and operational efficiency of the transport system to economic growth. Figure 27 schematically shows the proposed relationships between transport investment and economic growth, including direct transport benefits (e.g. reduced travel time and lower costs of travel) through transport infrastructure improvements that translate into economic benefits and finally overall economic growth. The links in Figure 27 proposed by Berechman (2000) suggest further that economic benefits are a function of direct/primary transport benefits (i.e. improved accessibility, reduced monetary travel costs, increased throughput or traffic volume as well as improved safety, reduced emissions and enhanced intermodality).

Figure 27. **Links between Transport Infrastructure Investment and Economic Growth**



Source: Y. Berechman, 2001.

Figure 27 illustrates the theory that realising the primary growth benefits will depend on the presence of positive ("allocative") externalities in various markets and are regarded as major cause of resource allocation in the economy, typically represented by economies of scale, size, scope, agglomeration, density and network. The combined effect of these impacts will result in additional economic growth, usually measured as changes in employment, output and productivity. Conversely, in the absence of such externalities, only the primary transportation benefits can be regarded as the total benefits from the particular investment (Berechman, 2001).

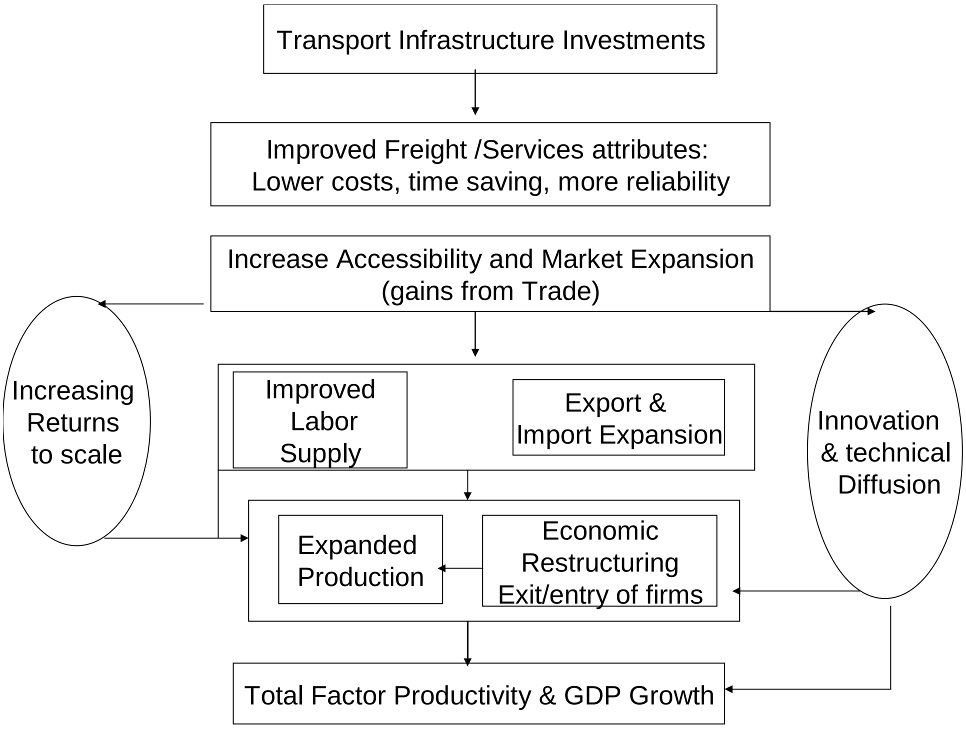
Some analysts have shown that various regions could experience long-term economic growth without transport investment growth, of course if transport services are not a bottleneck (Sen *et al*., 1998). Other variables like technological innovations, improved labour productivity, investment in business plant and equipment, human capital improvement, are also necessary for growth. The analysis has also shown, however that even in the case of well-developed economies, transportation infrastructure can impose some constraints on the economic development of the local economy (Boarnet, 1998; Sen *et al*., 1998). Even if in the short-run, the development of transport investment can improve the competitiveness of one region vis a vis adjacent regions, this could only last during a short period because capital and labour are mobile. Berechman concludes that, within a reasonable degree of regional accessibility that is a sufficient transportation infrastructure, growth can be achieved by an assortment of policies, not necessarily transportation-related (Berechman, 2001).

Figure 27 shows that various conditions in various markets have to be present to allow transport to have a positive impact on economic growth. The major factors are agglomeration economies, transport networks. Improving accessibility alone would not be sufficient to generate growth. This improvement would be just translated into travel time reduction, but not necessarily higher travel volumes and greater economic growth.

Figure 28 shows the full economic effects of transport infrastructure investments in a spatial general equilibrium effects perspective. Transport infrastructure and service improvements lead to lower costs and increase accessibility to various market actors (input suppliers, labour, and customers) market expansion and integration will follow. Opportunities for exporting and importing goods increase (Lakshmanan, 2002). First, export expansions lead to higher levels of output, which allow higher sales to improved efficiency, both via the restructuring of the economy (as firms enter and exit) and by promoting leaner production processes, which lower costs of production and raise productivity. Third, lower transport costs and increased accessibility enlarge the markets for labor and other factor inputs. Firms will likely draw labor from a broader area and with a greater range of attributes. Similar effects in land and other factor markets are likely as transport improvements open up new areas for economic activities.

However, in an integrated market, some feedback effects associated with expanded production are likely, which may dampen the initial strong positive impacts of transport improvements noted above. Since production expansion deriving from market expansion will raise the demand for labor and land, wages and rents will go up offsetting part of the initial lowering of costs and gains in competitiveness. Wage rises, if persistent, will have migration consequences. Finally, higher production may induce congestion in the networks and a rise in transport costs. The point to be made here is that transport improvements initiate a sequence of economic effects and feedback effects in a number of interacting markets. Figure 28 suggests that the two mechanisms in the oval boxes create, in the context of transport infrastructure improvements, conditions which enhance economic performance, and promote total factor productivity and growth.

Figure 28: **Transport Infrastructure Supply Freight Services Sector and Full Economic Effects**



Source: Larkshmanan, 2002

B) Transport Elasticity to Infrastructure Development

Many studies have been carried out in order to measure "output elasticities", i.e., the link between infrastructure investments and growth in GDP. This elasticity indicates the expected percentage change in production with a 1 percent increase of an infrastructure variable. To obtain this type of information, two main categories of studies have been used:

1. Time-series analyses where information from one country or region is gathered over a certain time period.

2. Cross-section analyses where information of productivity and economic growth are compared from a number of countries or regions at one point in time.

A third approach uses a combination of observations for several time periods and several cross-sectional areas ("pooled" data sets).

Results from time series analyses could be affected by false correlations, since many factors will grow smoothly over time, and selecting any two of them always shows a strong statistical link. Time gaps between investments in infrastructure and economic growth also affects the reliability of the results. Very high elasticities have been shown in some time series analyses but are not representative of a real link. As it is shown in Table 18 that summarises the results from different countries, several elasticities are higher than 0.50.

Table 18. **Output Elasticities Derived from Aggregated Production Functions**
(Data Sets Based on Time-series)

Country	**Output elasticity**
United States	0.29 - 0.64
Netherlands	0.48
Japan	0.15 - 0.39
Germany	0.53 - 0.68
Canada	0.63 - 0.77
Belgium	0.54 - 0.57
Australia	0.34 - 0.70
France, UK, Finland, Norway, Sweden	Wide range between highest and lowest value: i.e. between 0.1 and 0.8

Source: Johansson et al. (1996).

C) The Aggregate Approach – Output Elasticities

The issue is whether and how much transport infrastructure investment can stimulate innovation and economic growth. In the late 1980s important work was undertaken to study this question in the United States by Aschauer (1989) that tried to provide empirical evidence to justify the large public investments on transport infrastructure. Aschauer compared the rate of economic growth in different US states, with the transport infrastructure investment in those states. The output and productivity in regions and in times are compared according to greater or lower infrastructure investment. He used a Cobb-Douglas production function and aggregated national time series data for the U.S. to investigate the relationship between public infrastructure capital and aggregate output of the private sector.

This approach is also called the *aggregate investment approach* since infrastructure is considered as a direct injection into the economy stimulating short term demand as well as increasing capacity which raises long term potential growth. The assumption made is that new infrastructure investments projects have the economic effect of both increasing the level of economic activity and the productivity of private capital. These results have been found through an aggregate production function used as a model. Public infrastructure in some aspects is assimilated to a public good that means that the improvement of transport enhances the efficiency of firms.

Subsequent technical reviews of this work by other analysts suggested that the results were substantially exaggerated, due to various methodological and analytical flaws (SACTRA, 1999). In order to mitigate some problems that have arisen from the time series studies, subsequent studies are based on pooled time series and cross-section data. The results indicate a smaller and weaker contribution of public infrastructure investments, it has also showed that the composition of infrastructure capital matters; some type of infrastructure (e.g. highways) may have greater effects that others.

The econometric model used by Aschauer (1989) initially showed that the output elasticity of the infrastructure input to economic growth was very large. A strong correlation was found where growth was higher if transport investment increased. The estimated elasticity of output with respect to the public capital is 0.39, meaning that a 1 percent increase in the capital stock increases output in the private sector by 0.39%. The elasticity of the "core" infrastructure including highways, mass transit, airport etc. is about 0.24. These econometric results were in favour of the assumption that infrastructure investment is an important source of economic growth. Restricting public investment in infrastructure in order to reduce public spending was thus considered as counter-productive. On the contrary if the public investment is increased it could be expected that economic growth increase in turn. This growth would have enhanced private sector productivity, and more than paid for itself through increased public sector revenues linked to higher long run growth levels (Vickerman, 2001).

When the methods was reviewed in detail by other analysts, they found that the same data could be interpreted in the opposite way, i.e. that transport investment was the result of growth, not the cause of it (growth generates a latent demand for more transport, however, the market does not supply it, therefore, if the public sector chooses not to supply enough to satisfy the latent demand the lack of provision will be translated into a constraint on growth). Several specialists now consider that the study probably exaggerates the size of the effect. Some others approaches for example suggest output elasticities of infrastructure investment and growth around 0.1 (Lau and Sin, 1997).

Table 19 shows the variation in estimates. The coefficients, which in most cases are also elasticities (if the question estimated used log variables), show the strength of the estimated effect, that is, for a one percent change in the infrastructure variable the elasticity indicates the percentage change that can be expected in the productivity variable. Substantial reviews of the different studies on that matter have shown that the estimated results are largely dependent upon the econometric formulation. Simpler econometric specifications always have large estimates and on the opposite a sophisticated regression makes such estimates much smaller and weaker.

For instance Duffy-Deno and Eberts (1991) have used a simultaneous equations approach to estimate annual data for 28 metropolitan areas from 1980 through 1984. The result reveals that public capital stock has positive and statistically significant effects on per capita personal income. Many other studies using pooled time series and cross-state data provide controversial results. Garcia-Mila and Mc Guire (1992) specify a regional production function that, in addition to labour and private capital, includes highways and education. They employ a panel data set consisting of annual observations of 48 states from 1969 to 1983 to estimate input elasticity coefficients under a specification that allows for differences over time and across states. They find that both highways and education have significant and positive effects on output with an estimate of 0.045 for Highways.

Table 19. **Output elasticities derived from aggregate production functions**
(Pooled data sets used)

	Coefficient	Level of Analysis	Infrastructure Variable	Productivity Variable
Aschauer (1989)	0.39	National	Public capital	National output
Munnell (1990)	0.33	National	Public capital	National output
Aschauer (1989)	0.24	National	Core public capital	National output
Lynde and Richmond (1991)	0.20	National	Public capital	National output
Hulten and Schwab (1991)	0.03	National	Public capital	National output
Moomaw and Williams (1991)	0.25	State	Highway density	Total factor
Costa, Ellson, Martin (1987)	0.20	State	Public capital	Output
Munnell (1990)	0.15	State	Public capital	Gross State Product
Munnell (1990)	0.06	State	Highway density	Gross State Product
Garcia-Milà and McGuire (1992)	0.04	State	Highway density	Gross State Product
Deno (1998)	0.31	Metro Area	Highway density	Personal income
Duffy-Deno and Eberts (1989)	0.08	Metro Area	Public capital	Manufacturing output
Eberts (1986)	0.03	Metro Area	Core public capital	Manufacturing value added

Source: US Department of Transportation, Federal Highway Administration (1992)

D) The growth accounting approach

Another approach to examine the effects of transport infrastructure expansion on economic growth is growth accounting which has been used by Baum and Behnke (1997) and Baum and Kurte (2001); i.e., to determine the effect of a single factor (e.g. transport) on economic growth. The results of this approach for Germany suggested that a large part of the growth in the economy can be directly associated with the growth in transport and specifically with the growth in road transport. Capital accumulation is argued to have contributed around 38% to the growth of German GDP between 1950 and 1990, of which around 43% is attributed to transport and, of the productivity growth which contributed the remainder, two thirds is attributed to transport, one half of this being attributed just to road transport. Baum and Behnke suggest that half of German economic growth over this 40-year period is attributable to transport, half of which is attributable to road transport alone. This has been interpreted as a causal linkage suggesting that a substantial part of the increase in aggregate economic activity have been (solely) due to the transport enhancement.

One of the reasons for not accepting this argument is that the analysis does not demonstrate convincingly the real direction of causality. Even if there is some linkage between an increase of transport infrastructure and economic growth, the analysis does not show that similar rates of growth could not have been obtained by other types of investment. There is an argument that at certain stages of growth the expansion of transport infrastructure capacity is essential to enable growth to take place (even if it does not necessarily cause the growth), but once a certain level of provision is reached there is very little overall impact from further growth in the transport sector. Continued increases in transport capacity may lead to activities being relocated, but it does not lead, of itself, to higher aggregate activity.

The cases of highly productive countries with growth rates that attract private capital and productive labour and which in turn demand higher levels of infrastructure investment are problematic and lead to an opposite direction of causality (Banister and Berechman, 2000). In such cases, the causality direction is reversed, because the present state of high growth stimulates infrastructure investment. Disregarding such causality possibilities might result in problems of simultaneity in the empirical analysis, which, in turn, can generate wrong estimates.

A rather different approach represents transport improvements as time-savings, the value of which can be regarded as equivalent to a gain in productivity from the labour employed. Whether this potential output gain is turned into higher wages for the employee or into increased output (and hence increased employment) there is a welfare gain. The impact on economic growth will be less if the increased productivity is absorbed into higher wages. It seems likely that the impact of specific transport projects, even quite large projects, on the real wage will be very small. However, the question remains whether major programs which affect entire networks, such as a national roads program or the EU Trans-European Networks (TEN), can have a significant shift effect on the supply side of the economy.

The time-savings - productivity gain - growth argument has been used in the study on the impact of the TEN in the EU (European Commission, 2003). An aggregate relationship is used to generate the link between a given level of transport expenditure and the implied productivity gain and then between this productivity gain and the growth of output or employment. The estimates made are of potentially very substantial output/employment gains. EU GDP is estimated to be 0.25% higher and employment 0.11% higher by 2025 from the priority TEN projects and even greater employment gains (800 000 jobs or a 0.49% increase) are obtained from the full network.

The precise nature of the critical linkages between various components of the model is, however, not fully clear, especially the link between the transport elements and the macroeconomic model (in this case the European Commission's QUEST II model). The estimates of impact do seem high and there appears to be continuing (explosive) growth emanating from the initial shock. It is not clear how far this results from assuming a continuing program of investment or from some property of the model itself. There needs to be further validation in order to be confident about the size of the impacts.

Summary

The important increase in public infrastructure investment and particularly in highway infrastructure in some major countries of OECD in the 1950s and 1960s followed by sharp fall in infrastructure investments in the early 1970s and again in the early 1980s with at the same times a important decline of economy and productivity, stimulated considerable empirical work on the link between infrastructure investment and economic performance. However, these estimates are likely to have overstated the magnitude of the impact of public infrastructure investment on private sector output and productivity growth. Subsequent studies based on pooled time series and across-section data indicate a smaller contribution of public infrastructure investment and that the composition of infrastructure was important to determine the level of contribution. Some type of infrastructure (e.g. highway) may have *greater effect than others. The direction of causality is not clear in the sense that it is difficult to know if it is economic growth that is caused by infrastructure investment or a region of strong economic growth that can afford to build more in infrastructure growth. Substantial reviews of the different studies on that matter have shown that the estimated results are largely dependent upon the econometric formulation. Simpler econometric specifications always have large estimates and on the opposite a sophisticated regression makes such estimates much smaller. An important variable to take into account is the level of development of a country, it is clear that all countries need a well-developed transport infrastructure to be competitive in the new global markets. The question would be if in developed countries, where already a well connected transport infrastructure network of high quality is in place, how much additional economic growth would result from additional investment infrastructure.*

6. PRELIMINARY CONCLUSIONS

The purpose of the project is to identify instruments and policies that can help governments to reduce the negative impacts of transport activities while at the same time maintaining economic growth - generally understood as "decoupling". The main purpose of the first part of the project is to improve the understanding of the mechanisms that underline this relationship, and if possible, to quantify them; in other words, to examine how economic growth stimulates transport growth and whether transport growth leads to economic growth. The impacts of transport on the economy depend on numerous factors, some of those are: the stage of development of the economy, the quality and extension of existing infrastructure and the overall socio-economic situation of a country or region.

The analysis shows that taxes based on the distance driven and the environmental performance of vehicles and charge system can encourage important modal shifts and generate revenue for developing more environmentally friendly modes. One of the advantages of regulation is that it is an instrument that is targeted in achieving emissions reduction. Combining taxes and regulations and appropriate policy mixes could combine effectiveness (regulation) and dynamic efficiency. Usually internalising the various external costs of transport would affect the level of transport activities, thus further reducing the levels of the externalities.

The analysis of the transport trends in the different regions (Europe, the U.S and Japan)revealed the main economic driving factors that are behind these trends which include the supply of infrastructure that boosted transport, in particular the expansion of the highway system. This has facilitated movements while overall transport costs were decreasing. The lack of attractive alternatives to individual motorized transport explains the difference between the US and Europe as well as the US and Japan trends, the latter having much higher public transport performance than the US or Europe and thus a lower average level of motorization. Other constraints in terms of disposable income, available parking space and tax structures also influence the modal choice by individuals and businesses. Liberalization of road freight together with increased market integration lead to a strong boost of road transport.

One important finding of transport satellite accounts (TSA), is that sectors with a larger contribution to GDP, in terms of value, have a relatively smaller transport demand (e.g. manufactured goods) and the sectors with a lower contribution to GDP have a large transport demands (e.g. agriculture). One indirect driver of decoupling could be dematerialisation of the economy since decreasing the material intensity of a product could help to decrease the demand of transport.

Subsequent studies indicate a smaller contribution of public infrastructure investment and that the composition of infrastructure was important to determine the level of contribution. Some type of infrastructure (e.g. highway) may have greater effect than others. The question would be if in developed countries, where already a well connected transport infrastructure network of high quality is in place, how much additional economic growth would result from additional investment infrastructure

Further work

Some of the main drivers of passenger transport demand are income levels that drive motorisation, relative prices that boost or constraint the demand or choice of transport mode, the increases in average driving speeds due to improvements in vehicle technology and infrastructure, separation of home and workplace, more leisure time spent for travel and tourism, and family structure. One indicator that can be used is long-term transport income and price elasticities. Concerning freight transport demand, some of the main drivers are production increases, the length of haul, globalisation, market integration and industry consolidation, changes of consumer preferences, efficiency improvements (load factor, vehicle size), new production concepts (e.g. just-in-time procurement), and infrastructure investments.

At this level of the analysis it appears that further decoupling of environmental impacts from economic growth is achievable with an efficient use of charges, fees, taxes and other economic instruments included in a package of instruments combined (e.g. regulation) with other measures to encourage a modal shift from road to environmentally sustainable rail taking into account the load factor, locomotive technology and how electricity is generated. Other factors which could help to decouple transport impacts from economic growth are improvement in freight transport logistics, and further dematerialisation. All these policies have to be used with a particular attention on, and in accordance with, the circumstances and characteristics of countries. Some instruments that fit well in one country might not be adapted to another. This question and these different instruments will be examined in detail with the analysis of the country case studies in the following second and third stages of the project.

ANNEX EVALUATION AND MODELING TOOLS

A) Macro economic models

Economic theory suggests that investment, labour force and productivity growth underlie long-term economic growth. Thus, economic growth is caused by improvements in the quantity and quality of the factors of production that a country has available i.e. land and other natural resources, labour, capital and enterprise. Conversely, economic decline may occur if the quantity and quality of any of the factors of production falls. Economic growth, usually measured as output growth, is a long-term phenomenon, which depends on the economy's productive potential, i.e., on the supply-side of the economy. Therefore, sources of growth are generally considered as the increase in the different factors of production.

It is difficult to understand more deeply the cause of economic growth without using economic theory. Moreover, this will permit the understanding of the two main strands of explanation of the growth process, which are the endogenous and neo-classical growth models. The basic assumption of the macroeconomic models is that investments in transport infrastructure are a factor of production additional to the traditional factors of capital and labour in a production function. Investments in transport infrastructure are also considered as a direct injection to the economy and thus directly related to GDP (see figure 2). Therefore, we can estimate that economic growth is a quantitative change in economic performance, measured generally by the Gross Domestic Product (GDP), which is defined as the total value added in the economy.

Endogenous and neo-classical growth models offer different explanations for the growth process, but in both models, growth in total factor productivity (i.e. technological change) is an essential component of economic growth. The total factor productivity replaces the labour input by an index of two or more factor inputs, in order to capture factor substitution effects. Therefore, the growth of TFP reflects technological progress, increasing efficiency in the use of resources, and economies of scale. In the neo-classical model, assumptions about technological progress are essential for long-run growth in per-capita output. In endogenous growth models, productivity growth results from spill-over of human capital accumulation or inventive activity and this is what generates long-run growth in per-capita income.

Simple neo-classical growth models

The basic assumptions underlying the neo-classical growth model are:

- The productive capacity of the economy can be characterised by a constant-returns-to-scale production function with diminishing returns to capital and labour.
- Firms are price-takers in a competitive market place. In other words, no individual firm has any influence over market prices.
- Technological change (i.e. productivity growth) is largely exogenous (i.e. independent of the actions of the consumers and producers) and is available to all countries at no cost.

The implications of the neo-classical model of growth are straightforward. The first major implication is that sustained increases in per-capita income can be supported only by sustained increases in total factor productivity. In this model, output per worker can rise only if (a) the ratio of capital per worker increases or (b) total factor productivity increases and (c) labour inputs increase. Since this model assumes diminishing returns to capital, there is a limit to how much capital accumulation can add to output per capita. Hence, the only way to increase output per worker in the long run is to have sustained productivity growth. This is a major weakness of the neo-classical growth model, since growth converges to a steady state in the long run.

The second major implication of this model is the "conditional convergence thesis," which states that economies with lower initial levels of real output per worker relative to the long run level should experience faster economic growth. This property follows from the assumption of diminishing returns to capital: the lower the ratio of capital per worker, the higher the return to investing in capital. Hence, the lower the ratio of capital per worker, the faster the rate of capital accumulation and the faster the growth rate of output per worker. This implies long-run convergence in output per capita. Convergence is said to be conditional here since the long-run level of capital per worker and output per worker depend on the saving rate, the growth rate of the population, the existing technology factors that are unlikely to be policy dependant identical across countries and on policies that facilitate optimal resource allocative. The convergence thesis is strengthened by the assumption that all countries can acquire technological progress at no cost.

Concerning the influence of the extension of transport infrastructure, it can have direct positive impacts on growth through both short and long run effects. In the construction phase, the investment spending on transport projects (as with any construction projects) injects demand into the economy, while, in the long run, the additions to the capital stock raise productive potential.

Regarding the supply-side it is important to distinguish between level effects and growth rate effects, i.e. between changes in circumstances or policies that have a once-and-for-all effect on the level of GDP and those which affect the long run rate of growth of GDP. A good example for the former could be given by a reallocation of resources that increases the productivity of the economy. The latter could be illustrated by an increase in the rate of investment that gives rise to a permanent increase in the rate of growth of the capital stock.

Extended neo classical models: endogenous growth models

For several decades, the neo-classical growth model remained the benchmark model of economic growth. Starting in the 1980s, however, a number of newer, more sophisticated growth models have been developed. A key feature of these new models is that, unlike the neo-classical model, technological change is not assumed to be exogenous. Hence, the new growth models are sometimes dubbed "endogenous growth models" since a key task in these models is to explain where technologically driven productivity growth comes from. In particular, the accumulation of knowledge plays a key role in driving growth of productivity in these models. Models of economic growth which have the property of endogenous growth are those in which the long run growth rate is explained within the model and depends on innovative activity and/or investment decisions that result from economic stimuli.

Government as key policy criteria generally consider economic growth and competitiveness impacts. Competitiveness has been defined as "the degree to which the country can produce goods and services which meet the test of international markets, while simultaneously maintaining and expanding incomes of its people over the long term" (DTI, 1994). Competitiveness then is more to do with the economy's growth than with the efficient allocation of resources per se, but is often thought to be reflected in superior levels of productivity, namely the volume of output obtained per unit of input.

Usually, comparisons of productivity are made in terms of output per unit of labour input, but a better measure of overall efficiency is total factor productivity (TFP) which measures output compared with a weighted sum of all inputs (factors). TFP growth results from technological progress, more efficient use of resources and economies of scale. Transport and the links with other sectors is an integral part of the model – and thus, both influencing and being influenced by economic growth.

As defined above, competitiveness at the national level is primarily about growth rate effects stemming from growth in the capital stock and in TFP, i.e. growth of productive potential, rather than the efficiency of allocation of a given amount of productive resources. Yet productivity improvement results from efforts to reduce costs, while the accumulation of capital equipment and skills depends on investment decisions. At a deeper level, therefore, growth depends on incentives to invest and to innovate, and thus may be influenced by various aspects of microeconomic arrangements, such as the structure of taxation, or the amount of competitive pressure on managers of firms (Aghion and Howitt, 1998).

A relevant characteristic of the endogenous growth model is the fact that they are supposed to allow continuous growth and in parallel determining its level. For achieving this continuous growth the decreasing marginal product of capital must be avoided[1].

For the purpose of this study, the issue is to examine the role of transport infrastructure capital in such a model where innovation is endogenous. Transport improvements, might promote access and thus contribute to improved human capital in a region or country, promote efficiency through economies of scale in larger markets and influence innovation and creation of spatial clusters of economic sectors so that total factor productivity growth is promoted resulting in increasing growth rates of the economy.

Transport improvements have potentially an endogenous growth effect because they impact on the rate of innovation and transfer of technology, and in this way promote Total Factor Productivity Growth. These impacts of transport improvements can derive from industrial restructuring resulting from the entry and exit of firms and the opening of larger markets. These also can be one of the consequences of an increase in information flows where industries are spatially agglomerated.

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1. This can be achieved through four methods that have been developed in the economic literature:

1) The “AK model” is the basic method, which assumes that capital is the only input into production and that there are constant returns to scale. Under these assumptions the production function is given by $Y = AK$. Output will then grow at the same rate as net investment in capital.

2) The second approach is to match increases in capital with equal growth in other inputs. One interpretation of this method is to consider human capital as the second input, rather than just raw labour. If investments in education and training are increased, labour time will be more productive and therefore the level of human capital will be raised. If the production function has constant returns to scale in human capital and physical capital jointly, then investment in both can eventually raise output without limit.

3) The third alternative approach is to assume that output depends upon labour use and a range of other inputs. Technological progress then takes the form of the introduction of new inputs into the production function without any of the old inputs being dropped (Romer, 1990). This allows production to increase since the expansion of the input range prevents the level of use of any one of the inputs becoming too large relative to the labour input. An alternative view of technological progress is that it takes the form of an increase in the quality of inputs (Aghion and Howitt (1992)). Expenditure on research and development can result in better quality inputs, which are more productive. Over time, old inputs are replaced by new inputs and total productivity increases.

4) The fourth approach assumes that there are externalities between firms. These externalities are spread into the economy thanks to the mechanism of learning-by-doing (Arrow (1962). That means that an investment by a firm, leads to parallel improvements in the productivity of labour as new knowledge and techniques are acquired. Moreover, this increased knowledge is a public good so investment, and learning, by one firm flows into other firms.

Another key feature of endogenous growth models is that the very long-run growth rate can depend on government actions. In the basic neo-classical growth model, governments do not have an impact on the long-run growth rate. In an endogenous growth framework, however, government policy can affect the long run rate of growth, since government policy actions - e.g. taxation, provision of infrastructure, protection of intellectual property, regulations, maintenance of law and order, etc. - can affect the underlying rate of inventive activity. Government interventions, therefore, are considered to have a great potential for harm or good in these models.

TRANSPORT INFRASTRUCTURE AND JOB CREATION

In the economic literature transport schemes are sometimes presented as one of the origins of the creation of jobs. Indeed, conventional economic analysis assumes that market is perfect that means that prices adjust to demand and supply. In the case that demand is superior to supply an increase in prices will neutralise this difference with respect to the market equilibrium. According to this view, wage adjustments for different types of labour would fulfil this balancing role.

Therefore, the economy finds spontaneously its equilibrium level of employment and any increase in employment or output at one location must result in a reduction somewhere else in the economy. In this economical concept, the wage rate reflects the opportunity cost of a worker. In this state of equilibrium, the opportunity cost represents what a worker could earn in alternative employment and his value to an alternative employer. Therefore, the concept of transport schemes as the origin of job creation would not be founded and would be neutral in a general equilibrium. Some counter arguments could be presented since in the real world the labour market does not respond instantaneously to these additional signals.

In theory, the economic benefits of employment creation could be measured easily, but in practice, it may be very difficult to accurately estimate them in money terms since adequate information for the task is not available. Alternatively, the economic benefit from employment creation could be assessed in terms of gross public expenditure per job created and cost-effectiveness can then be compared with alternative interventions with a similar objective but it has to keep in mind that this approach also is difficult to implement.

The issue is to evaluate how many job-years of employment are created by the transport improvements. This requires the estimation of both the jobs lost and the income multiplier effects, which can also be at the origin of others jobs created (this is a short term issue and depends on the level of unemployment in a particular time and place in the categories where demand would be stimulated by the construction project).

<u>Summary</u>

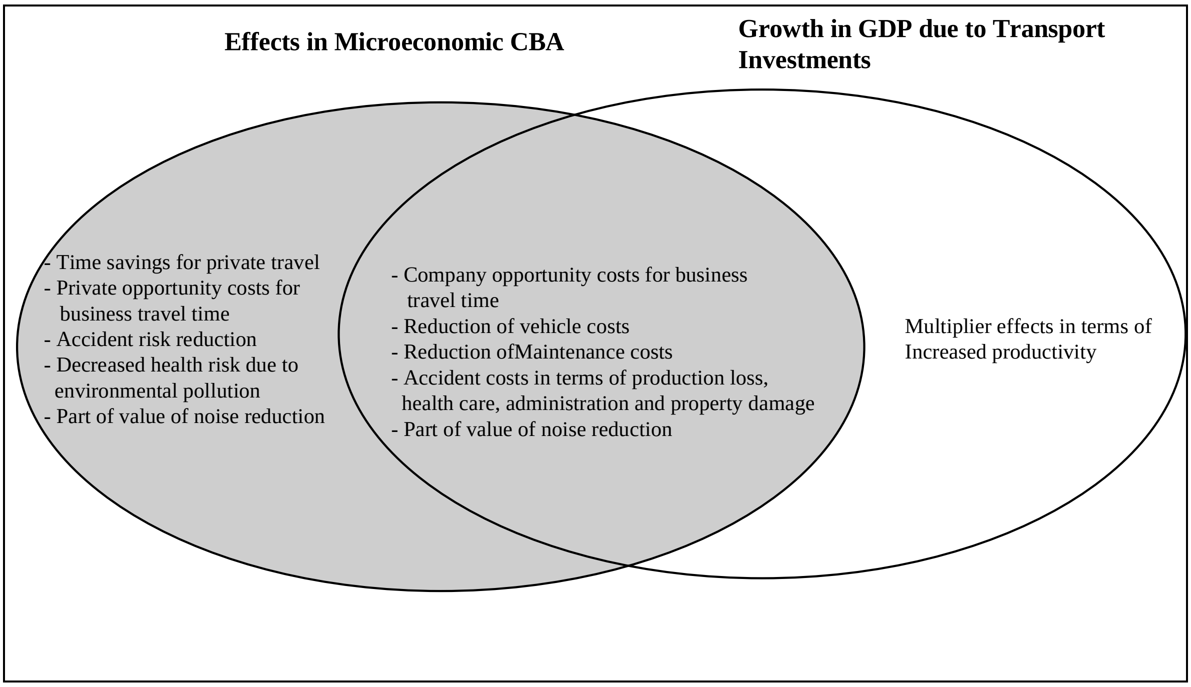
Macroeconomic models generally are complex, but do take into account network effects or multiplier effects in terms of increased productivity of the economy; i.e. an expansion of production through lower transport costs can result in new consumer demand due to rising income levels, which in turn will boost supply by firms that will generate more revenue and income. The interpretation of changes in GDP and expansion of infrastructure is difficult, as they can reflect important structural changes and adjustment processes in the economy. Induced effects on employment, income and property prices are also captured through GDP, and thus, the overall impact on the economy. However, the direction of influence or causality between economic growth and transport growth is difficult to assess. This is true for both macroeconomic models considered – the endogenous and neo-classical - growth model. Endogenous growth models assume that the rate of growth (including the effects from transport) is determined by choices made within the model. This is in contrast to neo-classical (exogenous) growth models where no internal factor would affect the rate of growth in the very long run.

B) Microeconomic analysis

An important question is to know which economic approach is the most adapted to be used for the determination of the impact of transport on the economy. Some studies have shown that almost 50% of the Cost Benefit Analysis net present value would not be covered in a macroeconomic method based on GDP-data (ECMT, 2001*a*). Taking as example the Swedish long term national road scheme Lindberg (1992) has analysed the impacts that would have been taken into account if a macroeconomic method based on GDP data had been used. In this example about 50% of cost reductions in the fields of travel time and accidents and about 30% of other cost reductions would not be reflected if a strict GDP approach had been taken.

The figure 4 shows that macro and micro economic assessments to a large extent measure different types of economic effects, but there is a core of common elements. Additional benefits and costs are covered in macroeconomic assessments and not in microeconomic assessments. For example a direct effect on business expansion can lead to an indirect effect by increasing the business activity of suppliers, also this affect can be followed by effects coming from increased personal income spending and from increased public spending due to greater tax incomes for the government (ECMT, 2001*a*).

Figure 4. **Schematic Comparison of Microeconomic Effects/CBA versus Macroeconomic/GDP-based Analysis**



Source: Lindberg G. (1992), in ECMT 2001.

Cost benefit analysis

In contrast to the macroeconomic approach linking aggregate infrastructure building to aggregate productivity growth, the microeconomic perspective tries to identify the link between specific infrastructure improvements and the productivity of specific production units. The microeconomic analysis underlines the direct and indirect micro-level benefits arising from changes in the freight transport services sector. The micro view is that transport improvements lead to a reduction of time travel and consequently decreases the overall costs of the vehicle. These positive elements, in return, could help to lower product prices, increasing product demand, and a higher level of economies of scale. The analysis of the economic impacts of changes of the transport system reveals two types of effects: there are costs in terms of construction and operating of the infrastructure and, on the other side, the benefits resulting from improved accessibility and savings of transport costs. Costs and benefits have to be attributed in the context of national accounts to the generation of gross output; they concern both the use of productive resources (labour, capital, nature) of an economy. Costs represent the consumption of resources and result in a reduction of the potential gross output. Benefits represent productivity increases (or savings on production factors/resources) that allow generating more wealth.

It is important to find a method that could be used for evaluating the economic effects of transport improvements. The method that is commonly used is cost benefit analysis (CBA) which is a tool that is intended to aid decision-taking in the public sector. At the opposite of the general ex post econometric analyses of the macroeconomic perspective, CBA is a tool which seeks to predict economic benefits to both households and firms and compare them with project, operational, external and other costs (Lakshmanan and Anderson, 2002). The calculation is made before the infrastructure is made. It involves the enumeration and valuation in monetary terms of all the costs and benefits of a project including the economic and social externalities. Future costs and benefits are expressed in present value terms using an appropriate discount rate. The criterion that a project has to satisfy in a CBA is that it has a positive net present value, i.e. that benefits exceed costs over its lifetime. In taking account of the costs of capital, CBA has allowed to take into account the opportunity cost of using the funds for an alternative project.

Concerning transport interventions and projects, cost benefit analysis considers journey time-saving to be of real value to travellers. In practice, certain valuation conventions are used to value time benefits. For travel time in the course of work, savings are often valued according to the gross wage rate plus employment-related overhead costs of the relevant class of employee. The value of working time-savings is the main way in which benefits of road schemes to business are represented in general in a CBA. In the SACTRA report for example, for all other journey purposes, including commuting and leisure usage, a standard average value of time savings is used which is currently 25 per cent of that attributed to the average working time value. All time saving, regardless of size, are assumed to attract the same value per minute.

Considering the demand for travel between a particular origin and destination, the CBA might include the volume of travel which will actually take place depending on its generalised cost, which will be determined by the interaction between supply (or conditions on the transport network) and demand.

In equilibrium, there is a difference between travellers' maximum willingness to pay in time and money for the journeys that they make (marginal benefit) and the cost that they actually have to pay. This difference is known as *consumer surplus;* it is the changes in this, in response to various interventions in the transport market that CBA takes as a prime indicator of user benefit. This concept can be applied to justify a road improvement scheme where it produces a consumer surplus (i.e., where marginal benefits exceed marginal social costs over the long term).

A CBA method applied for transport is conceptually very demanding. When transport costs change, it can be expected these be transferred, by various linking mechanisms. A reduction in transport costs might accrue to the transport firm or its employees, or to the manufacturer of the goods transported through falling transport prices, or to the final consumer through a reduction in the price of the goods. In principle, transport CBA requires knowledge of the relevant conditions in all the markets affected by a transport scheme in order that the desired demand curve can be correctly estimated. Then, this has to be equilibrated with transport supply.

Practical modelling exercises often ignore the principal characteristic of transport, i.e. the numerous interdependencies. For example, some evaluations of road schemes were characterised by a 'fixed trip matrix' assumption, where origins and destinations, and hence demand, are treated as fixed (as opposed to a 'variable trip matrix' which allows for changes in behaviour and demand in response to road improvements). The fixed trip matrix assumption allows only a single traveller response and ignores the possibility of other responses, such as change of time, and frequency of travel, mode and destination. The method does have serious shortcomings, since under congested conditions; the fixed trip matrix method could overestimate true benefits, perhaps significantly, by failing to allow for the congesting effect of induced traffic on the network service quality for all traffic.

Summary

Cost benefit analysis, primarily used for project evaluation at the micro-economic level, focuses on direct economic effects of improved transport provision. It has a transparent causal structure, as it assesses the direct effects of transport improvements; e.g., the costs (e.g. construction of infrastructure and operating costs) and benefits (e.g. travel and transport time-savings) to the various groups (providers, users, and the public). Thus, provide the net economic effects by taking into account social and environmental externalities (e.g. resource savings/losses) as well as other effects (e.g. accidents). Causality between a specific measure or action (e.g. improved transport provision) and the resulting effect (e.g. transport costs) can be determined. However, induced growth effects on the economy are only included to a certain degree; e.g., indirect effects of logistics restructuring from transport improvements.

*In practice, simplifying assumptions are made using cost benefit analysis. These simplifications can lead to reducing the accuracy of the method and therefore the results. Therefore, it can be concluded that the transport CBA has to be used very carefully for assessing the benefits of policy actions on transport and there impacts on growth. To conclude, the different approaches are complementary. Microeconomic CBA is adapted for assessing projects and should be used both to achieve an optimal capacity standard of a new investment and to compare the cost efficiency of different investment projects (*ECMT, 2001*a*). *Macroeconomic assessments should be used for complementary information on possible long term network effects which are not covered in CBA.*

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