COMPETE

Analysis of the contribution of transport policies to the competitiveness of the EU economy and comparison with the United States

COMPETE Final Report

Analysis of the contribution of transport policies to the competitiveness of the EU economy and comparison with the United States

Version 2.1

October 2006

Co-ordinator:

ISI
Fraunhofer Institute Systems and
Innovation Research, Karlsruhe, Germany

Partners:

INFRAS
INFRAS
Zurich, Switzerland

TIS
Transport, Innovation and Systems
Lisbon, Portugal

EE
Europe Economics
London, United Kingdom

Project funded by the
European Commission – DG TREN

COMPETE

Analysis of the contribution of transport policies to the competitiveness of the EU economy and comparison with the United States

---

Report information:

Report no:	**2**
Title:	COMPETE Final Report: Analysis of the contribution of transport policies to the competitiveness of the EU economy and comparison with the United States
Authors:	Wolfgang Schade, Claus Doll (ISI), Markus Maibach, Martin Peter (INFRAS), Fernando Crespo, Daniela Carvalho, Goncalo Caiado (TIS), Maurizio Conti, Andrew Lilico, Nazish Afraz (EE)
Version:	2.1
Date of publication:	31.08.2006 (with editing corrections October 23rd 2006)

This document should be referenced as:

Schade W, Doll C, Maibach M, Peter M, Crespo F, Carvalho D, Caiado G, Conti M, Lilico A, Afraz N (2006): *COMPETE Final Report: Analysis of the contribution of transport policies to the competitiveness of the EU economy and comparison with the United States*. Funded by European Commission – DG TREN. Karlsruhe, Germany.

Project information:

Project acronym:	COMPETE
Project name:	Analysis of the contribution of transport policies to the competitiveness of the EU economy and comparison with the United States.
Contract no:	TREN/05/MD/S07 .5358 5
Duration:	01.01.2006 – 31.08.2006
Commissioned by:	European Commission – DG TREN
Lead partner:	ISI - Fraunhofer Institute Systems and Innovation Research, Karlsruhe, Germany.
Partners:	INFRAS – Infras, Zurich, Switzerland. TIS - Transport, Innovation and Systems, Lisbon, Portugal. EE - Europe Economics, London, United Kingdom.

Document control information:

Status:	Accepted
Distribution:	COMPETE partners, European Commission
Availability:	Public (only once status above is accepted)
Quality assurance:	Ms Mahler-Johnston
Coordinator`s review:	Dr. Wolfgang Schade

Signature: Date:

Table of contents:

List of tables

List of figures

List of abbreviations

ACA	Additional Cost Approach (for congestion measurement)
ACI	Airports Council International
AEA	Association of European Airlines
AFTM, ATM	Air flight traffic management
AUS	Australia
AUT	Austria
b€	Billion EURO
BLX	Belgium & Luxemburg
bn	Billion
BTD	OECD STAN Bilateral Trade Database
CAN	Canada
CEDR	Centre of European Directors of Roads (Brussels)
CER	Centre of European Railways and Infrastructure Operators (Brussels)
CHE	Switzerland
CHPS	Czech Republic, Hungary, Poland and Slovakia countries
CODA	Central Office for Delay Analyses, Eurocontrol (Brussels)
ConsHH	Consumption of households
CZE	Czech Republic
DB	Deutsche Bahn AG (German Railways)
DNK	Denmark
DWL	Deadweight Loss Approach (for congestion measurement)
EC	European Commission
ECMT	European Conference of Ministers of Transport
ESA	European System of Accounts
ESP	Spain
ETS	(European) Emission Trading System
EU	European Union
EU15, EU-15	15 EU member states before May 2004
EU10, EU-10	10 new member states acceding to the EU in May 2004
EU8, EU-8	8 of the 10 NMS excluding Cyprus and Malta
FCD	Floating car data
FHWA	US Federal Highway Administration
FIN	Finland
FRA	France
GBR	United Kingdom

GDP	Gross domestic product
GER	Germany
GPS	Global positioning system
GRC	Greece
GVA	Gross-value added
HGV	heavy goods vehicle (> 12t gross weight)
HUN	Hungary
IATA	International Air Traffic Association
ICAO	International Civil Aviation Orgainsation
IEA	International Energy Agency
InterP	Production of intermediates
IO-table	Input-Output-table
IRL	Ireland
ITA	Italy
IVEC	Index on vulnerability of the economy to congestion
JIT	Just-in-time
JTV	journey time reliability/variation
km	kilometre
kph	kilometres per hour
LGV	light goods vehicle (< 12t gross weight)
LOS	Level of Service
LP	Labour productivity
m€	Million EURO
MotorV	Road vehicle production sector
MSCP	marginal social cost pricing
NLD	The Netherlands
NLE	Narrow Logistics Expenditure
NMS	10 new member states of the EU as of May 2004
NMS5, NMS-5	5 of the NMS i.e. Czech Republic, Hungary, Poland, Slovenia, and Slovakia
NOR	Norway
OECD	Organisation for economic co-operation and development
OthVeh	Sector for production of trains, ships, planes (= non-road vehicles)
P. T.	Public Transport
PBKAL	Paris-Brussels-Cologne-Amsterdam-London high-speed rail network
PCU	passenger car unit
pkm	passenger kilometres

POL	Poland
PQA	Perceived Quality Approach (for congestion measurement)
PRT	Portugal
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (US Transport Strategy of 2005)
SUV	Sports utility vehicle
SVK	Slovakia
SWE	Sweden
t	tons
TEA-21	US Transportation Equity Act for the 21st Century
TFP	Total factor productivity
tkm	ton kilometres
TMC	traffic message channel
TTI	Texas Transportation Institute
UCT	Unaccompanied combined (freight) transport
UIC	International Union of Railways (Paris)
UK	United Kingdom
US	United States of America
US-DOT	United States Department of Transportation
US-EIA	United States Energy Information Administration
vkm	vehicle kilometres
VOT	value of time

EU and US fact sheet

Table 1: Glance on structural parameters of the EU and the US

		European Union						United States	
	Unit	**EU15**		**EU10**		**EU25**		**US**	
		2000	2004	2000	2004	2000	2004	2000	2004
Area	1000 km²	3,236		738		3,974		9,360	
Population	mill	377	381	75	74	452	455	282	294
GDP (current prices)	bill EURO	8,710	9,963	381	486	9,091	10,449	10,689 (5)	9,434 (5)
Cars	1000	179,020	189,672 (1)	20,567	22,824 (1)	199,587	212,496 (1)	191,930 (3)	205,672 (3)
Motorways	km	51,625	55,093 (2)	2,863	3,038 (2)	54,488	58,131 (2)	55,567 (4)	56,818 (4)
Railways	km	151,781		49,997		201,778		159,792	
Passenger performance	bill-pkm	4,779		972		5,751	5,970	7,586	8,087 (1)
Freight performance	bill-tkm	3,078		385		3,463	3,804	5,383	5,524 (1)

(1) 2003. (2) 2002. (3) includes car, pickups and sports-utility-vehicles. (4) includes interstates, freeways and expressways. (5) in current dollars: 2000: 9,817; 2004: 11,734 bill $.

Source: EC 2002, EC 2005a, ERF 2004, EUROSTAT 2006a, FHWA 2004, own calculations

Foreword

Competitiveness is a key word of today's policy discourse. Nevertheless, competitiveness constitutes a concept with many different meanings and even conflicting definitions. In a US study similar to COMPETE the authors Lakshmanan, Anderson and Li (2005) quote that in the literature the position can be found that the concept of competitiveness can be assigned to companies but not at all to nations. It becomes even more difficult when it comes to the question of how transport fosters competitiveness of a nation.

However, Lakshmanan et al. then argue in a qualitative manner to conclude that the "*physical and non-physical infrastructure of the US transport systems are key ingredients of the competitiveness of US firms in the international arena.*" Though the intention of the authors might have been to present a robust causal chain how transport improved the US competitiveness analysing trade data, transport evolution, transport cost data etc. it is finally a qualitative argumentation stating that high quality transport generates scale economies in capital service provision, logistical savings of time and cost, locational flexibility for companies and national economic integration creating scale economies for transport users and hence improves the competitiveness of the whole nation.

COMPETE tackles the same question of how transport contributes to the competitiveness of the EU and, additionally, how effective it is compared with the US. Though COMPETE broadened the scope of analysis by including congestion impacts, by analysing structural change and by analyses applying economic models the finally proved, quantified causal chain on how transport actually improves competitiveness of nations could not be provided.

COMPETE succeeded in elaborating and quantifying a large number of data for the EU and the US like transport operating cost data, congestion data, trade data, data on the economic and spatial structure and finally the productivity of the transport sector. However, the final step to quantify the impact of transport on competitiveness is left open and, similar to the Lakshmanan et al. study, has to be bridged by a qualitative line of arguments.

The summary of this line of arguments is provided in Table 2 on the following page. Finally we would argue that:

- concerning intra-regional transport the status of the EU transport system with higher sophistication of logistic systems and larger supply of transport alternatives contributes better to the competitiveness of the EU than the US transport system for the US.
- concerning inter-regional transport from or to the EU and the US both transport systems are of equal effectiveness in promoting competitiveness, though the EU system disposes of a more sophisticated port structure and better land connections while the US system has a more developed air transport system.

Furthermore, we would argue that besides the more advantageous spatial structure of the EU compared with the US also the EU transport policy of the past 15 years contributed successfully to improve the logistics system and the co-evolution of alternative modes and by that succeeded to foster European competitiveness, not only as such but also in comparison with the US.

Table 2: Summary of results of the seven COMPETE areas

Area	Topic	EU25	US
Spatial structure	Economic centre	50% of GDP concentrated within <1200 km distance	4 economic centres with distances >3000 km
	Average pop-density of medium size cities	2,280 persons/km² for 122 cities with 0.2 to 1 million inhabitants	1,360 persons/km² for 90 cities with 0.2 to 1 million inhabitants
Transport policy	Similar national and supra-national objectives	Balancing modes, eliminating bottlenecks, user orientation, globalisation, efficiency, safety, security	Safety, mobility, global connectivity, environmental stewardship, security, put people first
	Similar policy implementation	Planning and creating supra-national transport infrastructure	Planning and creating supra-federal-state transport infrastructure
		Foster transport innovations	Foster transport innovations
	Policy differences	Focus on transport charging	Focus on low fuel taxation
		High-speed rail network	Few high-speed rail lines
Operating cost	Transport expenditure	19% of GDP in 2005	24% of GDP in 2005
	Unit cost passenger in 2005	Road: 27 EUROcent/pkm rail: 17 EUROcent/pkm	Road: 23 EUROcent/pkm rail: 11 EUROcent/pkm
	Unit cost freight in 2005	Road truck: 14 EUROcent/tkm rail: 11 EUROcent/tkm	Road truck: 20 EUROcent/tkm rail: 1 EUROcent/tkm
Congestion	Policy priority	Top priority	Top priority
	Public view	More severe problem	Not a severe problem, growing importance
	Congestion monitoring	Fragmented, best for air transport, mostly kept private for rail	Urban roads and air well-developed, else fragmented
	Urban road transport	In capitals and urban arterials	In urbanized areas
	Interurban road transport	In EU economic centre	Port hinterland and highway crossings
	Rail	Inter-operability at border crossings, high speed and port hinterland	Systematic punctuality problem at long-distance services
	Ports	Rotterdam approaches limits, most other ports well below capacity	Most ports at capacity, limited alternatives esp. at Pacific Coast
	Airports	Severe for major hubs and related network carriers	Severe for Eastern US hubs; top-5 airports below capacity limits
	Most affected sectors	Transport services (esp. road freight, airlines, logistics), food, retail	Transport services (esp. airlines)
Structural change	Trade	Strongest growth Intra-EU	Strongest growth NAFTA, China
	Logistics	Strong growth of logistics sector	Moderate growth of logistics sector
	Bottlenecks	North-Atlantic ports, central road network, international railways	Pacific ports, some urban road networks
Economics	Productivity of transport	EU15 high growth in 1990ies	Moderate growth in 1990ies
	Total factor productivity of transport (TFP)	TFP differentials partly explained by differences in capital intensity between countries	Similar growth as in top performing countries of EU15
	Share of transport on production	10% in 2002 of which 4.2% transport equipment, 5.8% transport services	6.2% in 2002 of which 3.2% transport equipment, 3% transport services
Competitiveness	Intra-EU and Intra-US transport, respectively	Though more congested, the transport system in the EU seems to be less constrained due to advantages of spatial structure, partially less costly modes, higher sophistication of logistics and the greater supply of alternative modes. Hence, it better contributes to the competitiveness of the EU than the US transport system for the US.	
	International transport from/to EU or US, respectively	Advantages of the EU ports system and availability of more land connections stand against the more developed US air transport system such that Europe gains in global freight shipment competitiveness, while the US manages global passenger flows more efficiently. The relatively higher dependency of air transport increases US vulnerability (security issues are influencing quality and capacity more and more).	

Source: COMPETE

Executive summary

Background

The European Commission tendered this study broadly to analyse the importance of transport in fostering European competitiveness and to capture the role of a number of influencing factors shaping the impacts of transport, in particular the operating cost and congestion. A core element of the analysis should be the comparison between the EU and the US. The main objectives of the COMPETE project are fivefold:

- To analyse past, current and expected future trends of operation costs of transport for the EU and US.
- To draw a Panorama of Congestion for the EU and the US.
- To describe trends of structural economic change and their potential impacts on transport.
- To investigate how changes in costs and congestion, in economic structures as well as of transport policies affect the productivity of the transport sectors, and
- To estimate how the transport system itself influences productivity and competitiveness of the European economies.

Transport policies in the EU and the US

The broad concepts of transport polices in the EU and the US are comparable, as the EU formulated in its White Paper of 2001 the four main objectives (1) shifting the balance between modes of transport, (2) eliminating bottlenecks, (3) placing users at the heart of transport policy and (4) managing the globalisation of transport. The US sets out in the strategic plan for 2003 to 2008 the objectives (1) safety, (2) mobility, (3) global connectivity, (4) environmental stewardship and (5) security. Of course, the latter objective was also considered in the EU as a high priority after the terrorist attacks in September 2001.

Also both, the EU and the US have recently highlighted the objective of transport to generate innovations and vice versa the need to bring innovations into the transport system, in particular new propulsion concepts and alternative fuels. In terms of introduction of transport pricing policies the US is converging towards the EU, as the latter is promoting transport pricing since about a decade while in the US only in recent policy programs transport pricing is considered as an option to be tested in pilot applications.

Another significant difference between the two policy approaches concerns fuel taxation. In the EU countries fuel taxation is about five to fifteen times higher than in the US. The usage of fuel tax revenues in the US is strictly dedicated for infrastructure provision, in particular highways, while in some EU countries at least a share of fuel tax revenues goes into the general government budget.

Besides a reflection on the transport policies in the EU and the US a glance on the actual situation of transport should provide the starting point for the following analyses. Table 3 presents the modal-split for passenger and freight transport for the year 2000 comparing the

EU15 with the US. Obviously car transport is the dominating mode of passenger transport for both regions. In the EU15 rail and bus attract significantly higher shares than in the US, while air transport is nearly double in size in the US than in the EU15.

For freight transport the differences are even more significant with road being the strongest mode in EU15 while it is rail in the US[1], though road also holds a strong position in the US. The most amazing differences for freight transport concern rail and sea shipping which differ by about five times with rail being stronger in the US and sea shipping in the EU15.

Table 3: Passenger and freight modal-split at pkm and tkm for EU25, EU15 and US [%]

Passenger modes	**EU25 2003**	**EU15 2000**	**US 2000**	**Freight Modes**	**EU25 2003**	**EU15 2000**	**US1 2000**
Passenger car (1)	76.8	77.8	84.8	Road	43.5	44.3	29.8
Bus / coach	8.1	8.6	3.4	Rail	10.1	8	38.3
Railway	5.8	6.4	0.3	Inland waterways	3.3	4	9.4
Tram + metro	1.2	1.0	0.3	Oil pipeline	3.4	2.7	15.1
Waterborne	0.6	0.5		Sea (domestic/intra-EU)	39.6	40.9	7.4
Air (domestic / intra-EU)	7.5	5.9	11.2				

Source: EC 2003, EC 2005c, (1) including two wheelers and light vans in US

Despite these differences in the actual transport situation - which to a significant extent are due to the different geographic structure of the EU and the US with longer travel distances in the US - the transport policies in both world regions are rather congruent with respect to the core topics of COMPETE i.e. to reduce transport cost and congestion, to improve transport productivity and overall competitiveness.

Total operating cost in the EU and the US

Total operating cost in the EU25 account for 1982 bn EUR or 19% of GDP. For the US, the corresponding figure is 2’278 bn EUR or 24% of national GDP (see Table 4). The biggest part in the EU25 are operating cost for road passenger transport (64%). The second largest part is road freight transport with 22% in EU25. In contrast, in the US road passenger and road freight transport reach similar shares with 45% for the former and 47% for the latter. The total operating costs for the other modes (rail, air, water) are in both regions considerably lower.

---

[1] A recent publication of the US-DOT (2006a) provides different modal shares for freight given as composite estimates measured in terms of ton-miles for the single modes in the year 2002: road: 37.2%, rail: 33.7%, inland-waterway: 11.9%, air: 0.3%, pipeline: 16.9%. The difference emerges due to the inclusion of a number of sectors that in statistics derived from the US Commodity Flow Survey (like the one shown in Table 3) have not been considered.

Table 4: Total transport operating cost in the EU and the US (2005) in [bn. EUR]

Transport mode	EU15	NMS5*	EU25**	USA
Road passenger	1'239	37	1'276	1'039
Road freight	420	20	441	1'072
Rail	84	7	92	26
Air	155	6	162	137
Water	12	n.d.a.	12	4
Total	**1'911**	**71**	**1'982**	**2'278**

** NMS5 means the following 5 countries of EU10: Czech Republic, Hungary, Poland, Slovenia, and Slovakia. ** Without Baltic countries, Malta and Cyprus. n.d.a.: no data available. Source: COMPETE calculations.*

The most important influencing factor on total operating cost (i.e. total expenditures of transport users for their transport activity) is transport performance of each country, which is based on national transport statistics. Comparing the total operating costs in relation to GDP of European countries, Western Europe has a higher share of GDP than Eastern Europe (calculated for NMS5). Looking at the different countries, we observe a high share of costs in the US as well as in Finland, France and Denmark and a low share in Slovakia and Ireland (see Figure 1).

Several reasons are to consider in order to interpret the country-wise results properly. A main reason is the higher share of individual passenger transport due to higher income (e.g. higher density of cars, more leisure trips). This explains the relatively lower share of costs to GDP in Europe. Another reason is the national transport levels, for example the high level of passenger and freight kilometres per capita or per GDP of US and Finland compared to other European countries. A third element (as well true for Finland) is the level of average costs. Finland for example reveals – compared to other countries – rather high costs per vehicle kilometre as well as high freight transport intensity. The US on the other hand have rather low costs per vkm, but also a high (freight) transport intensity with comparably lower efficiency (e.g. load factors).

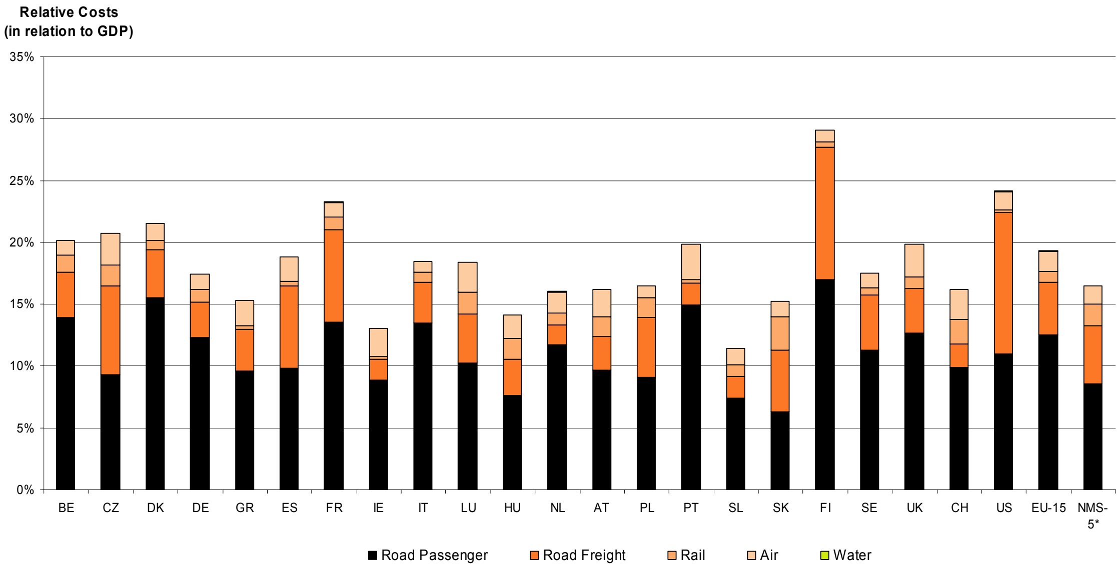


Figure 1: Total operating costs in relation to GDP

Source: COMPETE calculations. See section 2 and COMPETE Annex 1.

Average operating cost

Average operating cost can be distinguished per unit of transport performance (pkm or tkm) and per vehicle-kilometre (vkm). These values differ significantly between the different regions of the EU and the US. In some cases, the EU provides more efficient transport services while in others it is the US. Table 5 and Table 6 show that for road transport it is always that the EU15 is the most expensive region in terms of cost per vkm, followed by the US and the NMS (here NMS5). However, due to the higher load factors in the EU15 the cost per tkm of road freight transport is most expensive in the US followed by the EU15 and then the NMS.

Table 5: Average transport operating costs per veh-km in the EU and the US (2005) in EUR/veh-km (for rail: EUR/train-km)

Transport mode	**EU-15**	**NMS-5***	**EU25****	**USA**
Passenger cars (EUR/veh-km)	0.43	0.21	0.42	0.29
Buses (EUR/veh-km)	1.87	0.67	1.78	1.77
Coaches (EUR/veh-km)	1.33	0.59	1.22	1.42
HDV (EUR/veh-km)	0.89	0.34	0.85	0.87
LDV (EUR/veh-km)	1.11	0.46	1.03	1.00
Rail (passenger & freight) (EUR/train-km)	27.74	11.42	24.99	23.77

** NMS-5 means the following five of the ten new EU member states: Czech Republic, Hungary, Poland, Slovenia, and Slovakia. ** Without Baltic countries, Malta and Cyprus.*

Table 6: Average transport operating costs per passenger-km and ton-km in the EU and the US (2005) in EUR/pkm and EUR/tkm

Transport mode	**EU-15**	**NMS-5***	**EU25****	**USA**
Passenger				
Passenger cars (EUR/pkm)	0.28	0.10	0.27	0.23
Buses (EUR/pkm)	0.12	0.04	0.11	0.20
Coaches (EUR/pkm)	0.10	0.03	0.09	0.07
Rail passenger (EUR/pkm)	0.19	0.03	0.17	0.11
Air passenger (EUR/pkm)	0.45	0.77	0.46	0.15
Freight				
HDV (EUR/tkm)	0.15	0.07	0.14	0.20
LDV (EUR/tkm)	5.39	1.81	5.05	3.46
Rail freight (EUR/tkm)	0.12	0.06	0.11	0.01
Air (EUR/available tkm)***	0.75	0.84	0.75	0.47
Short Sea Shipping (EUR/tkm)	0.009	n.d.a.	0.009	0.004
Inland Waterways (EUR/tkm)	0.008	n.d.a.	0.008	0.006

** NMS-5 means the following five of the ten new EU member states: Czech Republic, Hungary, Poland, Slovenia, and Slovakia. ** Without Baltic countries, Malta and Cyprus. *** available tkm rely to passenger and freight transport. n.d.a.: no data available.*

Source: COMPETE calculations. See section 2 and COMPETE Annex 1.

Future trends of operating cost

Due to a number of trends the **average operating cost** for transport is expected to slightly rise in the future. Major reasons will be the continuous increase of quality of transport, the increase of fuel prices due to a number of reasons like scarcity effects or climate policy approaches. Dampening effects would come from the further liberalisation process in Europe and the modal-shift e.g. towards rail presupposed that rail transport further improves its quality.

The **total operating costs** are expected to grow even stronger due to the combination of real price increases and growth of transport demand.

Panorama of Congestion

The COMPETE project has developed a detailed Panorama of Congestion by interviewing experts in all European Member States, the US and Switzerland, supported by global as well as country-wise literature reviews on transport quality measures, the status of congestion and related policy options. The interviews were based on a questionnaire that partially is filled by international experts and partially by COMPETE project partners on the basis of telephone interviews and literature reviews. In addition, two separate case studies on comparing the situation in European and US airports and seaports have been carried out as these two markets appear highly dynamic.

Table 7 briefly summarises the findings by mode and draws a direct comparison between Europe and the US (for details see section 3 and Annex 3). It gets obvious that, besides aviation, the EU is facing less congestion problems than the US. Thus, the EU seems to be better prepared to take the expected rise in international freight transport. In particular the better situation in seaports makes Europe competitive in the fast growing trans-continental logistics market.

Table 7: Synthesis of country reviews

Mode	**Europe**		**US**	
Inter-urban roads	Mainly Randstad and Ruhr areas and urban access	**C** ↘	Highway intersections and around agglomerations	**B** ↘
Urban roads	Severe congestion in some cities, no general problem	**C** ↘	Steadily increasing but not perceived as major problem	**D** ↘
Rail	Only at port hinterland lines; technical standards	**B** →	Considerable lag in grade-separated facilities in major lines	**D** ↘
Aviation	Problems in major hubs (London, Paris); airspace	**C** ↘	Constant investments and still recovery from 9/11	**B** ↗
Waterborne transport	Only port hinterland transport (Rotterdam)	**B** →	Port capacity and congestion on hinterland routes	**D** ↘

Legend: A (= congestion-free) to E (totally congested): Current situation. ↘↘ (fastly declining quality) to ↗↗ (clearly improving conditions): expected future transport system quality

Panorama of Congestion: interurban road transport

Quantitative information from official studies on inter-urban road congestion in Europe and the US is sparse and heterogeneous. The most comprehensive data sets are provided by the UNITE project (Nash et al. 2002) and by Maibach et al. (2004) mainly for Western European countries (Figure 2).

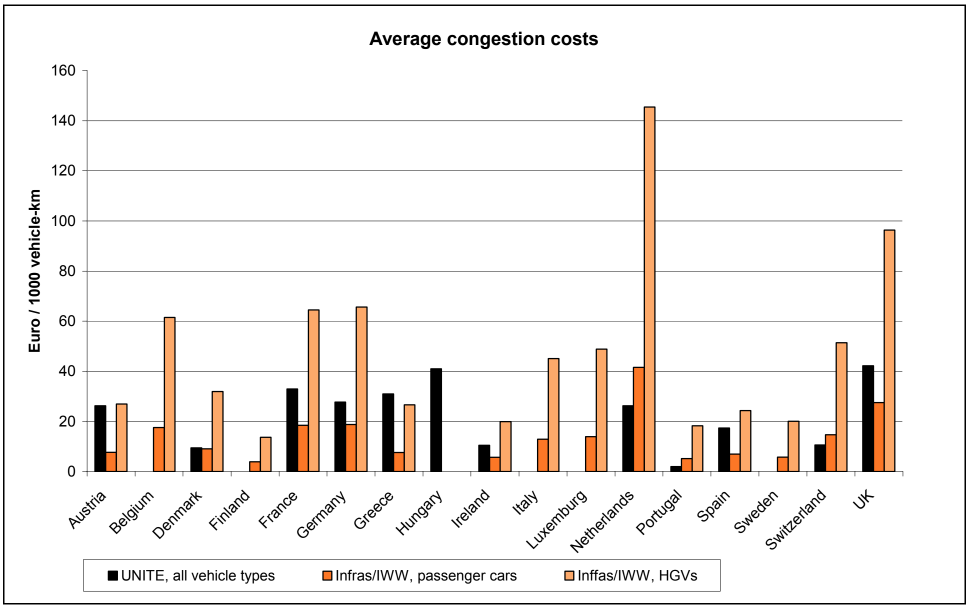


Figure 2: Average congestion costs for EU15, Switzerland and Hungary

Source: Infras/IWW: Maibach et al. (2004), UNITE: Nash et al. (2002)

The state of road congestion across Europe differs between countries and regions:

- Germany, the Benelux countries and the southern part of the UK take an outstanding position as here the density of large urban areas causes considerable congestion on the entire trunk road network.
- France, Poland, Spain and a number of periphery countries perceive congestion on the trunk road network as a problem around urban areas.
- In particular in Poland an additional problem is the poor physical quality of trunk roads.
- In a large number of periphery countries, including Scandinavia, the Baltic countries, Slovakia, Slovenia and Greece inter-urban congestion is not a real issue.
- The Alpine countries are mainly affected by congestion caused by holiday and leisure car traffic. But different to Switzerland, the Brenner route in Austria suffers a congestion risk from heavy lorry traffic.

In the US inter-urban congestion is a problem at interstate highway crossings and around metropolitan areas. In particular hinterland connections to important ports are frequently congested. Nevertheless, across the entire country congestion currently appears much less expressed than in Europe.

Forecasts of congestion for the US and for most European countries assume a rise in congestion levels. This appears particularly alarming for the anyway highly congested areas in the UK, the Netherlands and the Ruhr area, but also for US interstate highway crossings.

Panorama of Congestion: urban road transport

Urban road congestion to a large extent depends on the size of the city and on the (non-) availability of high quality alternative modes. Table 8 presents the travel time index, e. g. the ratio between average and free flow speeds in peak traffic, for some European cities and for an average over 85 US urban areas, where available over time.

Table 8: Travel time index in EU and US cities 2003

Area	Travel time index		
	1993	2004	1993-2004
Paris, Ile-de-France		1,34	
Greater Copenhagen area		1.40	
Greater London		1.84	
Average of other English cities	1.24	1.32	0.08
US 85 Area Average	1.28	1.37	0.09
US Very large average (13 areas)	1.38	1.48	0.10
US Large average (26 areas)	1.19	1.28	0.09
US Medium average (30 areas)	1.11	1.18	0.07
US Small average (16 areas)	1.06	1.10	0.04

Source: Own estimations; Schrank and Lomax (2006)

The most congested urban areas are located in the UK, in Central and in Southern Europe. The most affected agglomerations are Paris, London, Prague, Athens and the big Spanish and Italian cities. In some cases, e. g. Prague, peak traffic has spread out to the off-peak periods, such that off-peak is only visible during night time. For other big and medium-sized capitals, such as Berlin, Zurich, Vienna, Warsaw, Stockholm, Helsinki or Copenhagen usual peak hour or only mild congestion is reported. In most of these cases congestion is rather a problem of access links as is reported for Polish and French Conurbations.

Though the TTI Urban Mobility Study (Schrank and Lomax, 2006) reports a significant increase in urban congestion, remarkably, it is not considered a major problem for most US citizens as the ability to relocate to non-congested areas within a city or across states is high. Other urban problems, such as security, school quality and environment, are considered more severe. The TTI mobility index shows that congestion rises more dynamically in large and medium sized areas than in very large agglomerations.

Panorama of Congestion: rail transport

Comparing annual punctuality figures of European and US railways (Figure 3) indicates, that European companies are generally more punctual than Amtrax on the US. But it also gets obvious that long-distance services are less reliable than local services

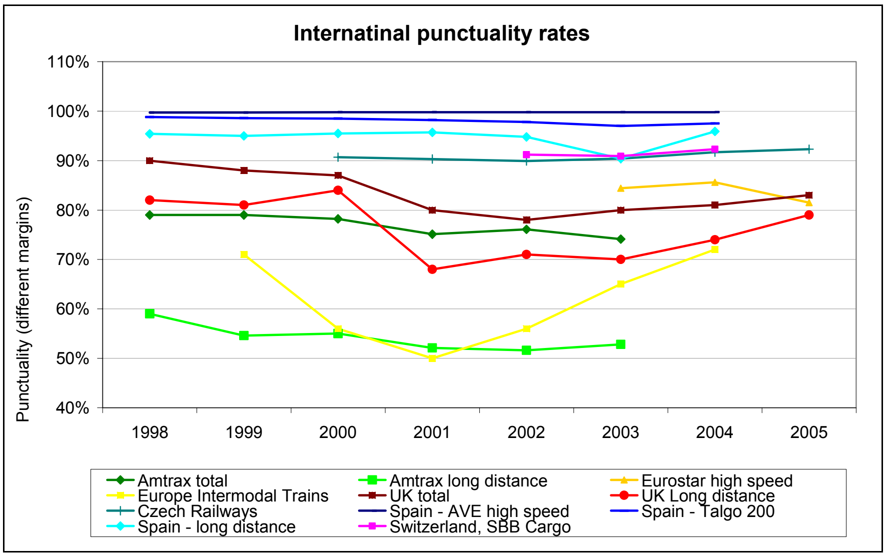


Figure 3: Time series of punctuality data for selected railway undertakings

In Europe major rail bottlenecks include the French high speed lines, French and German lines which have not been upgraded for high speed trains (e.g. East-West connections in France and the Rhine axes), and the connections from Dutch seaports to the German border. Further, capacity shortages on the German network reach out to Switzerland and to the Netherlands. The New member states report that the physical quality of the network, of the stations and the rolling stock, incident and track works cause more delays than pure capacity restraints.

Due to missed investments in the past, US networks are even more congested. Major bottlenecks are the lag in grade-separated facilities in the Los Angeles and Chicago regions causing considerable problems in freight shipment.

Panorama of Congestion: aviation

For Europe the results show capacity shortages at the London airports, being much more critical than at other major hubs, such as the Paris airports, Frankfurt or Madrid. Most of the US airports have still not recovered from the 2001 crises. Among the top-5 US airports only Los Angeles urgently suffers from congestion and in Atlanta some problems with ATM delays are indicated. Chicago, Dallas and Las Vegas operate below their capacity limits and show no signs of severe congestion.

Comparing the long-term trends in overall delayed flights between Europe and the US (Figure 4) reveals that delay rates in the two regions across all airports are similar, but the EU development appears slightly more dynamic. While until the mid 1990s intra-European flights have been more on time, their punctuality has dropped significantly after the Kosovo conflict in 1999 and since then has remained worse than US punctuality figures.

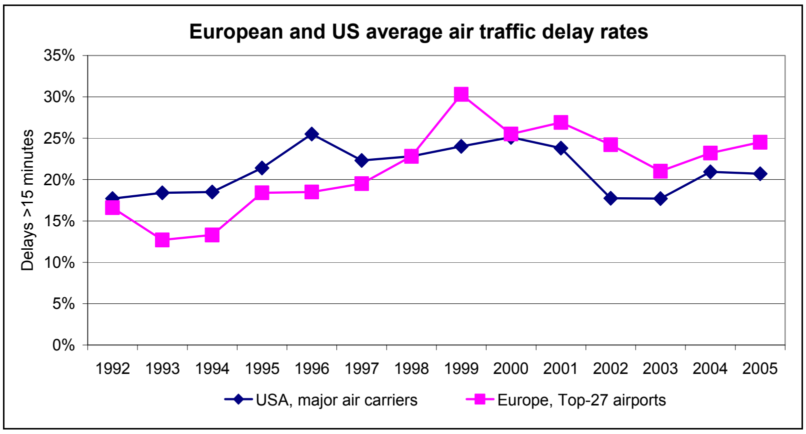


Figure 4: Long-term comparison between delay rates in US and European air transport

Sources: BTS (2006) and AEA (2000 to 2006)

Panorama of Congestion: waterborne traffic

Case studies of 20 European and US ports and the COMPETE country reviews show a clear discrepancy between the highly congested US ports and the European market. EU ports and inland navigation networks do not operate under full capacity utilisation and thus are ready to take the strong increase in container movements expected for the coming decades. In contrast, the US faces a strategic problem as most ports are located within urban areas and thus can not be further expanded.

International practice of measuring congestion and delays

In road transport there are several applied approaches to measure congestion, which widely differ between countries in Europe. In England annual measurements of travel speeds on urban and inter-urban roads are performed since 1993, while since 1998 in the Netherlands the extension and duration of traffic jams on motorways are automatically detected and assessed and the region of Ile-de-France continuously evaluates speed and flow measurements on motorways. Other countries or regions, such as Germany, Switzerland, the French Mediterranean arc, Scotland and the Greater Copenhagen Region perform one-off studies on traffic congestion mainly based on modelling traffic flows. The most continuous and comprehensive approach, however, is followed by the US. The Urban Mobility Study models urban congestion in 85 areas of different size using time series of traffic flows dating back to 1982.

In scheduled transport the measurement of delays is rather straightforward compared to road transport. To maintain operations, railway companies are generally well-informed about level and causes of delays. However, to large extent these delay statistics are kept secret. Flight delays in Europe are published by Eurocontrol and by the Association of European Airlines' (AEA) annual consumer reports since 1999. Similar reports are available for the US Department of Transport. Delay statistics in the shipping sector are only kept by some ports for internal controlling purposes.

European approach for congestion measurement

The review of studies in the field and the Panorama of Congestion have shown that the US and Canada are quite advanced in measuring and monitoring congestion on their road networks, compared to Europe. Although there are interesting indicators in some Member States, a regular monitoring of road congestion between countries is hardly possible. Hence, on the basis of the studies reviewed the following recommendations for a harmonised and pragmatic approach for congestion measurement in Europe emerge:

- Congestion monitoring should be based on transparent indicators which can be measured regularly. Most interesting are delay based indicators (in relation to a benchmark such as free flow travel speed for road transport and a maximum late time in scheduled services).
- The delay monitoring must be dynamic by providing robust time series and it must reflect the compliance of current traffic quality with policy targets. Therefore the reference travel speed in road transport or the delay margin in air traffic must be held constant over time. For road 60% of free flow or maximum permitted speed is recommended. In rail passenger 5 minutes and in high quality rail freight and in aviation 30 minutes delay margins are recommended.
- Most urgent is the elaboration of a European system of a quality monitoring for road transport, based on traffic speed monitoring on specific sections and daytimes and the development of representative speed-flow functions across Europe, especially focussed on the TEN-T network and on critical urban access links.
- In first instance recurrent congestion on a selected day in the year should be monitored in road transport. In a later stage all delay causes should be added by establishing a continuous monitoring scheme. In scheduled transport all delay purposes by delay cause should be considered.
- Data sources in road transport are speed and flow measurements by automatic counting posts (UN, national or local) or floating car vehicles. Speed-flow diagrams should be estimated case by case to capture local conditions.
- Further it is recommended to establish a European road traffic control centre harmonising and assessing traffic messages. As a very first step towards such a system for traffic conditions the daily number of traffic messages can be evaluated by severity and cause towards an initial traffic quality indicator. This approach is in particular suitable for motorways.
- For rail transport it is recommended to enforce railway companies to present detailed annual delay statistics, comparable to the Eurocontrol analyses in air transport. In a second stage the analysis of additional time losses due to missed connections is recommended (for rail and hub airports).

Index on vulnerability of the economy to congestion (IVEC)

Since, only the transport sector itself disposes of partly quantitative information on the economic vulnerability to congestion and related costs of congestion we developed a quantitative indicator measuring the sectoral vulnerability to congestion, the so-called *Index on vulnerability of the economy to congestion* (IVEC).

The IVEC combines quantitative information on the transport intensity of the different sectors and data from the input-output-tables together with qualitative information on a sector like the relevance of Just-in-Time production patterns, the involvement in transport chain issues, the perishableness of goods, the relevance on the demand side such as delivery to clients in urban areas and the quality of infrastructure.

The IVEC was calculated for 11 countries including the US. Taking the sectoral average across the 11 countries it revealed a high vulnerability to congestion for the transport sectors themselves, the food and retail sector and the agricultural products sector as well as some service sectors that provide services in urban areas like health and social work as well as post and communications sector.

The IVEC can then be aggregated on country level for the 11 countries to provide an aggregate picture for the **potential** vulnerability of the countries to congestion. This potential reflects quantitative aspects like transport intensity and sectoral structure as well as qualitative elements like quality of domestic infrastructure. The calculation of the IVEC then results into **four groups of countries in terms of their economic vulnerability to congestion**:

- Group 1 "Low vulnerability": Czech Republic, Germany, Hungary.
- Group 2 "Mean vulnerability": Spain, US, France.
- Group 3 "Increased vulnerability": Poland.
- Group 4 "high vulnerability": United Kingdom, Netherlands, Finland, Denmark.

The IVEC does not show whether a country suffers today from congestion, but whether the economic structure of a country (of sectors and transport intensity per sector) is generally more or less vulnerable to congestion. This means if two countries have a similar high level of congestion, the country with a higher IVEC will be more negatively influenced in its economic performance e.g. due to the specific sectoral structure.

A comparison of IVEC information with the Level-of-Service (LOS) information from the Panorama of Congestion provides insights on for which countries the economic development is already burdened by negative impacts from congested (inter-urban) roads. Three examples can be distinguished:

(a) *Finland* has a high vulnerability to congestion (IVEC=167) but the LOS-indicator is "A" for inter urban roads, such the Finland has to take care that LOS-indicator does not detoriate in order to avoid retarding influences from congestion on economic activity.

(b) *Germany* has a low vulnerability (IVEC=86) but a LOS-indicator of "D" for inter-urban roads, such that despite of a poor LOS-indicator the German economy is not strongly negatively influenced by congestion because the general structure of the economy is not very vulnerable to congestion.

(c) The *Netherlands* have a quite high IVEC (=156) and a LOS-indicator of "E" on inter-urban roads, so the economic development is already suffering from congestion.

Hence, out of these three countries the combined IVEC and LOS indicators would suggest that additional investments to improve inter-urban road capacity would be most effective and efficient in the Netherlands.

Impact of congestion on transport users

Since businesses could take a number of strategies to avoid or minimize the negative impacts of congestion, interviews with representatives of different sectors have been conducted to find out how congestion is perceived by the sectors and which countermeasures are taken. The interesting picture emerged that – besides the transport sector itself – most sectors do not see congestion as a problem for the success of their business. Based on the interviews and a literature review on the potential impacts of congestion, we draw the following conclusions:

- The economic consequences of congestion must be differentiated into GDP-relevant and not-GDP-relevant. GDP-relevant are the direct costs by suffering and avoiding congestion and the indirect costs due to decreased reliability of different economic sectors. In addition, congestion has an increasing effect on labour cost. Not GDP relevant are the time losses of passenger transport, except for business purposes (e.g. delays in air transport).
- The transport sector is highly affected and vulnerable to congestion, especially road transport, if non recurring congestion is affecting reliability. As a potential cause of loss of clients, reliability can be much more important than direct costs. Therefore the transport and logistics sector use several strategies such as night haulage, information and planning instruments to increase reliability. Besides the transport sector, the food and retail sector with delivery to urban areas is very vulnerable to congestion as well. Both confirm the results of the IVEC sectoral indicators.
- For other sectors, congestion is not seen as a major problem, although the relevance is increasing. Congestion is one (amongst many others) factor to induce change of location (e.g. shopping and production sites) leading to urban sprawl.
- It is difficult to pass congestion costs over to consumers in the freight sector. Quality differentiation is only common for specific transport services, such as express delivery and high speed rail, where penalties for late arrival are used.
- In order to quantify economic impacts of congestion costs, the value of time (VOT) approach is most relevant. It covers however not all related costs. Most important is an additional valuation of reliability. The empirical relevance is quite heterogeneous. Most scientific studies point out that the size of reliability costs is about 10 to 20 % of the value of time costs. At maximum – according to road hauliers replies – the ratio can reach more than 100%. A differentiation according to economic sectors might be useful, since the relevance varies between sectors and countries considerably.

- There are influences of congestion on competitiveness between modes of the transport sector. In general, rail transport is supposed to profit from congestion in urban areas and specific corridors. Intra-modal distortion in competitiveness is however not significant. The vulnerability between European countries and the US is quite different, depending on the structure of the economy, the transport intensity and the quality of infrastructure. The vulnerability is higher in Northern&Central European countries with high network density and Eastern European countries with low infrastructure quality. Compared to that the vulnerability of the US transport sector is less significant, besides for the US air transport sector which is facing strong competition and hence is rather vulnerable to congestion.

In order to consider the different economic impacts, measures to overcome congestion must be seen in a broader context. Besides efficient pricing and infrastructure enlargement, incentives to shift to public transport in urban areas and sensitive corridors, information systems in order to anticipate congestion properly, quality controlling and penalty systems for fair pricing of transport and maximal conditions for environmentally sound use of off peak situations (esp. night haulage) and increase of load factors are important. The EU policies in regard to improvement of rail interoperability, road management systems and air traffic management play an important role to improve transport infrastructure quality and to minimise economic impacts of congestion.

Mega-trends, structural changes and impacts on logistics

The most dominant trend is globalisation, of course. The globalization process must be understood as a set of inter-connected world-wide mega-trends, with relevant impacts on logistic processes at micro level and, consequently, on transport systems. The main mega-trends can be identified as follows:

- **Population change**, that can affect the transport sector in several ways: an increase in population increases transport demand (both for passengers and freight) with a potential source of congestion; or the reduction in population expected for many EU countries in the years to come can affect negatively, for instance, the sustainability of public transport systems through the revenue side and reduced population density.
- **Opening of national economies**, with the entry of new international economic players like China and India, the creation of multinational free trade areas (like NAFTA or the EU Internal Market) and the subsequent rise of international trade.
- **Increase of international investment**, with the global spread of activities of the multinational enterprises that extend their production and distribution activities to several countries throughout the world.
- **Advances in technologies**, turning information and communication equipments portable, cheaper and affordable, triggering the emergence of new services and products and allowing a reduction in information and communication costs of transport, stimulating the global interchange of products.

Scaling down these trends to Europe they imply an integration of the New Member States (NMS) into the internal market, a continuous increase of Intra-European trade flows, a strong increase of trade flows to and from China and India, a specialisation of EU15 on the production of high-technology manufactured goods and a secondarisation of the NMS economies.

These trends translate into a number of developments shaping future logistics in particular (1) the concentration of production at specific locations to gain economies of scale and economies of density, (2) the development of hub-satellite networks (for similar reasons), (3) the increase in vehicle size (again economies of scale, and scarce infrastructure), and (4) the growing use of inter-modal loading units.

Potential bottlenecks for European logistic systems in the future

The described mega-trends and the resulting transport and logistic trends adapt future European transport flows in terms of modal-split as well as direction and size of flows. Considering the capacity and the quality of infrastructure in European regions five major potential bottlenecks for long-distance transport can be identified:

- Ports bottleneck in the North-Atlantic and Baltic ports, which offer good quality infrastructure but, in some cases operate close to capacity.
- Railway bottleneck in Eastern Europe due to partially low quality infrastructure and problems with interoperability and cross-border integration of networks.
- Railway bottleneck in Southwest Europe due to significant interoperability problems and partially low quality networks that are poorly interconnected.
- Road bottleneck in Eastern Europe due to high density of transport flows running on networks of varying quality and facing significant local bottlenecks.
- Road bottleneck in Central Europe due to high density of transport flows operating already close to capacity and facing significant regional bottlenecks.

Impact of transport infrastructure on economic growth

To analyse the impact of transport infrastructure on economic growth two approaches have been followed: first, a thorough literature review collected the state-of-the-art in terms of empirical findings and in terms of setting-up economic models to analyse the impacts for the European countries, and, second, two such models have been set-up and calibrated to analyse the impact of past investments onto transport infrastructure. The following findings could be derived from the two approaches:

- Economic theory suggests that transport infrastructure promotes economic growth by reducing transportation costs – thereby increasing specialisation and the degree of division of labour - promoting the development of spatial clusters of economic sectors and promoting innovation.
- Our review of the empirical evidence of the impact of infrastructure on economic growth suggests that the elasticity of output with respect to public capital is in the

0.1-0.2 range, i.e. a one per cent increase in public capital would tend to increase output by 0.1-0.2 per cent.

- Our growth model suggests that a plausible figure for the elasticity of output with respect to public infrastructure is at the bottom of or even slightly below this 0.1-0.2 range.
- On macroeconomic level, we did not find convincing evidence that transport infrastructure is too low in the EU (or, equivalently, that the rate of return to transport infrastructure expenditure is higher than the cost of funds) or too low relative to the US.

Productivity development of transport and impacts on other sectors

Three steps have been undertaken to analyse the productivity of the transport sector both in relation to transport policies and their impacts on productivity and in relation to productivity impacts on transport using sectors. First, data and literature on the productivity development of transport in the EU and the US is collected and analysed. In parallel, labour productivity and total factor productivity (TFP) are considered. Second, an econometric analysis of the influence of transport policies on transport productivity is undertaken, focusing in particular on infrastructure and liberalisation policies. Third, again applying an econometric analysis TFP growth of transport using sectors is linked to TFP growth of transport sectors. The following findings could be obtained by the analysis:

- Labour productivity growth in the transport sector has been higher in the past 15 years in the EU than in the US and, as a result, labour productivity levels in the transport sector are high relative to the US. There is also evidence of a process of convergence in the levels of labour productivity in the transport sector within the EU.
- The econometric evidence suggests that countries with less technology advanced transport sectors tend to experience faster productivity growth rates in their transport sectors.
- Liberalisation has limited direct effects on productivity growth in the transport sector, but instead appears to work indirectly by making catch–up more rapid and by increasing the productivity impact of additional infrastructure expenditure.

Economic importance of transport

The two transport sectors, i.e. manufacturing of transport equipment and transport services, constitute an important element of the European economies, which developed different than in the US. The importance of transport as a self-contained economic sector can be measured as its contribution to employment and production of the different economies. Comparing the two regions EU15 and US it can be stated that about 10 years ago transport equipment was of similar importance contributing about 1.4-1.8% of total employment. This declined slightly to 1.2-1.5% in 2002. Transport services have a roughly double-size share than transport equipment on employment and remained nearly stable between 1995 and 2002 for the US and the EU15.

More significant are the differences of the contribution of transport to the total production of the economies. For transport equipment we first observe that the share on production is more than double the share on employment both in 1995 and even more pronounced in 2002, and second that in the EU15 the share is growing until 2002, while it decreases in the US. The share of transport services develops similarly with a slight decline in the US and a moderate growth in the EU15 between 1995 and 2002.

In total in 2002 the share of the two transport sectors on production amounts to 10% for the EU15 and 6.3% for the US. A significant part of this difference of importance of transport between the EU15 and the US emerged in the period between 1995 and 2002, which is actually a period where a number of European transport policies and developments became effective, such that it can be argued that the EU policies contributed significantly to this positive development. Two things should be kept in mind looking at these results: first, different data sources provide a bandwidth of results e.g. looking at input-output tables, which are not available for all countries for both points of time, the share of transport on total production value also amounts to about 10% while taking the values of the EUROSTAT Structural Business Statistics transport would account 13% of total production value of the EU25. Second, this result refers to monetary values and hence is not valid in the analysis of decoupling of transport, which focuses on decoupling of physical units (volume or performance) from monetary units (GDP).

Impact of transport on competitiveness

Three approaches enable to describe the impact of transport on competitiveness: first, the share of transport cost on total product cost indicates the potential impact of transport on the competitiveness of the transported goods. The ECOTRA study (TRT 2006) showed that besides for agricultural products with at maximum 10% share of transport cost the shares are small and hence the influence of transport on competitiveness according to this indicator is small. Second, and leading to a similar conclusion is the share of transport intermediate input to total output of transport using sectors calculated from the input-output tables. On average the value for the EU15 countries is 2.2% though for some sectors it can be above 10%, which then becomes significant for competitiveness.

Third, an analysis of labour productivity (LP) and total factor productivity (TFP) provides an indicator for competitiveness by comparing LP and TFP across countries. In particular LP in the EU15 showed a strong increase during the 1990ies, which implies increased competitiveness against the US.

However, these indicators for competitiveness are all monetary indicators, though transport also affects other aspects like reliability and travel time which do not show up in these monetary indicators but can be relevant for competitiveness. In particular in the case of reliability this is confirmed by the sectoral interviews of COMPETE.

Impact of European transport policies on competitiveness

The previous analyses have shown that liberalisation together with implementation of new transport infrastructure may induce an improvement of competitiveness of transport sectors. In particular this holds for the railway sector, which in the past 15 years was subject to significant liberalisation and infrastructure policies in Europe. These policies e.g. enabled new entries on the freight rail market that are specialized on specific sectors as well as long-distance cross-border transport of freight rail.

Especially some sectors that are of significant importance for the European economies, like automobiles and chemicals, benefited most from these improvements that fostered the competitiveness of railways. Today it can be observed that both sectors increasingly use railways for their transport purpose (e.g. block trains for automobiles). Since, these sectors are core sectors constituting the European competitiveness on the world markets it can be expected that the European transport policies exerted positive stimuli for this development and hence for European competitiveness.

Conclusions on future transport policies to promote European competitiveness

Basically we argue in COMPETE that the past and current EU transport policy is successful in promoting European competitiveness, though it was not always the core focus of transport policies to foster competitiveness. But also European policies to reduce environmental impacts of transport or to revitalise the railways contributed to two assets that fostered European competitiveness in comparison with the US: first, **the push to generate innovations** coming from environmental policies and policies to promote intermodality and interoperability within the EU transport system, and second, the **supply of transport alternatives** let it be public transport or cycling for urban areas or long-distance rail transport or short-sea-shipping for freight transport. Of course, these policies do not enfold their positive stimuli in short-term but in our comparison of EU and US over 15 years it seems that they significantly contributed to the success of the EU transport system and its provision of services in this period. Hence, we suggest to continue both the environmental policies and the policies to provide transport alternatives always having a close look on how this could contribute to generate innovations for the EU. An example of this would be the shift to light-weight fuel efficient cars as well as alternative transport fuels for road transport that should both reduce environmental impacts and stimulate innovations.

Looking at the US with a fivefold modal-share of rail freight it seems, even when considering the geographic differences, that railways in the EU should reasonably capture a larger share of modal-split in particular in what concerns long distance transport. Hence, policies that foster cross-border rail transport (e.g. interoperability, cross-border rail infrastructure) and rail freight reliability (e.g. dedicated freight networks) are of high importance to catch-up to the US in this feature.

From the mere point of view of competitiveness it would be suggested that the EU aspires to benefit more from its geographic advantage i.e. from the fact that 50% of its GDP is generated in about 20% of its area in the centre of Europe, while the US is facing a situation with four far-off economic centers. Comparably shorter transport distances and high benefits of agglomeration provide such a region with a natural competitive edge, but the transport system has to be enabled to cope with the arising problems of density and potential congestion. Of course, the EU by building up the inter-city high speed network between Paris, Brussels, Cologne, Amsterdam and London (PBKAL), by extending capacity of airports and ports in the region (mainly driven by national and regional authorities) and by encouraging member states to introduce sophisticated road, rail access and airport pricing and traffic demand management systems is aware of the situation, but on the other hand such a policy is constrained by the cohesion objective of the EU, which is putting more emphasis on the connections with(in) peripheral regions of the EU. In particular, the road pricing instruments provided by directives 2006/38/EC and its preceding legislations bares the danger of raising the costs for remote countries to access the core markets of the Community (Viegas at al. (2005)). Here seems to emerge a conflict of objectives between competitiveness and cohesion.

In the EU15 the economic importance of transport services has been grown significantly compared to the US. Improvement of quality of services and in particular reliability of transport services should have contributed to this development. As shown by the user survey on congestion impacts reliability is most important for many transport using sectors. Hence, EU policy to foster competitiveness will have to further increase quality of services and reliability. This could come from a number of different measures like (congestion) road pricing, improved intermodality and interoperability of railways.

An important aspect in the future should be the maintenance of transport infrastructure since deterioration of infrastructure would reduce quality of service and reliability and hence competitiveness. This is in particular important as at the same time in the next few decades a significant share of transport infrastructure reaches an age where it has to be renewed or at least where its maintenance has to be increased to preserve the quality of service. This is a long-term problem and a long-term risk for competitiveness that has to be tackled by long-term strategic planning by the EU. Since this is mostly a national task, the EU task should be to point out to this risk (e.g. by asking for monitoring quality and maintenance of existing infrastructure) and by developing guidelines for undertaking the strategic maintenance planning on national level.

Of course, liberalisation of transport markets in the EU - having reached different degrees of liberalisation for the different modes - promoted EU competitiveness by increasing efficiency and reducing cost. But looking e.g. at US air transport where market liberalisation and deregulation led to a situation that the whole sector over many years produces a deficit and is highly vulnerable to external shocks like the 9/11 terrorist attacks any liberalisation should take care that it does not overdraw. Liberalisation is able to kick-off the causal chain towards more competition, lower prices but also lower margins and hence greater vulnerability e.g. to external shocks but also to the impacts of congestion. Hence, any liberalisation policy has to carefully observe, first, if margins would become too low for the transport sectors to avoid for the sector as a whole not to be resilient against external shocks anymore, and second, if trends towards oligopolistic or even monopolistic market power develop that would reverse the benefits of liberalisation and would establish new barriers to market entry. In such cases, a further liberalisation, though it might bring about further short-term efficiency gains, should not be beneficial for competitiveness in the long run.

Structure of this report

This report is structured into 9 sections. Following this Executive Summary is the brief comparison between EU and US transport policies. Section 2 provides transport operating costs for all modes and section 3 explains the status and measurement of congestion in the EU and the US. Section 4 presents the impacts and the sectoral responses to congestion. Section 5 deals with mega-trends, their influences on logistics and transport as well as the structural economic changes linked to both. Section 6 discusses the impact of transport infrastructure on economic growth, while section 7 describes modelling and impact assessment of productivity in the transport sector. Section 8 uses the previous sections and elaborates on the importance of transport for competitiveness of the EU and the US. This is followed by the conclusions, a section on further research questions and the references. Eight annexes, which are provided as separate documents complete this report.

1 Transport policy in the European Union and the United States

1.1 Strategic policy documents in the EU and the US

The major strategic transport policy documents of the EU are the White Paper on "The future development of the common transport policy - A global approach to the construction of a Community framework for sustainable mobility" (EC 1992) and the White Paper on "European Transport Policy for 2010: time to decide" (EC 2001), which is reviewed by external consultants in detail in 2005 (e.g. De Ceuster 2005). An adaptation of European strategies is published in "Keep Europe moving - Sustainable mobility for our continent" (COM(2006) 314, EC 2006). These strategic documents are accompanied by a number of modal- or topic-related policy documents e.g. on infrastructure funding, on revitalising of railways, on motorways of the sea.

The four major objectives of the 2001 White Paper are (1) shifting the balance between modes of transport, (2) eliminating bottlenecks, (3) placing users at the heart of transport policy and (4) managing the globalisation of transport. The review of this White Paper though confirming the objectives of both previous White Papers slightly shifted the focus and added a new objective by putting less emphasis on modal-shift and more emphasis on efficiency improvements of the major modes, in particular road, and by highlighting that transport is one of the drivers for innovative solutions that could both improve the transport system of Europe and become an asset of Europe to be exported to the world market.

The US transport policy in the last two decades developed through three major acts related to surface transport: the International Surface Transportation Efficiency Act (ISTEA) in 1991, the Transportation Equity Act for the 21st Century (TEA-21, US-DOT 1998) and the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU, US-DOT 2005a) in 2005. Separate acts like the Wendell H. Ford Aviation Investment and Reform Act for the 21st Century (AIR21) in 2000 for air transport covered the other modes. Every 3 to 5 years the US-DOT publishes a strategic plan for about the following 5 years. Currently the Strategic Plan 2003 to 2008 promoting the strategic objectives: safety, mobility, global connectivity, environmental stewardship and security provides the guidelines for policy-making (US-DOT 2003). From time-to-time long-term visions for the transport system are prepared by the US-DOT like "The Changing Face of Transportation" (US-DOT 2000). The latter also emphasizes the EU White Paper objective to "place users at the heart of transport policy" stating to develop a "vision that puts people first and strives to leave no one behind".

Summarising the strategic documents it can be noted that the **major objectives are quite similar between the EU and the US** e.g. providing mobility, increasing safety and security, managing globalization and protecting the environment. However, some differences can be observed looking closer into the details. One difference concerns **transport pricing** policies: the EU has strongly promoted these policies in the recent years (e.g. by publishing a White Paper, several directives and fostering research) but decreased the emphasis in the recent review, while pricing policies have not been in the focus of TEA-21 but receive more attention in the current strategic documents of the US. Of course, these opposing tendencies in the EU and the US reflect the different degree of implementation of transport pricing in the two world regions.

On the other hand, to promote **innovations** for transport and by transport has been earlier emphasized by the US policy and there the review of the EU White Paper is catching-up the US headstart. In practice, this can be observed e.g. at the "race" for developing new engines and cars to shift the transport system towards alternative fuels like biofuels or hydrogen where the EU established the *Hydrogen and Fuel Cell Technology Platform* (HFP) while the US founded e.g. the *California Fuel Cell Partnership* (CaFCP) and the *FreedomCAR and Vehicle Technologies* (FCVT) initiative.

1.2 Transport policy implementation in the EU and the US

At a first glance the structure of the EU and the US the latter being one country since more than 200 years and the former being a grouping of 25 countries with different cultures and policy-making contexts seems to be quite different. However, also the US integrates 50 Federal States, some of them like California as large as the largest European countries, to form the nation. This similarity also shows up in major elements of the transport policy: first, both EU and US develop plans and fund infrastructure to **create supra-national transport infrastructure**. For the EU these are the Trans-European-Transport-Networks (TEN-T) starting with the 14 projects of the Essen list in 1994, extended to 19 projects plus Galileo in 2001 and in 2005 after the accession of 10 new member states comprising 30 priority projects with funding requirements of 225 billion EURO for the major projects. In the US the three past transport acts amounted to similar orders of magnitude for spending on highways and transit infrastructure and improvements (ISTEA about 150 billion $, TEA-21 about 200 billion $ and SAFETEA-LU about 240 billion $ of which about 77% are dedicated to highways, each for a period of 5-6 years). The SAFETEA-LU act includes programs similar to the concept of the TEN-T like the *High Priority Projects Program*, the *National Corridor Infrastructure Improvement Program* and the *National Highway System Program*. All these programs are defined to implement a US nationwide i.e. cross-federal states highway and corridor system (including also a few high-speed rail corridors), which in fact is rather close to the TEN-T basic idea of generating a European-wide multi-modal transport network.

A further similarity between EU and US strategic policy making is the **consideration of cross-border (or close to border) infrastructures**, which received special attention by the EU e.g. expressed by higher EU funding shares for cross-border infrastructures. In addition to the US national corridor programs further specific programs to build transport infrastructure to connect to the US neighbours Canada and Mexiko like the Coordinated Border Infrastructure (discretionary) program form part of TEA-21 and SAFETEA-LU, respectively. In both cases, the EU and the US the lower regional benefits and the higher significance of such cross-border infrastructure for trade and globalization provide the argument for the (supra-)national funding.

Congestion is recognised as a significant and growing problem in both the EU and the US policy documents. The US SAFETEA-LU beyond its program on *Congestion Mitigation Provisions* includes a program to establish a nationwide harmonised Real-Time Management Information System, which should collect real-time performance information of the national highway system to steer measures against congestion and to relief congestion. In the EU such a harmonised system is not foreseen, yet. But suggestions how such a congestion monitoring can be started are given in this report.

The US National policy promotes **cycling and walking** modes as in TEA-21 it is one of the objectives to foster these modes. In SAFETEA-LU the program *Safe Routes to School* is set-up, which should enable walking and cycling for children on their way to school. In the EU the subsidiarity principle hinders the EC to develop cycling or walking policies since these are clearly local issues. However, the EU indirectly aspires to positively influence urban transport policy via the CIVITAS program and those projects of CIVITAS that promote sustainable urban mobility including better opportunities for walking and cycling. The review of the 2001 EC White Paper (EC 2006) also foresees to develop an Urban Transport Green Paper for 2007.

The most significant difference between the transport policy of the EU and US concerns the level of **fuel taxation** and hence fuel prices. Taxation of fuel in the European countries is about five to fifteen times higher than in the US, where it is about 6 Eurocent/l gasoline. In the US more than 80% of the fuel tax revenues go into highway funding and about 15% into funding of transit systems. Similar approaches are followed in European countries though the dedication for infrastructure funding is less strict or not even required.

1.3 Policies and trends affecting transport cost, congestion and logistics

Three mega-trends can be identified that are of utmost importance for the transport system. The first mega-trend are the demographic changes affecting in particular passenger transport. This trend differs to some extent between the EU and the US. Common to both regions is the ageing of the societies, which changes the transport patterns increasing the importance of the patterns of the "grey hair" generations. However, in the EU the birth rates are reduced significantly in the past years such that population in the future is stagnating or even will decline, which is not expected for the US, yet. This means, for the EU population growth as one of the drivers of passenger transport will cease in the years to come reducing also the contribution of passenger transport to congestion.

The second mega-trend is constituted by globalization. Increasing globalisation drives the economic interaction between different countries and world regions and, hence, trade flows are growing leading to a continuous increase of freight transport. But also passenger transport is fostered by globalisation due to the growing number of business trips in the global economy and the growth in tourism always looking for farther destinations. For both, passenger and freight transport this implies longer distances and longer transport chains and hence increased cost per trip that have to be counterbalanced by improved transport efficiency to keep transport viable.

The third mega trend is the price increase of fossil fuel, which is driven by the continuous growth of world demand due to the fast economic development in countries like China and India and the limitations on the supply side i.e. the geological restrictions to pump more crude oil out of the existing wells (peak-oil) and the limitations of the refinery capacity. Growing crude oil price will of course drive the transport fuel prices and hence the transport cost. However, the linkage between crude oil price and the price for gasoline or diesel is dampened by the fuel taxes, which differ significantly between the EU and the US. The lower fuel taxes in the US lead to relatively higher fuel price increases for transport in the US, while in the EU where in some countries the taxes paid on fuel are higher than the crude oil cost such that a 100% increase of crude oil price would on average result only into a 40% increase of fuel price in the EU (see also ECORYS 2006). In that sense, the transport cost in the US will grow stronger than in the EU by the raise of the crude oil price. This holds for road transport, while e.g. air transport does not pay fuel taxes at all such that the crude oil price increases directly feed through into the air transport cost.

2 Transport operating cost in the EU and the US

2.1 Methodology

2.1.1 Systems delimitation and structure

Transport operation costs are those costs directly related to the production and the use of transport services. These costs are borne by private and public transport operators and are thus internal costs. From a macroeconomic point of view, these costs occur in the financial balance of the transport sector and other economic sectors. In order to allocate economic consequences properly, it is important to distinguish between commercial transport and individual transport services on the one hand and public and private transport services on the other hand:

Table 9: Economic characteristics of operating costs

	Commercial	Individual
Public/ Professional	Transport operating cost are beard by the transport provider and passed to an economic sector using this transport services: Professional freight transport (all modes): Professional passenger transport such as air transport, rail/bus transport, taxi for commercial use (business trips occurring as costs in the financial balance of economic sectors,	Transport operating costs are beard by the producer and passed to the individual user. For the individual user, the costs are end consumption: Passenger commuter, shopping and leisure/tourism trips with public transport (rail/bus, air transport)
Private	Transport operating costs are beard by the internal transport provider and are relevant for commercial purposes: Internal freight transport (esp. road), commercial passenger car trips with own car.	Transport operating costs are beard by the individual user and are completely end consumption: Passenger car transport for commuter, shopping and leisure/tourism trips

The table indicates that operating costs can be seen from different angles. The producer's perspective focuses on the production of transport services. Within economic balances, this accounts for public/professional transport providers for commercial and individual use. These costs are usually included in economic Input-Output-Tables. In order to get a full picture, it is necessary to add the private transport services. The user's perspective is focussing on transport prices. Within the commercial sector, these costs are occurring in the economic balance as transport costs and are included in national Input-Output-Tables. The use of individual transport however is end consumption and must be added to the transport sector in order to get a full picture.

In order to quantify transport operating costs, we will refer to the **producer's perspective**: How much do public and private transport operators pay for the production of transport services? In order to get a proper systems delimitation, the following issues have to be considered:

- Transport services and infrastructure: From a producer's point of view, infrastructure costs are considered by the price which is paid for infrastructure use. This can be included in charges and taxes (such as for road transport) or in direct infrastructure fees (such as track prices for rail or landing charges for air transport).
- Time costs of individual transport (e.g. value of times for drivers) are not considered, since they are not included in macroeconomic accounts.
- Operating costs for 'normal traffic conditions' and congestion costs: In order to distinguish **operating costs** and **congestion costs**, it is important to define a so-called accepted level of service, on which basis operating costs for specific transport modes may be estimated: Within this study operating costs (without congestion costs) and congestion costs for transport users will be distinguished. Financial deficit of public institutions and external accident and environmental costs will not be considered,

Operating costs are based on the following cost elements:

Table 10: Structure and elements of operating cost

Element	Structure	Description
Traffic modes and means	Road	Passenger car, HDV[2], LDV, Buses, Coaches
	Rail	Passenger/Freight
	Aviation	Passenger/Freight
	Inland Waterways	Freight
	Short sea shipping	Freight
Cost components	- Wear and tear	- Variable costs of vehicle / rolling stock use (e.g. maintenance)
	- Personnel	- Drivers wages/Wages of other personnel
	- Capital cost	- Depreciation/Interest of invested capital (e.g. rolling stock)
	- Energy cost	- Fuel and/or electricity costs (incl. fuel/energy taxes)
	- Insurance	- Insurance premia
	- Infrastructure charge	- Charges dedicated to infrastructure use
	- Other taxes and charges	- Other taxes and charges, such as Vehicle circulation tax, purchase tax, road or track user charges, environmental charges
	- Additional cost	- Overhead, additional costs for further services
Countries	EU 25, US and Switzerland	Territoriality principle
Base year	Most recent	Traffic performance based on 2004 figures,

---

[2] LDV: Light duty vehicles, HDV: Heavy duty vehicles

2.1.2 Procedure for quantitative estimation

Operating costs of different transport modes in different transport countries are depending on many factors, such as

- Transport volumes
- Fleet structure and age
- Market prices and financing conditions of equipment (vehicle market, garage, maintenance equipment, interest rates, insurance etc.): These prices are in addition dependent of the level of liberalisation of the equipment market.
- Energy consumption (depending on average energy use of the fleet)
- Structure of charges and taxes (infrastructure use, road taxes, environmental taxation)
- Wage level (usually depending on general economic conditions according to GDP per capita
- Level of competition/liberalisation of the transport sector.

There are two approaches possible to consider these influence factors per country and per transport mode:

- Top down: Transport costs per country based on input-output table information: This approach follows the logic of the production of public/professional provision of transport services. The approach however is too narrow, since private transport and individual passenger road transport is not included. In addition the available information within input-output tables is very rough.
- Bottom up: Estimation of specific costs per transport mode and –mean and aggregation according to national transport levels.

Within COMPETE, we use a harmonised bottom up approach, which starts from typical specific costs for exemplary transport means and countries. These countries cover a representative set all over EU25 and US. Since data sources are however not always consistent (different years, different structure of cost elements etc.), a transfer procedure is necessary, in order to get information for all countries and make specific cost comparable. The use of a transfer mechanism based on selected macroeconomic key indicators such as national fleet structure information, average fuel consumption, GDP per capita purchase power parity adjusted, national interest rates and different levels of liberalisation. For the specific modes, the following procedures were used (see details in COMPETE Annex 1):

- Road: Information from a representative set of countries (based on different sources) for operating costs of a typical average vehicle; value adjustment procedure and aggregation with the figures of EUROSTAT (2006b)
- Rail: Information of international railways statistics for most of the countries, value adjustment transfer and aggregation
- Air transport: Information of individual airlines and international air statistics
- Waterways: Information of international studies and specific countries.

2.2 Operating costs 2005[3]

2.2.1 Total operating costs per country

Total transport cost in EU25 account for 1’988 bn EUR which corresponds to 19% of the GDP. For the US, the corresponding figure is 2’278 bn or 24% of national GDP. The biggest part (54%) are operating cost for road passenger transport. The second largest part is road freight transport (36%). Here the share is much bigger in the US than in Europe. The total operating costs for other modes (rail, air, water) are considerably smaller.

Table 11: Total transport operating costs in the EU and the US (2005) – Data in bn. EUR

Transport mode	Western Europe (EU15)	Eastern Europe*	EU25**	USA
Road passenger	1'239	37	1'276	1'039
Road freight	420	20	441	1'072
Rail	84	7	92	26
Air	155	6	162	137
Water	12	n.d.a.	12	4
Total	**1'911**	**71**	**1'988**	**2'278**

** NMS-5 means the following five of the ten new EU member states: Czech Republic, Hungary, Poland, Slovenia, and Slovakia. ** Without Baltic countries, Malta and Cyprus. n.d.a.: no data available. Source: own calculations (for details see COMPETE Annex 1).*

When discussing the differences between the total or average operating costs of the different countries, it is very important to bear in mind that the costs are not only influenced by the cost level per country (which is best reflected in the average costs per vehicle-kilometre), but also by other factors like the mileage (veh-km per year), the transport performance (tkm/year, pkm/year) and the load factors (t/veh) and occupancy rates (p/veh). These relations are visualised in Figure 5.

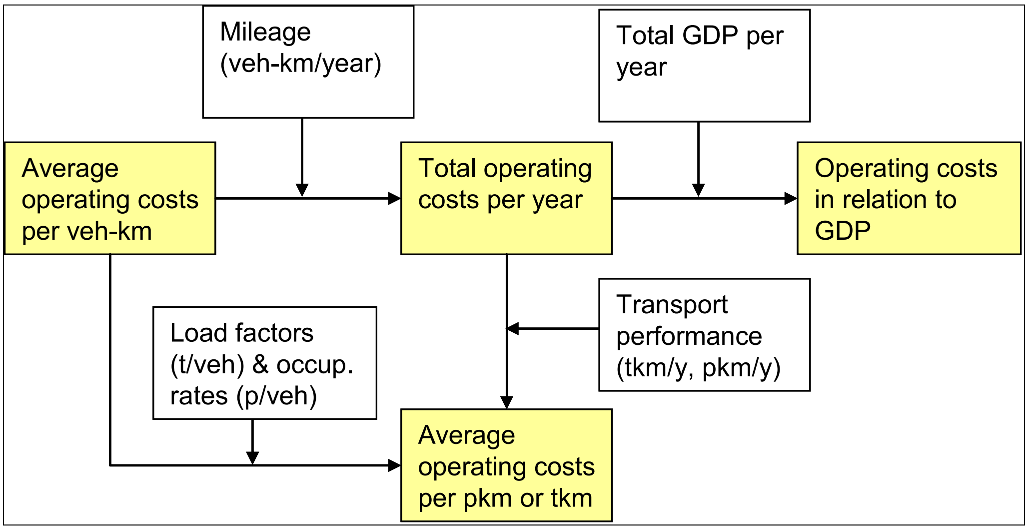


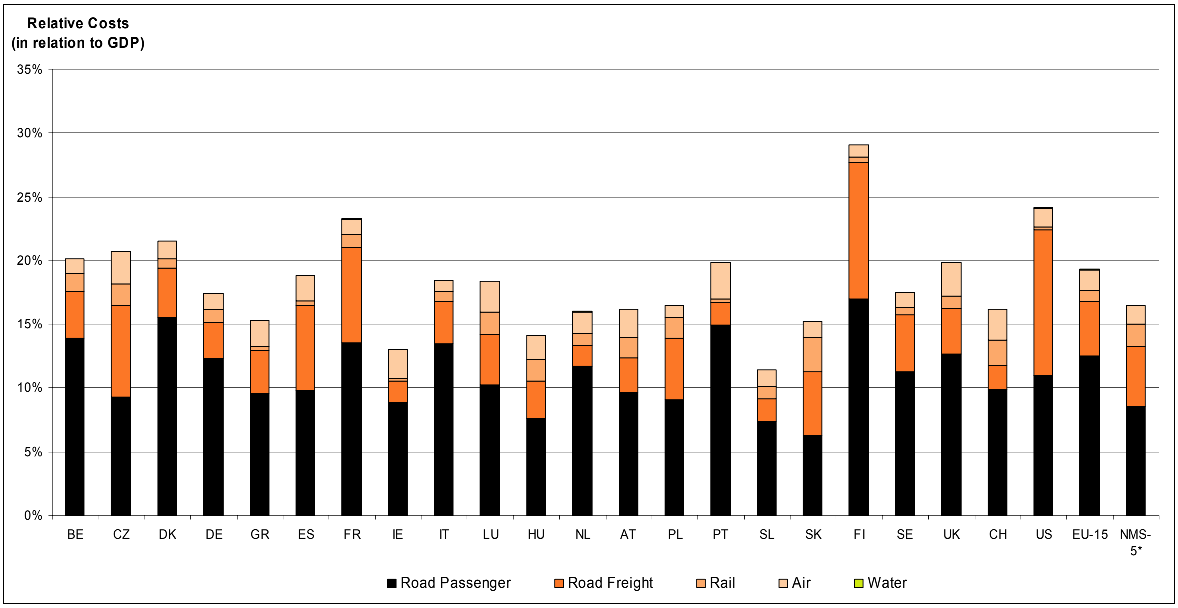
Figure 5: Relations between different operating cost measures (yellow boxes) with the corresponding influence factors (white boxes)

---

[3] Detailed figures per country can be seen in COMPETE Annex 1.

The most important influence factor is the transport performance of each country, based on national transport statistics. Comparing the relative costs (in relation to GDP) of European countries, Western Europe has a higher share of GDP than Eastern Europe. Looking at the different countries, we see (besides the US) a high share of costs in Finland and France and Denmark and a low share in Slovakia and Ireland. There are several reasons to consider in order to interpret the country-wise results properly. A main reason is the higher share of individual passenger transport due to higher income (e.g. higher density of cars, more leisure trips). This explains the relatively lower share of costs in the new member states in Eastern Europe. Another reason are the national transport levels (mileage, transport performance), for example the high level of passenger and freight kilometres per capita or per GDP of US and Finland compared to other European countries. A third element (as well true for Finland) are the level of average costs (see next section). Finland for example has – compared to other countries – rather high costs per vehicle kilometre and a high freight transport intensity. The US on the other hand have rather low costs per vkm, but also a very high (freight) transport mileage which leads to high operating costs in total and in relation to GDP.

The relative data of total operating costs in relation to the GPD (Figure 6) is a figure that helps to compare the total operating costs between the different countries. However, it has to be pointed out that the total operating costs of a country do not only cover costs which are part of the GDP, but all costs for operating transport means. A considerable part of the total operating costs, however, are not part of the GDP, mainly the imports which are subtracted from GDP calculations. The main part of the fuel costs, for example, corresponds to imports. In addition, a great part of the vehicle costs can be attributed to imports, depending of course on the countries automotive sector. Therefore, the data in Figure 6 does not state that in the US, for example, 24% of the GDP is generated by transport. However, it shows that the total expenditures paid by the US transport users for their transport operations in the US corresponds to 24% of the US GDP in 2005.



Source: COMPETE calculations. For details see COMPETE Annex 1:

Figure 6: Total operating costs in relation to GDP in 2005

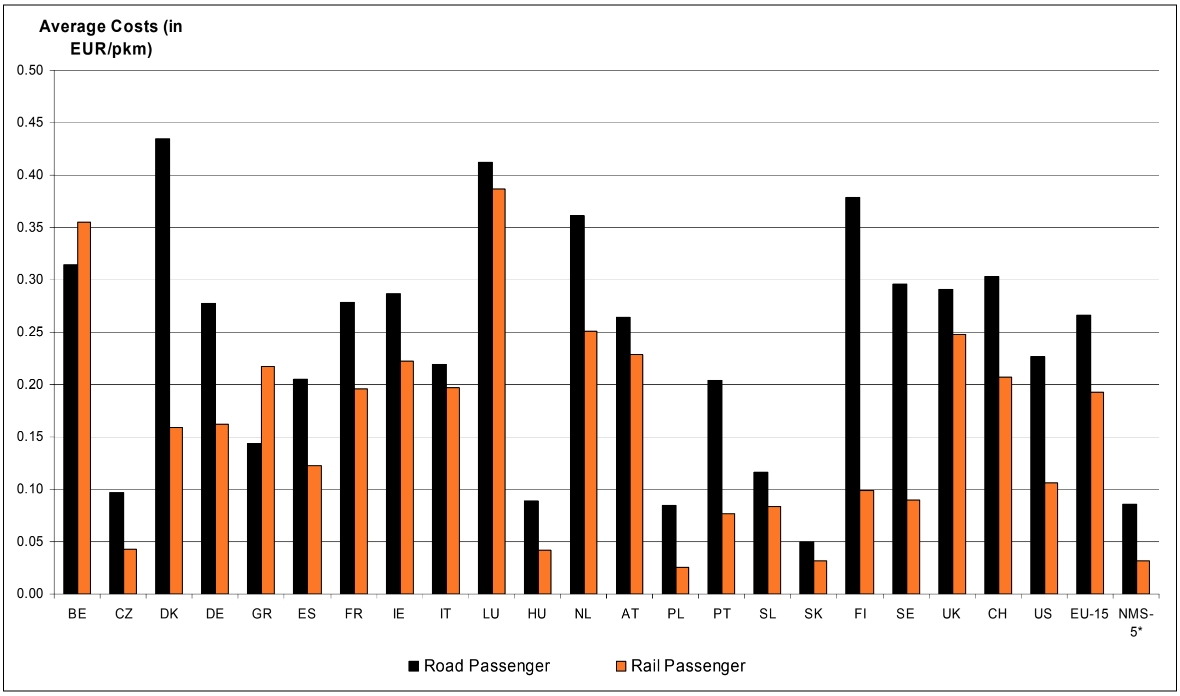
2.2.2 Cost structures

The comparison of **average costs** (per tkm, per pkm) is interesting between road and rail. Figure 7 shows the result for passenger transport. With 0.27 EURcent per pkm, Western Europe has the highest level of costs. Besides higher input prices, the relatively higher share of taxes is a major reason. Rail costs are in comparison considerably lower. This is due to better load factors (especially in urban areas or frequented corridors) on the one hand and due to the fact, that railways do not recover their full infrastructure costs, compared to road transport. In other words: Their taxes and infrastructure charges are considerably lower. The difference is however smaller in Western Europe than in Eastern Europe or the US. The differences between individual countries are quite significant and are depending very much on transport performance (pkm, tkm), which means that countries with a high transport performance have comparably lower average costs per pkm or tkm, which could be seen as a kind of economies of scale of larger transport systems.

Figure 8 shows the results for freight transport. The difference between Western and Eastern Europe is considerably higher, mainly influenced by lower wage levels for drivers. Most interesting is the difference between road and rail in the United States. The most important reasons tend to be the very high load factors of the railways due to their high efficiency (much longer trains, double stack containers).

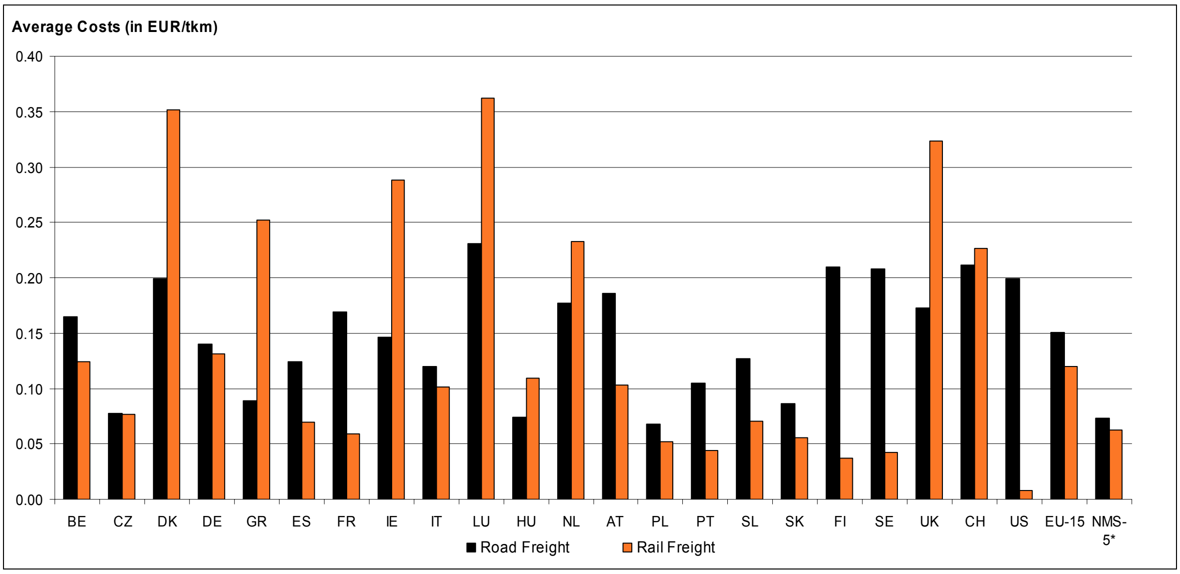
When looking at the average costs per tkm for road freight transport it is remarkable that the costs are higher in the US than in EU-25, although this is vice versa for the average costs per veh-km (see Figure 9). The reason for this is the big difference between the road freight load factors (t/vehicle) in the US and in Europe. According to the traffic data, the average load factor for heavy duty vehicles is 7.4 tons/vehicle for EU-15, whereas it is only 5.0 tons/vehicle in the USA. This lower load factor in road freight transport in the US leads to a lower efficiency per ton-kilometer.

In fact, when comparing the average costs per vehicle-km or train-km (Figure 9, Figure 10) with the average costs per ton-km or passenger-km (Figure 7, Figure 8), it must be stressed that the average costs per tkm and pkm are highly dependent on the load factors (tons per vehicle) and occupancy rates (passengers per vehicle) of trucks, vans, railways, buses, cars, etc.



Source: COMPETE calculations. For details see COMPETE Annex 1.

Figure 7: Average costs (per pkm) for passenger transport – EU, CH and USA



Source: COMPETE calculations. For details see COMPETE Annex 1.

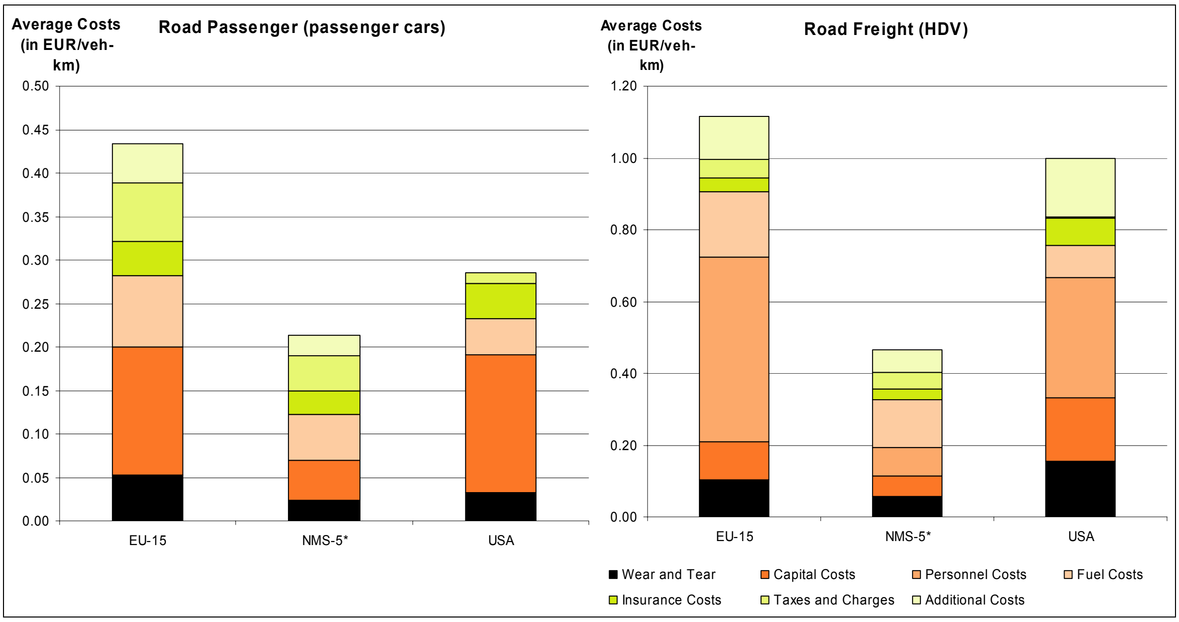
Figure 8: Average costs (per tkm) for freight transport – EU, CH and USA

Generally speaking, the average operating costs per vkm, pkm and tkm are the highest in EU-15, followed by the USA and the lowest in the new member states (NMS-5). The only exception of this is the average cost per ton-km in the US (see Figure 8), which is very small for rail freight transport (see explanation below) and unexpectedly high for road freight transport (reasons explained above).

The most striking fact is the extremely low rail freight operating cost per tkm in the USA compared to Europe. Here again, the main reason is the big difference between the load factors since the average costs per train-km are only a little smaller in the US than in EU-15 (see Figure 10). Whereas the average load factor in EU-15 is 320 t/train, the load factor in the United States is more than eight times higher (3000 t/train), according to the available transport data. This is mainly because distances in rail freight transport are much longer in the US and train compositions consist of much more wagons than in Europe, which can – amongst others – be explained by geographical and topographical circumstances. Other studies show very similar data of the average costs per tkm of freight trains in the US (e.g. Lakshmanan et al. 2005 show average rail freight operating costs of about 1-1.5 EURcent/tkm) and therefore support our data.

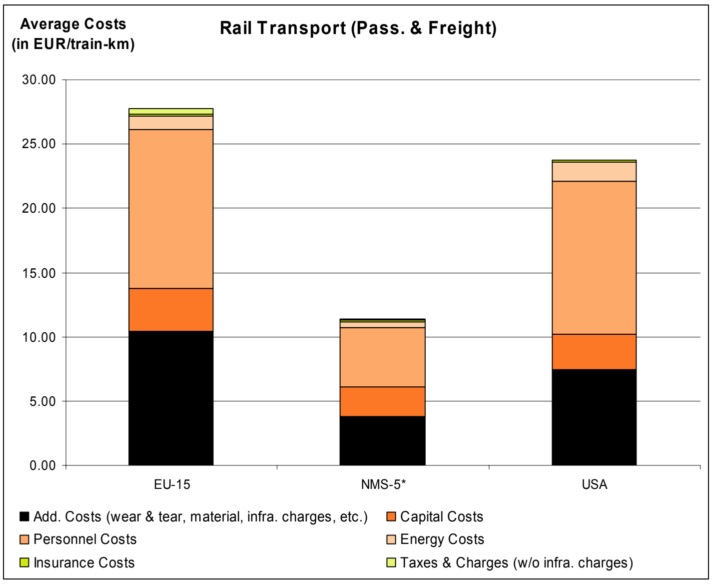
The differences between EU-15 and the NMS-5 are similar for all transport modes when looking at the average costs per vehicle-km and train-km (Figure 9andFigure 10). When looking at the average costs per passenger-km and ton-km, however, it can be seen that road passenger costs are much lower in the new member states than in the EU-15. The main reason for this is the significantly high difference in the average occupancy rate of passenger cars (number of passengers per vehicle): in the EU-15, the average occupancy rate of passenger cars (which dominates the road passenger category) is 1.54, whereas in the NMS-5 the average occupancy rate is 2.16 persons per car.

Figure 9 and Figure 10 show the distribution of cost categories on average costs for road and rail. As for road passenger transport, capital costs, fuel costs and taxes and charges are predominant, personnel costs are most important for road freight. The share of fuel costs (incl. excise duties) in the US is considerably lower than in Europe. For rail transport, personnel costs and running costs are predominant. It is interesting, that the difference between Western Europe and US is rather small, if average costs are expressed as costs per train km.



Source: COMPETE calculations. For details see COMPETE Annex 1.

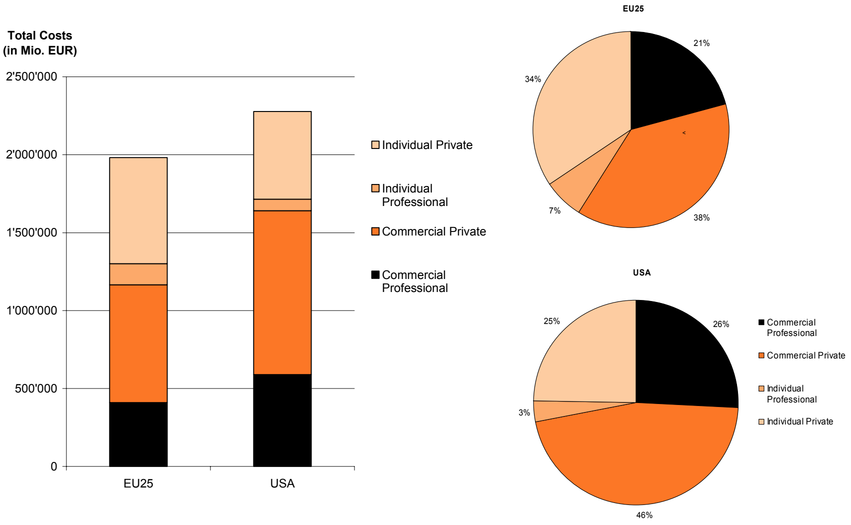
Figure 9: Average costs (per vehicle-km) for road passenger and road freight transport



Source: COMPETE calculations. For details see COMPETE Annex 1.

Figure 10: Average costs (per train-km) for rail transport – aggregated data

Figure 11 refers to the economic and sectoral structure of operating costs. Around 25% of road passenger transport is for commercial business. Around 20% of road freight transport is internal transport, not carried out by professional road hauliers, and around one third of air transport is for business activities. In total around two thirds (Europe) and three fourth (US) of the transport operating cost is for commercial activities.



Source: COMPETE calculations. For details see COMPETE Annex 1.

Figure 11: Share of commercial and individual transport costs in the EU and USA

2.3 Trends

2.3.1 The influence factors

Operating cost levels and structures have changed over time. This holds for all modes. The following Table 12 shows the most important influence factors:

Table 12: Influence factors relevant for the development of transport operating cost

Element	Development Past and Future	Relevance for different modes	Effect on operating cost
General transport development/ Transport demand	Increase in the past and in the future	Road and air transport and container shipping are most dynamic (EU and US)	Increase in total cost closely related to GDP growth; probably no change of average costs per pkm/tkm unless the increased transport demand leads to scarce infrastructure which means higher op. costs
Liberalisation in the transport sector and productivity potentials	Different speeds in different sectors will carry on	Most dynamic development in the road freight and air transport sector (US has been more dynamic in the past, EU is more dynamic since EU enlargement)	Pressure on operating cost (esp. running cost, personnel cost)
Capital financing conditions (liberalisation, rolling stock market, interest rates)	Improved efficiency in the rolling stock market, improved conditions	Rolling stock markets and financing instruments have become global. More capital intensive sectors (rail, air) are profiting (EU and US)	Capital cost will probably increase because interest rates are generally getting higher in the future and future technological progress (increasing quality of rolling stock) tends to result in higher investment costs
Energy prices and efficiency	Fossil fuels: increase in the late past and in the future. Different trends for electricity price: decrease due to liberalisation processes vs. increase due to higher prices of fossil fuels for electricity generation.	Road and esp. air transport will face increased prices, with bigger substitution potential for road. Rail transport might profit from lower or at least stable energy prices.	Energy cost will increase for air transport and probably road transport. Energy cost for rail transport might remain stable or at least increase slower.
Transport taxation and charges	Depending on transport policy (internalisation of external cost, climate policy)	More dynamics in Europe than in US, esp. for road transport. Rail: Infrastructure charges might develop along competitiveness in relation to road	The volume of taxes and charges might increase slightly, esp. for road and air transport.

Source: COMPETE elaboration

2.3.2 Development in the past

The following figures show the development in the past, based on specific studies and price indices for input factors and transport services. The transport prices have inspite of efficiency gains increased both in EU and the US in nominal terms. The growth rates in the EU and in the US (plus 25 and 30% respectively) between 1996 and 2005 are similar. However there are differences in development over time. Due to earlier liberalisation processes, the development in the US faces a reduction in transport prices in the late 90ies.

In real terms – compared to the consumer price development – transport prices and operating costs have increased in the EU slightly, whereas the development in the US is along the general price index, i.e. no significant change in real terms.

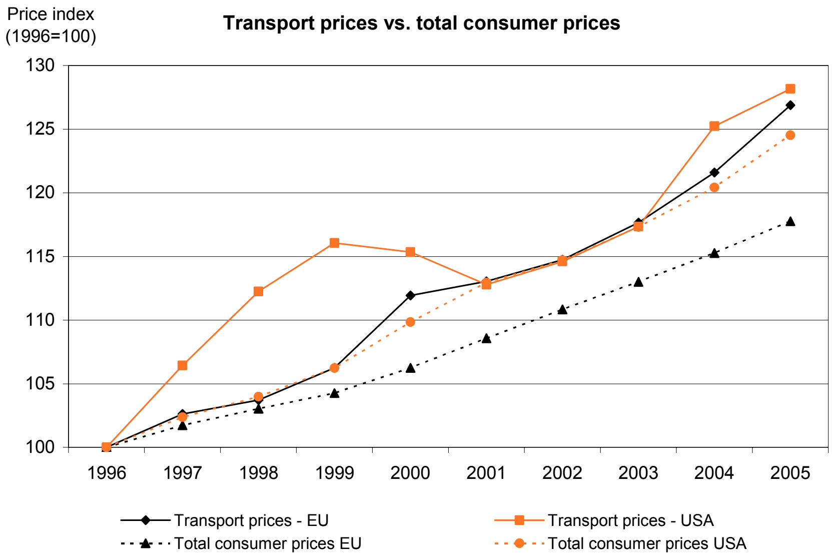
Considering country-wise results, we refer to a study of NEA (2004) for the road haulage sector:

- Total road haulage costs (in nominal prices): In most countries of Western Europe road haulage costs have increased by about 20-30% between 1995 and 2004. Exceptions are Spain (+37%) and Great Britain (+46%) where road haulage costs have grown more. The reason for this development are increases in capital costs and additional costs (taxes, wear and tear, insurance) which have been above-average in Spain and Great Britain. In addition, fuel costs have risen more in Great Britain than in the other countries analysed.

- Labour costs have increased permanently in all countries of Western Europe analysed. Between 1995 and 2004 the labour costs rose by about 25 - 30% in Germany, Denmark, Belgium, Austria and the Netherlands. In other countries, however, labour costs have increased by 40-50% in the same period (Spain, Italy, France, Great Britain).

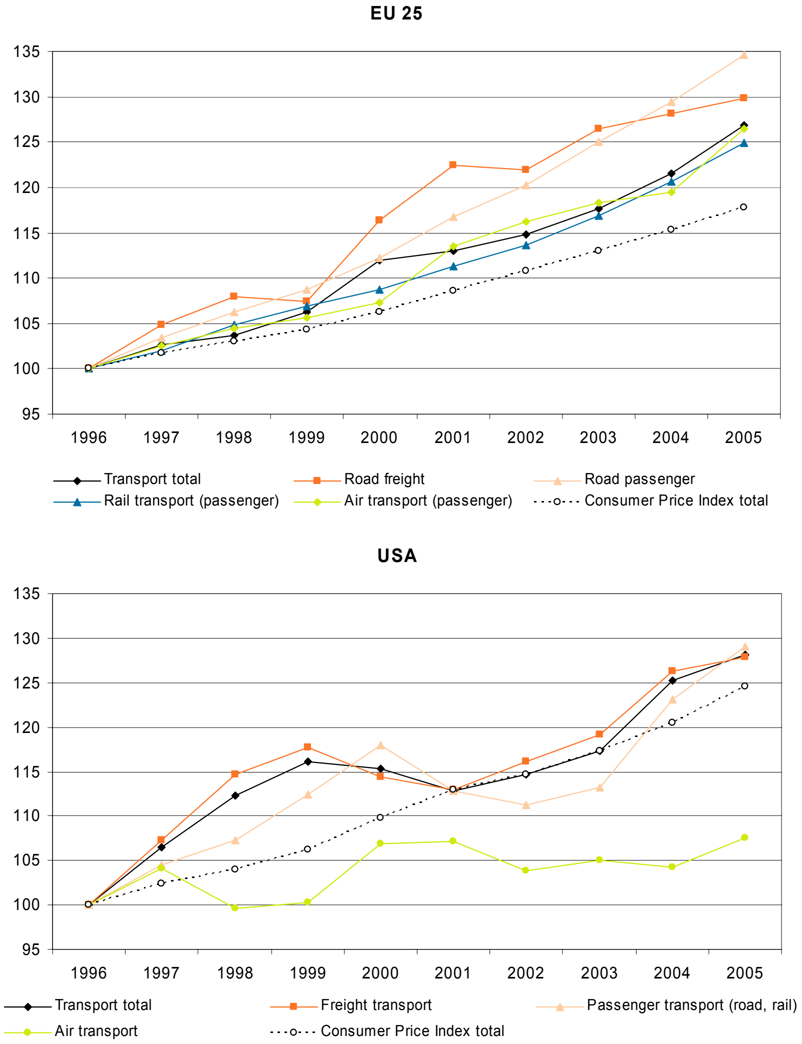
- In most countries the capital costs have remained more or less stable in the last ten years. In Germany and Great Britain, capital costs in the road haulage sector have increased by about 10-15% between 1995 and 2004. In Spain, capital costs have grown even by 24% in the same time. In Sweden and Belgium, capital costs have decreased by about 10% and in Italy by over 15%.

- Whereas for personnel and capital costs, the price development has been more or less continuously in the last ten years, the fuel cost development shows different phases. Between 1995 and 1998, the fuel costs have been more or less stable in all European countries (slightly increased costs in 1996 and 1997). Then, after a slight drop in 1998, fuel prices rose quickly in 1999 and 2000 by about 20-40%. Between 2001 and 2004, fuel prices remained more or less constant with slight ups and downs. Overall, fuel prices have increased between 1995 and 2004 by about 30-45% in most countries of Western Europe. In Sweden (+16%) and Belgium (+24%) the prices have risen less than in the other countries whereas in Germany (+55%) and above all in Great Britain (+73%) fuel prices have increased by over 50% in the last ten years.



Source: EUROSTAT online database (www.eu.int/comm/eurostat), online statistical database of the US Bureau of Transportation Statistics (www.bts.gov)

Figure 12: Transport price development vs. consumer price index in the EU and the USA



Source: EUROSTAT online database (www.eu.int/comm/eurostat), online statistical database of the US Bureau of Transportation Statistics (www.bts.gov)

Figure 13: Transport price development for the EU and the US (Index: 1996 = 100)

2.3.3 Future trends

The level of operating cost will remain an important factor of competitiveness fort the transport sector. However it is important to state that transport quality is the other decisive factor. The increase of transport prices in the past (as shown above) is strongly related to the increase of transport quality (e.g. due to rail and road infrastructure extension, larger and more modern passenger cars, modernisation of railway rolling stock, etc.). In the near future, this quality development will remain on the agenda and lead to a further increase of operating cost. Most decisive are the following issues:

- Further development of the liberalisation process, especially in Europe: One can expect a convergence process between Eastern and Western Europe in the road sector and a consolidation of the fast changes in the air transport sector.
- Further development of energy prices and related climate policy approaches: All existing forecast show an increase in fossil fuel prices due to scarcity effects on the one hand (peak oil) and climate policy approaches, such as Emission Trading Systems (ETS) and post Kyoto principles. Most vulnerable for this development is the aviation sector, where around 30 to 40% of operating costs are related to fuel cost. Compared to other transport sector, the substitution potential is quite low. The car manufactures sector has shown that fuel efficiency gains have been offset by the increasing weight and power of new vehicles, in addition to the generalisation of new functions such as air condition. Therefore the positive effects of the efficiency gains on the operating costs are more than outweighed. Larger and more powerful passenger cars also lead to increasing investment costs (capital costs) and therefore higher operating costs. An important example for the increasing weight and power of new vehicles is the development of so-called sports utility vehicles (SUV).
- Relative importance of competitiveness road-rail: In order to increase competitiveness, the rail sector (esp. freight) has to increase its productivity in due time. The speed of the future productivity increase in the rail sector is depending on the level of implementation of the EU railways policy in different countries (increase of transnational interoperability, increase of labour productivity, increase of service quality). The development in the transalpine market shows, that there is still a price increase for (subsidised) combined transport services, since railways do not pass their reduced operating cost to shippers, in order to gain profit for necessary future investment (rolling stock, terminals).

The following table summarises the expected development for the different modes in a qualitative way. It shows that **average operating cost** (per vehicle-km) will develop relatively above the general price development, which means an **increase in real terms**. There is a tendency that re-regulation processes and fuel prices are increasing the costs in those transport sectors, where fuel prices are playing a predominant role and infrastructure scarcity is increasing. The productivity effects in the past might not hold on in a similar way in the future. This is especially true for air transport, where there are no real potentials for a further decrease of operating cost. Still big potentials are visible within the rail sector (and partly for ports), especially in running cost for cross-border freight transport.

In total, this means that average operating costs and thus (within competitive transport markets) transport prices will increase more than in the past in nominal terms. In real terms there are slight increases. Total operating costs (i.e. expenditures on transport) however are increasing still rapidly due to general transport growth.

It has to be stressed that all the statements in Table 13 refer to average costs per vehicle-kilometre. The unit costs per ton-km and passenger-km are – additional to the factors described in Table 13 – further dependent on the future development of load factors in freight transport and occupancy rates in passenger transport. The future trends in occupancy rates of passenger cars is difficult to predict. Since the number of multi-car households is generally further increasing and individual transport is getting stronger and stronger, the occupancy rate of passenger cars will further decrease (ceteris paribus). This process might be stopped or at least slowed down if road pricing schemes for passenger cars are becoming more common in the European Union and energy prices continues to grow. In road freight transport, load factors are presumably increasing slightly in the future since further efficiency gains will be achieved due to competition in the road haulier sector and new charging systems for heavy duty vehicles (distance-based road charges). In the air transport sector, load factors and occupancy rates will significantly increase in the future, since larger aircraft will be introduced, above all in long-distance transport.

Table 13: Future development of average transport operating costs (per vkm, real prices)

	Transport mode				
Cost factor	**Road passenger**	**Road freight**	**Rail**	**Air**	**Water**
Personnel costs	↘ Private transport: no personnel cost. Public transport: Ongoing liberalisation process in public transport leads to decreasing costs.	→ Cost pressure from Eastern Europe. However, liberalisation process in the road freight sector is already very advanced. Therefore, little scope for decreasing costs.	↘ Ongoing liberalisation process in the rail sector leads to cost pressure.	→ Further cost pressure from low cost carriers and due to liberalisation process in the air transport sector. However a consolidation process has to be expected.	→ Wages are already low due to global competition. Further liberalisation process (above all for ports) will hardly change the situation.
	Personnel costs will rise generally in the long term, if workforce is getting scarcer in the EU (due to demographic development). In the short term, however, there can be an ongoing pressure on wages because the level of unemployment is still high.				
Capital costs	↗ Interest rates are generally getting higher in the future compared to the low level nowadays. Future technological progress tends to result in higher investment costs. Liberalisation process in rolling stock sector has already taken place and led to productivity gains (e.g. rail sector).				
Fuel costs	↗ Continuous increase in fuel prices (petrol, diesel)	↗ Continuous increase in fuel prices (petrol, diesel)	→ Electricity costs will remain more or less stable (liberalisation in electricity sector vs. increasing fossil fuel price).	↗ Continuous increase in fuel prices (kerosene)	↗ Continuous increase in fuel prices (diesel, oil)
Infrastructure costs (charges, taxes)	↗ Infrastructure is getting scarcer. KM-charges and road pricing will be important.	↗ Infrastructure is getting scarcer and external costs are being internalised.	→ Falling costs due to productivity gains of the rail (infrastructure) sector. Opposite effect because of growing infrastructure scarcity.	↗ Infrastructure is getting scarcer, especially in big hubs. Environmental charges are on the political agenda (integration ETS)	↗ Port infrastructure (terminals) are getting scarcer
Additional costs	→ Costs will develop along the general price development				
Total operating costs (per vkm)	→↗	↗	↘	→↗	→
Comparison of different regions: - EU 25 - Western Europe - Eastern Europe - USA	Private transport: The increase in fuel costs will have bigger effects in the US, since the average fuel consumption is higher in the US than in Europe.	Infrastructure scarcity is more pronounced in Europe than in US. In EU15 infra. scarcity is problem of limited road capacity vs in EU8 it is rather a problem of poor infrastructure quality. Internalisation of external costs is an EU issue.	Higher potential for cost reduction in the EU since the liberalisation process is already more advanced in the US.	Higher potential for productivity gains in the EU since the liberalisation process is already more advanced in the US.	Bigger potential for increased productivity gains in Eastern European ports.
	In Eastern Europe personnel costs will increase compared to Western Europe.				

Source: COMPETE

3 Congestion in Europe and the US

3.1 Introduction

Traffic congestion emerges from the mutual disturbance of vehicles, trains or aircrafts when transport infrastructure capacity approaches saturation. In terms of the consequences a difference between road transport and scheduled services appears. In road transport congestion is perceived by increasing mutual disturbance, reduced manoeuvrability and consequently by decreasing vehicle speeds while in scheduled transport slots or tracks are pre-planned and thus, at least theoretically, congestion is precluded. In this case the scarcity of infrastructure is more obvious than road-like congestion effects. In both, road and scheduled transport, congestion brings about a rising unreliability in travel times.

The measurement of congestion may emerge from various rationales, including the monitoring of transport system quality over time or against policy targets, indicating the need for policy interventions, verifying the effect of policy measures or assessing the impact of transport conditions on social welfare and economic competitiveness in absolute terms, over time or across regions. Each of these purposes demands for specific attributes of congestion indicator systems.

In this chapter the order of magnitude of transport congestion in the 25 EU Member States, Switzerland, the US and Canada are presented after a brief overview of existing studies. Emerging from best practices in assessing transport congestion the chapter then proposes a stepwise approach towards the establishment of the European harmonised methodology for monitoring congestion. The information on which the analyses are based on was collected by interviewing relevant bodies in the Member States and the US and by an extended literature review. More detailed information on the panorama of congestion is provided by Annex 2 and by the country reports in Annex 3.

3.2 Applied approaches towards congestion monitoring

In recent years an increasing number of studies and policy approaches on measuring and quantifying transport congestion have emerged. The Trans-Atlantic comparison shows, that the tradition to carry out congestion monitoring in urban areas is far more developed in the United States than in Europe. On the other hand Europe's attempt in quantifying trunk road performance is more developed than in the US. These differences are to a large extent driven by the characteristics of transport problems, which are dominated by the high population density in Europe in contrast to the fast growing mega cities in the US. Selected approaches from Europe, the US and Canada are described in turn.

3.2.1 Inter-urban road transport

3.2.1.1 Recent activities in Europe and the US

Road congestion on the European trunk road network has been addressed by a number of studies and is officially observed by some individual countries. On a pan-European level the most comprehensive studies delivering primary data are the UNITE project funded by the European Commission's 5th framework programme (Nash et al. 2002) and the study "External Costs of Transport" launched by the International Union of Railways (Maibach et al.

2004). UNITE has collected delay data for all modes in 12 out of 18 European countries, which were used to assess congestion costs by the difference of actual against average travel speeds. In contrast the UIC-Study has applied several measures derived from a European road transport model, including the delay approach, the welfare-economic deadweight loss approach and estimates of expected road pricing revenues to quantify urban and inter-urban road congestion. Further the EC-funded study TEN-STAC (NEA et al., 2003) has evaluated several scenarios of Trans-European corridors. As one of the measures applied congestion was computed by comparing actual to free flow travel speeds.

In the US inter-urban congestion is assessed by the White Paper on freight transport bottlenecks (Cambridge Systematics 2005b). The study identifies major bottlenecks, in particular where important ports are located within urban centres and at freeway intersections. The report estimates total costs of roughly 9 billion Euros ($7.8 billion) compared to 1.6 billion Euros estimated for the EU15 and Switzerland by Maibach et al. (2004).

On the country level, approaches to monitor congestion are known from the UK, Germany, France, Belgium, Denmark, the Netherlands, Switzerland and from the US. In contrast to the European studies the national surveys mainly focus on monitoring traffic quality rather than on assessing congestion costs. The following paragraphs briefly introduce the national procedures applied.

In the UK separate approaches are taken by the Department for Transport for England and by the Scottish Executive. The DfT carries out peak and off-peak speed measurements by the floating car technique every two years since 1993 (DfT 2005). Measures proposed to monitor congestion are time lost per vehicle mile and the best performance of the 10% lowest peak hour speeds. For Scottish roads archived flow data are used to model congestion indicators, including additional travel time, costs and travel time reliability (Scottish Executive 2003). Both methods limit the assessment to recurrent congestion against free flow traffic conditions.

Since 1998 the Netherlands track congestion on their inter-urban road network by measuring and accounting the length of traffic jams by motorway segment (AVV 2005). Further, some countries, including Austria, Switzerland and the Netherlands are preparing or operate online traffic quality information systems.

Apart from these regular approaches, a number of one-off studies on traffic congestion have been reviewed: The German Ministry for Transport, Building and Urban Development has carried out a bottleneck study applying the Level-of-Service approach to the motorway network in 2000 and 2015 (IVV and Brilon 2004).

In Switzerland the Office for Road Transport (ASTRA) has assessed the costs of congestion on Swiss roads for 1996 (Infras 1998) by analysing congestion records in combination with traffic flow data. in 2002 a separate study for the Canton Zug using speed measurements was performed (Infras 2003) and currently ASTRA has tendered an update of the 1996 study for the entire country.

In the course of the Lyon-Turin high speed line the PACA region in southern France, CETE Mediterranee (2004) have carried out a study on the congestion in major urban areas and on the trunk road network in the region. The study analyses the saturation of motorways and urban access links relative to total capacity limits and a “discomfort threshold” comparable to LOS-Level E as defined by the US Highway Capacity Manual.

In the US the Highway Performance Monitoring System (HPMS) regularly monitors traffic data, which forms the basis for the Urban Mobility Study (Schrank and Lomax 2006). Inter-urban highway congestion is, however, not measured on a regular basis for passenger traffic yet, but the Federal Highway Administration (FHWA) has currently initiated a study to close this gap (CS and TTI 2005). For inter-urban freight transport, Cambridge Systematics (2005) estimates truck congestion and forecasts it to 2020 in the basis of HPMS data.

3.2.1.2 Methods applied

The studies can be characterised by several issues as follows:

- By the method of recording traffic conditions: They might either be measured as travel speeds or by accounting traffic jams. Speed measurements can be performed by dedicated measurement vehicles, by speed measurement via induction loops or radar, by applying traffic volume measurements to speed-flow diagrams or by a combination out of these methods.
- By geographical and time scope: Congestion measures might either capture entire networks or selected links of particular importance. Further monitoring might be continuous over the year or be carried out at selected days or hours of day.
- By the scope of congestion: Studies distinguish between “recurrent” and “non-recurrent” congestion. Recurrent congestion only considers regular congestion caused by traffic overloads, while non-recurrent includes all delay purposes.
- By the type of indicators computed: There is a great number of congestion indicators, including the travel time index (= actual by reference travel time), speed index (= actual by free-flow speed), time lost per vehicle kilometre, share of traffic below a particular threshold, share nof vehicle or network kilometres affected by congestion, etc.

Table 14 gives an overview of the methodologies applied by the national studies and monitoring procedures reviewed. The pros and cons of the different methodologies will be discussed in more detail in Section 3.4 towards a harmonised approach for Europe including all modes of transport.

Table 14: Summary of studies on inter-urban congestion, methodologies

Country / reference	Data source	Geographical scope	Scope of congestion	Reference condition	Indicators
UNITE (Nash et al. 2002)	National speed / delay statistics	EU15, CH, EE, HU; trunk roads	Time and operating costs, recurrent	All-time average speed	Total / average congestion costs
Maibach et al. (2004)	European transport model	EU15 + CH, all trunk roads	Time and operating costs, recurrent	Free-flow speed	Delay costs, Dead-weight loss MSCP revenues
TEN-STAC (NEA et al, 2003)	European transport model	EU25, TEN corridors	Time costs, recurrent	Road capacity limit	Total time costs
England (DfT, 2003)	Floating cars during 6 months	Most busy trunk road sections	recurrent, time losses	Night time speed at lowest traffic levels	Time loss per vehicle km
Scotland (Scottish executive, 2003)	Modelling + measurement vehicles	Trunk roads	recurrent, time losses		Total time loss, time loss per vkm, Total costs, journey time reliability Share of vkm by LOS
Germany (IVV, Brilon 2004)	Modelling with empirical speed flow curves	Motorway network 2000, 2015	Time losses, recurrent	75 kph for cars at dry weather	Share of network-km with min. 30 cong. hours per year
France (CETE Metditerranee, 2004)	Transport network model	Motorways, PACA privince (soutern France)	Time losses, recurrent	road capacity, discomfort threshold	Hours per day above capacity / dinscomfort, days p. a. with min. one cong. hour
Netherlands (AVV 2005)	Traffic jam detection by induction loops	Entire trunk road network	Time losses, all purposes	Duration and lengh of queues	Total congestion severity (km*min)
Switzerland (Infras 1998)	Traffic jam counts, flow data analysis	National roads and agglomerations	Time, operating, environmental and accident costs	Off-peak speed	Total tim, energy, environmental and accident costs
USA (Cambridge System. 2005)	HPMS data, modelling	Highway intersections	time losses of freight transport	n. a.	Time losses per section; time costs

vkm = vehicle-kilometre, MSCP = Marginal social cost pricing

Table 15 provides some selected results. The figures indicate that goals and approaches of the studies are very heterogeneous, such that a comparison of congestion levels between countries or regions is not straight forward on this basis. This incompatibility is due to differences on all levels of the characteristics as described by the above enumeration.

Table 15: Summary of studies on inter-urban congestion, selected results

Study	Indicator	Segment	year	Value
UNITE (Nash et al. 2002)	Total costs share of GDP	Mainly motorways, partly trunk and urban roads	1998	1.2 %
Maibach et al. (2004)	Total costs share of GDP	All roads, passenger All roads, Freight	2000	1.11 % 0.02 %
TEN-STAC (NEA et al, 2003)	Total costs share of GDP	Parts of TEN, passenger and freight	2000	0.01 %
England (DfT, 2003)	Time lost per vkm (seconds)	Motorways, weekday peak Trunk roads, weekday peak	2000	6.7 7.6
Scotland (Scottish Executive 2003)	Time lost per vehicle kilometre (seconds)	All trunk roads, all periods	2003	4.95
Germany (IVV, Brilon 2004)	Share of frequently congested network	Motorways	2000 2015	31 % 42 %
France (CETE Met-diterranee, 2004)	Days above discomfort threshold	Motorways in PACA province	2000	> 70 %
Netherlands (AVV 2005)	Total traffic jams (mill. km*minutes)	All motorways	2000 2005	8.0 10.5
Switzerland (Infras 1998)	Total time costs, M€ Excl. small delays,M€	All roads	1996	710 412
USA (Cambridge Systematics 2005)	Time losses (mill. h) Time costs by GDP	Motorway intersections	2004	243.3 0.07 %

vkm = vehicle-kilometre, M€ = million Euros

3.2.2 Urban roads

On a trans-European scale the case studies of the UNITE project (Doll 2002) has computed marginal external urban congestion costs for morning peak traffic in four European medium-size cities: Brussels, Edinburgh, Salzburg and Helsinki using the Saturn traffic model.

Since 1993 the UK department for Transport (DfT) records travel speeds in English urban areas and on major inter-urban road links (DfT, 2005). Urban and inter-urban speed studies are carried out in alternate years, whereas for London Transport for London performs similar measurements for the British capital every three years. Further comparable travel speed measurements are provided by the UK Commission on Integrated Transport for a number of world cities (Dunning 2005) and by the OECD (OECD 1998).

The most advanced study on urban road congestion in Europe is carried out by Hvid 2004 on the wider Copenhagen region (Hvid 2004). The study has carried out extensive speed and flow measurements across the Copenhagen road network in order to derive location-specific speed-flow curves. These where then used to determine area-wide and street-specific congestion measures.

The prefecture of the Ile-de-France province provides analysis of traffic flow data on the main arterial around Paris dating back to 1998. Measured are traffic volumes, travels speeds and traffic jams by course for 15 Sections of the motorway and national road network in Ile-de-France (Prefecture de la région d'Ile-de-France 2005). Further, Appert (2004) proposes a saturation indicator giving the relation between current and free flow speed as a measure of congestion in Lille, Marseille and Lyon. Estimates of congestion-related time, operating and pollution costs for cars and urban buses in large Spanish cities 1995 are available from Muñoz de Escalona (2004) resulting from traffic model applications.

As concerns the monitoring of traffic quality in urban areas over time the US and Canada are far ahead of many European countries or regions. As part of the Mobility Monitoring Programme the US Urban Mobility Report is unique as it tracks trends for 85 urban areas since 1982 to date. It computes levels of recurrent congestion on urban highways and arterials based on road network and traffic density data for peak hours at a typical day. The major indicators are annual delays per traveller and the travel time index. Moreover, time costs and fuel wasted for private vehicles and additional operating costs for commercial vehicles are estimated.

Referring to the TTI methodology in 2006 Transport Canada has issued as study on the costs of traffic congestion, including delays, fuel consumption and greenhouse gas emissions for nine Canadian cities (TC 2006).

The methodological aspects tracked for urban congestion monitoring are equal to the interurban case (see Section 3.2.1). As above, Table 16 presents some methodological issues of the above mentioned studies and Table 17 shows a selection of results.

Table 16: Summary of studies on urban congestion, methodologies

Country / reference	Recording method	Geographical scope	Scope of congestion	Reference speed	Indicators
US (Schrank, Lomax 2006)	Volume data + capacity functions	85 cities, arterials + major local links	time, fuel, recurrent + all purposes	Designed travel speed	Travel time index, total costs
UNITE (Doll 2002)	Transport models	4 medium-sized cities	recurrent, time losses	Equilibrium travel speed	Marginal social costs
England (DfT, 2004)	Floating cars during 6 months	Links > 10000 veh/day + links of local importance	recurrent, time losses	Weekday off-peak speed	Time loss per vehicle km
Paris (Prefecture Ile-de-France 2005)	continuous by induction loops + police reports	Ile-de-Frace, main arterials	Time losses, all purposes	60 kph	length of traffic jams; vkm below 60 kph
France (Appert)	Network model application	Montpellier, Nice. Lille	Time losses. recurrent	None	Speed index
Copenhagen (Hvid 2004)	Traffic volumes + local speed-flow curves	Greater Copenhagen, city roads and motorways	Time losses. recurrent	average off-peak speed	Share of critical congestion, time lost per vkm
Spain (Muñoz de Escalona, 2004)	Regression from Madrid & Barcelona	Details: Madrid and Barcelona; all cities over 200000 inh.	Not available	Not available	Time costs operating costs pollution costs

Table 17: Summary of studies on urban congestion, selected results

Study	Indicator	Segment	year	Value
US (Schrank, Lomax 2006)	Travel time index	All areas	2003	1.37
		Very large areas		1.48
		Medium sized areas		1.18
	Average annual delay per traveller (	All areas	2003	47
		Very large areas		61
		Medium sized areas		25
UNITE (Doll 2002)	Marginal social costs (Euro-Cent / vkm)	Brussels	1998	25.2
		Edinburgh		11.6
		Salzburg		16.4
		Helsinki		4.3
England (DfT, 2004)	Seconds lost per vehicle kilometre (weekday peak)	Greater London	2000	65.8
		other conurbations		34.4
		Other large urban areas		36.9
		All urban areas (inkl. London)		46.4
Paris (Prefecture de la région d'Ile-de-France 2005)	Share of traffic volumes below 60 kph	Ile-de-France, main arterials	2003	18 %
			1998	16 %
		A86 By-pass	2003	20 %
			1998	19 %
Copenhagen (Hvid 2004)	Seconds lost per vkm	Municipality	2001	50
		Motorways		25
	Network affected by critical congestion	Municipality	2001	2 %
		Motorways		11 %
France (Appert)	Speed index = atual / free flow speed	Montpellier	n. a.	0.68
		LIlle		0.72
Switzerland (Infras 2003)	Total hours lost per day, share by purpose	Commuters	2000	42 %
		Business		17 %
		Leisure		35 %
		Freight		5 %
Spain (Muñoz de Escalona, 2004)	Total time costs (million Euros)	Madrid, cars	1995	1301
		Madrid urban buse		199
	Total costs per inhabitant (Euros)	Madrid	1995	486
		Barcelona		264

3.2.3 Scheduled transport services

For scheduled transit services only a very limited number of studies addressing the problem of congestion exist. First, this can be explained by the limited policy relevance as scheduled services are regulated by service and network operators. Second, data availability is often a problem and finally, the presence of time tables suggests very simple indicators, which are less attractive for research.

The most important scientific study on congestion in rail, air and public transit is the UNITE project (Nash et al. 2003) suggesting a simple delay approach. The necessity of weighting train or plane delay figures with the affected passengers and the problem of missed connections is discussed, but, due to data availability, not considered in the practical estimation of congestion costs. Further approaches exist on the urban level. The Copenhagen congestion study (Hvid 2004) has estimated speed-flow curves for urban services and the congestion study for Switzerland (Infras 1998) has addressed the problem of P. T. delays using data from the operators.

Statistical information and the development of delay indicators in air transport in Europe is provided by several sources for Europe and the US in comparable quality. In the rail sector Europe suffers from the presence of a large number of former state owned and now partly privatised railway undertakings, which do usually not provide access to delay data. A positive exception is the UK, where Network Rail publishes detailed delay analyses. For urban services a limited number of municipalities, such as London, Dublin and Paris, publish statistics of performance indicators.

Besides the delay of services, congestion in scheduled transport also has a dimension related to the comfort of travelling and the crowding of vehicles. This fact is discussed in the UNITE project, but has been dropped from the transport cost analysis due to the non-availability of respective quantitative information. Nevertheless the problem of overcrowded services is acknowledged by some member states, e. g. France (Sauvant 2002) and the UK (House of Commons 2002). In the UK the installation of automatic passenger counting devices has just started, but will take some time to be universal. Detailed figures, however, are needed as average deily or yearly values do not allow to adequately analyse overcrowding effects. Eventually, we disregard the related effects in analysing the congestion situation in Europe and the US, but acknowledge it being a topic for further investigation.

3.3 The Panorama of congestion

For drawing a panorama of congestion for Europe and the US the literature review presented above is complemented by the results of the COMPETE country reviews carried out for the 25 EU member states, Switzerland and the US and by two specific studies on EU and US maritime and aviation markets. The detailed country reviews have been collected in Annex 3, while the specific air and port studies are integrated in Annex 2 to this report.

3.3.1 Inter-urban road transport

3.3.1.1 Evidence from available studies

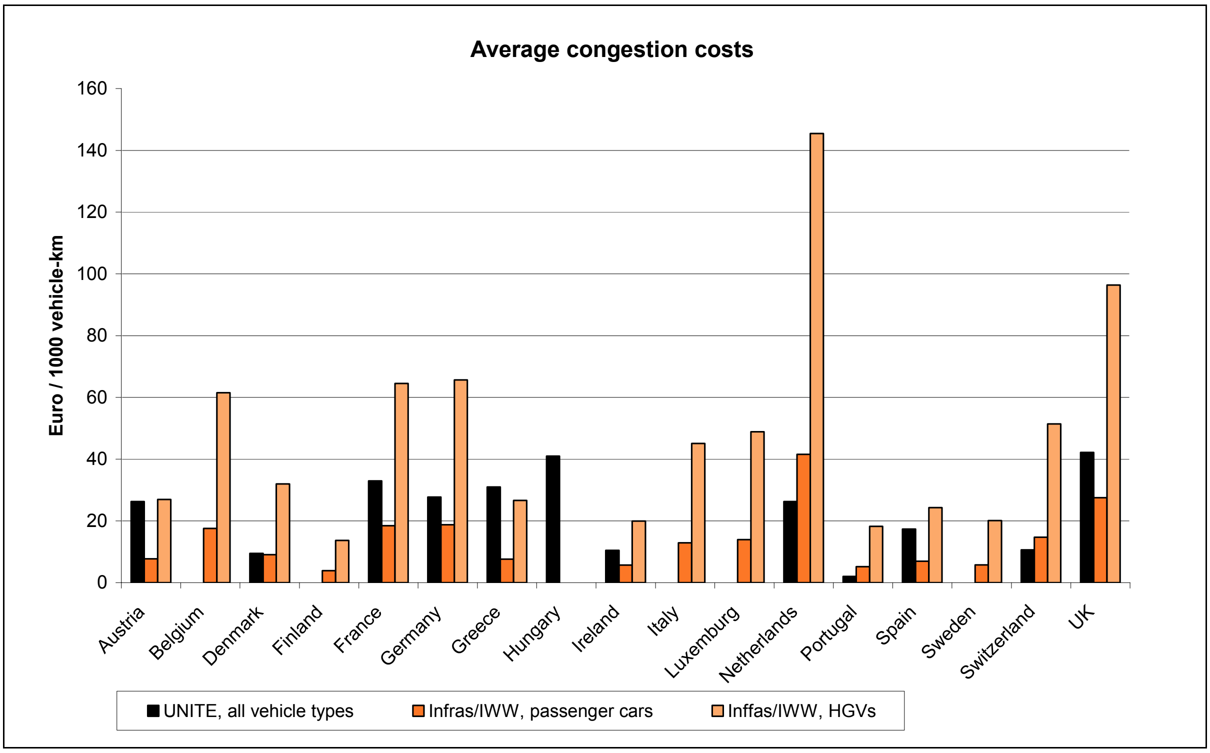
A panorama of inter-urban road congestion based on quantitative figures is best presented by international studies as national approaches are rare and differ widely in their methods and assumptions. Mainly for western Europe the UNITE project (Nash et al. 2003) and the study "External Costs of Transport" by Infras and IWW (Maibach et al. 2004) deliver the most comprehensive results. The average costs per vehicle kilometre of all vehicle types (UNITE) and separately for passenger cars and HGVs (Infras/IWW) for the EU-15, Switzerland and Hungary are depicted in Figure 2 for the year 2000 4.

Maibach et al. (2004) finds the highest average costs for the UK, Benelux, France, Germany, Switzerland and Italy, forming the so-called "blue banana" of industrialised areas across

---

[4] For Maibach et al. (2004) average costs relate to the deadweight loss measure. The difference between HGV and passenger car congestion costs explains by the higher value of time and the higher capacity units of HGVs. for the UNITE values a breakdown by passenger and freight vehicles was not possible.

Europe [5]. The se results are only partly confirmed by the UNITE estimates, which are comparably low for the Netherlands and high for Austria and Spain. Moreover, UNITE reports high congestion costs for Hungarian inter-urban roads.



Symbols and source: Infras/IWW: Maibach et al. (2004), UNITE: Nash et al. (2002)

Figure 14: Average congestion costs for EU15, Switzerland and Hungary

Table 18 presents rather old figures for the year 1993, but they provide an insight into the affected network and the users' perception of congestion conditions. The figures reveal that within Europe the UK and the Netherlands suffer most from congestion, while the road quality is perceived very good in Scandinavia and in the US.

---

[5] The dominance of the Dutch and the UK figures, but also the high average congestion costs for Switzerland, are reported to be overestimated by the underlying transport model, which is mainly due to differences in the network representation.

Table 18: International comparison of congestion figures 1993

	Road network (km/1000 inh.) 1993	Motorways (km/million inh.) 1993	Congestion (% of links) 1993*	Perceived road quality 1995**
USA***	14,5	331	--	9
Japan	6,2	37 (1987)	--	6,2
United Kingdom	6,2	56	24,1	5,9
Germany	7,6	136	7,9	8,3
France	15,8	129	4,5	8,5
the Netherlands	6,1	141	14,8	5,9
Belgium	12,9	169	5,9	8,3
Denmark	13,7	127	0	9,1

Source: ECMT 1998

3.3.1.2 Evidence from Country reviews

The COMPETE country reviews have taken a more qualitative view on the problem of congestion in the Member states, Switzerland and the US. The results are broadly in line with the indicators presented in Figure 2, but look behind the local drivers of congestion. This is not always capacity shortage, but – in particular in some New Member States – a problem of road infrastructure quality. Further the analyses reveal that in Europe congestion is mainly a problem of urban access links with the exception of the very densely populated Randstad region (Netherlands) and the Ruhr area (Germany). Freight traffic is particularly penalised by capacity problems in port hinterland transport, e. g. at Rotterdam and Rostock.

Table 19 draws the comparison between the US and six European regions by summarising the COMPETE country reviews [6]. The table classifies current congestion from "A" (no problems) to "E" (severe regular congestion across large parts of the networks) and the expected direction, in which transport quality emerges. Besides the more peripheral regions Scandinavia, the Baltic states, southern Europe and Ireland, many European regions show dense or saturated networks.

In contrast, the US reports problems only at highway intersections and some neuralgic spots. These bottlenecks are, similar to Europe, located at seaports and at interstate road crossings.

In both, Europe and the US, congestion tends to worsen in the future. In its "State of Logistics Report 2006" the US Council of Supply Chain Management Professionals (CSCMP) provides US transport infrastructure no better than the mark "D+" and constitutes, that the US has lost ground against foreign countries concerning the state of transport infrastructrure. The study concludes that the US was not prepared to take the expected strong growth in the logistics sector in the coming decades (CSCMP 2006).

Besides investment in new or improved road infrastructure, a number of member states and the US have implemented or plant to install ITS solutions for traffic demand management as a means to fight congestion. The recent introduction of electronic road pricing in Germany and Austria, however, do not indicate an influence on congestion levels to date. Thus, active

---

[6] A detailed summary by country including information on data collection methods and policy plans is contained in Annex 2. The individual country reports are collected in Annex 3

traffic control measures, e. g. ramp access control and speed regulations, appear to be more appropriate. The US department of Transport has recently published a national strategy to fight congestion (DOT 2006b), calling on investments, technical solutions, incentives and soft measures in order to address the problem of congestion from many sides. Also the UK Department for Transport follows a policy strategy particularly relating to congestion reduction in the Ten Year Plan 2000 (DfT 2000b). Other consistent national strategies are not known.

Table 19: Synthesis of country reviews - inter-urban road

Region	Current state of congestion	Expected development of congestion	LOS slope
United States	Serious congestion on interstate highway crossings and where congestion is caused by metropolitan areas	Increase due to lag of grade-separated junctions and access points. Particular problem for port access traffic.	B ➘
Germany and Alpine	High congestion in Ruhr area; Brenner corridor and urban access routes; no Problems in rest of Austria and Switzerland	High increase in Germany, no severe problems in Alpine region due to rail investments and road charging	B-D ➘
France and Benelux	Particular Randstad region (NL); international motorways are currently close to saturation	Stagnating demand in BE; increasing border crossing traffic in FR, NL and LU	B-E ➘
UK and Ireland	Perceived a major issue by government particularly in England, less severe in Ireland	Stablelisation by policy measures in the UK; increase due to truck traffic in Ireland	B-D ➔
Scandinavia and Baltic	Few times per year on holidays on limited network part on two lane roads	No information, but due to Scandinavia's remote location no dramatic change expected	B ➔
Central Europe	Good: Slovenia and Hungary; bad road quality in Poland and Slovakia; all: bottlenecks around big cities	Pessimistic due to lag between fastly growing traffic and infrastructure investments	B-D ➘
Southern Europe	Only in specific parts under construction in fairy days and some weeks in summer	No information for IT, No congestion predicted in the next 10-15 years	C ➔

Source: COMPETE

3.3.2 Urban road congestion

3.3.2.1 Evidence from available studies

There is no unique way in Europe to assess urban congestion. The most advanced approaches are followed by the UK department for Transport and Transport for London by regularly measuring vehicle speeds. For English towns, Paris and Copenhagen the available information was sufficient to estimate a travel time index similar to that computed by the Texas Transportation Institute for the US (Schrank and Lomax 2006). The Travel time index gives the ratio between the actual average and the free flow travel speed and thus indicates the increase of journey times due to congestion[7].

Table 20 reveals that the development of the travel time index indicating the severity of congestion in English cities is in line with the development of urban congestion in the US between 1993 and 2004. The same holds for the comparison of 2004 values except for London, which seems to suffer extraordinarily under congestion.

---

[7] As the data sources are quite different the comparability of the results presented in Table 20 is restricted.

Table 20: Travel time index in EU and US cities 2003

Area	Travel time index		
	1993	2004	1993-2004
Paris, Ile-de-France		1,34	
Greater Copenhagen area		1.40	
Greater London		1.84	
Average of other English cities	1.24	1.32	0.08
US 85 Area Average	1.28	1.37	0.09
US Very large average (13 areas)	1.38	1.48	0.10
US Large average (26 areas)	1.19	1.28	0.09
US Medium average (30 areas)	1.11	1.18	0.07
US Small average (16 areas)	1.06	1.10	0.04

Source: Own estimations; Schrank and Lomax (2006)

3.3.2.2 Evidence from Country reviews

The comparison of European and US cities based on the synthesis of the COMPETE country reviews (Annex 3) is presented by Table 21. The most congested urban areas are located in the UK, in Central and in Southern Europe. The most affected agglomerations are Paris, London, Prague, Athens and the big Spanish and Italian cities. In some cases, e. g. Prague, peak traffic has spread out to the off-peak periods, such that off-peak is only visible during night time.

For other big and medium-sized capitals, such as Berlin, Zurich, Vienna, Warsaw, Stockholm, Helsinki or Copenhagen usual peak hour or only mild congestion is reported. In most of these cases congestion is rather a problem of access links. However it needs to be stated that the reduction of urban congestion in Europe is partly due to the increasing sprawl of urban areas, which also considerably impacts daily travel and commuting times.

Table 21: Synthesis of country reviews - urban road

Region	**Current state of congestion**	**Expected development of congestion**	**LOS slope**
United States	Steadily increasing in spread and severity, but not perceived a major problem, even in large metropolitan areas	Congestion continues to grow; transport improvements do not keep pace with demand growth	**D ↘**
Germany and Alpine	Typical peak hour congestion in DE and AT; access problem in CH due to regulation	Only increasing problems at urban bypasses expected	**C →**
France and Benelux	Major bottlenecks: Paris, Brussels Lyon and Bordeaux; other usual peak traffic	Expected increase in France and Luxemburg against decrease in Belgium	**B-D ↘**
UK and Ireland	Greater London area highly congested; other cities rather modest	Increasing demand in medium term predicted; long-term relaxation for IE	**C–E ↘**
Scandinavia and Baltic	Moderate congestion even in capitals	Further reduction by road tolling in Stockholm; some increase expected for Helsinki	**B- C →**
Central Europe	Very big Problem in Prague and Budapest; other usual peak and access congestion	Further increase due to catching-up in economic development; insufficient construction	**B- E ↘**
Southern Europe	Severe congestion in big and some medium sized cities besides Cyprus and Malta	Strong increase for Athens and in Italy and Spain; positive expectations for Lisbon	**C - E ↘**

Source: COMPETE

The TTI Urban Mobility Study (Schrank and Lomax 2006) shows that congestion in US cities had been increasing significantly along all dimensions (duration, geographical sprawl and severity) since the 1980s. Further, the model calculations reveal that congestion rises more dynamically in large and medium sized areas than in very large agglomerations. Remarkably, congestion is not considered a major problem for most US citizens as the ability to relocate to non-congested areas within a city or across states is high. US Citizens tend to value congestion less critical than e. g. social security, health care, school quality or safety in bigger agglomerations on a national level.

3.3.2.3 Prospects and policy options

The future expectations for both, the congested cities in Europe and the US, are rather pessimistic. Limited space availability makes capacity extension measures less applicable. The country reviews report on a variety of alternative measures envisaged by individual countries or cities. While capacity expansion programmes are particularly reported for the US, Germany and Poland, other countries focus more on traffic management, ITS and the promotion of public transport. Intelligent Transportation Systems (ITS) receives attention by most countries hoping that they could gain extra capacity and thus reduce congestion. Against the current trend Budapest plans to replace signalling systems by roundabouts.

The greater London area is probably the most congested zone in Europe. However, the introduction of the London Congestion Charge in 2003 has considerably improved the situation. Vehicle speeds have been rising by 5% and both, the frequency and the punctuality of public transport has considerably improved. Similar positive experiences have been made by the trial of the Stockholm congestion charge and by city access control in Zurich.

3.3.3 Rail transport

3.3.3.1 Evidence from available studies

Giving a comprehensive picture of the quality of Europe’s railway market is rather difficult as detailed punctuality figures by delay cause are treated as private information by many railway undertakings. Thus, only annual delay figures and peace-wise information on causes or on specific services is available. And even this information is to be treated with care as first, regular delays may be eliminated by the railway undertakings through adjusting time tables and second, the values often reflect the delay at the trains’ final destination, which does in no way reflect the passengers or shipments affected. Moreover, additional travel times of passengers due to missed connections are not captured by official delay statistics.

Table 22: Railway punctuality figures in EU and US

Country / company	Type of service	Margin	Punctuality	Year
US, Amtrax	Long-distance passenger Short-distance passenger	20 - 30 min. 10 - 20 min.	53 % 77 %	2003 2003
Europe	Thanys Eurostar	5 min. n. a.	84.4 % 89.2 %	2005 01-10/2004
Germany, DB	Passenger	5 min.	95 %	2004
UK, all operators	Long distance sector London & south east Regional sector	10 min. 5 min. 5 min.	79 % 85 % 82 %	2005/06 2005/06 2005/06
France, RFF	South-east HSL North HSL Atlantic HSL	5 min. 5 min. 5 min.	82.2 % 87.1 % 86.3 %	2005 2005 2005
Poland, PKP	Passenger	5 min.	97.0 %	2004
Switzerland, SBB	Passenger	5 min.	92.3 %	2004
Finland, RHK	Inter-Urban Urban	5 min. 3 min.	97.6 % 90.0 %	2004 2004
Czech Republic	All passenger	5 min.	92.3 %	2005/1
Spain	High speed – AVE High speed – Talgo 200 Long distance trains	3 min. 10 min. 10 min.	99.8 % 97.5 % 95.9 %	2004 2004 2004
Europe, UIRR	Intermodal freight	60 min.	72 %	2004
Germany, Railion	Freight	30 min.	90.6 %	2004
Switzerland, SBB Cargo	Freight	n. a.	92.3 %	2004
Finland	Freight	15 min.	94 %	2004

Source: Data from country reports in Annex 3

The comparison shows that US quality standards in rail punctuality are far below the high standards of European railway undertakings. But the distances in the US, and thus total travel times, are much longer in the US and Amtrax reports on mixed passenger and freight services, while EU punctuality figures are usually restricted to passenger services. Time series of punctuality presented in Figure 15 show that there might be high fluctuations in on-time arrivals and that long-distance services are generally below the average of all services.

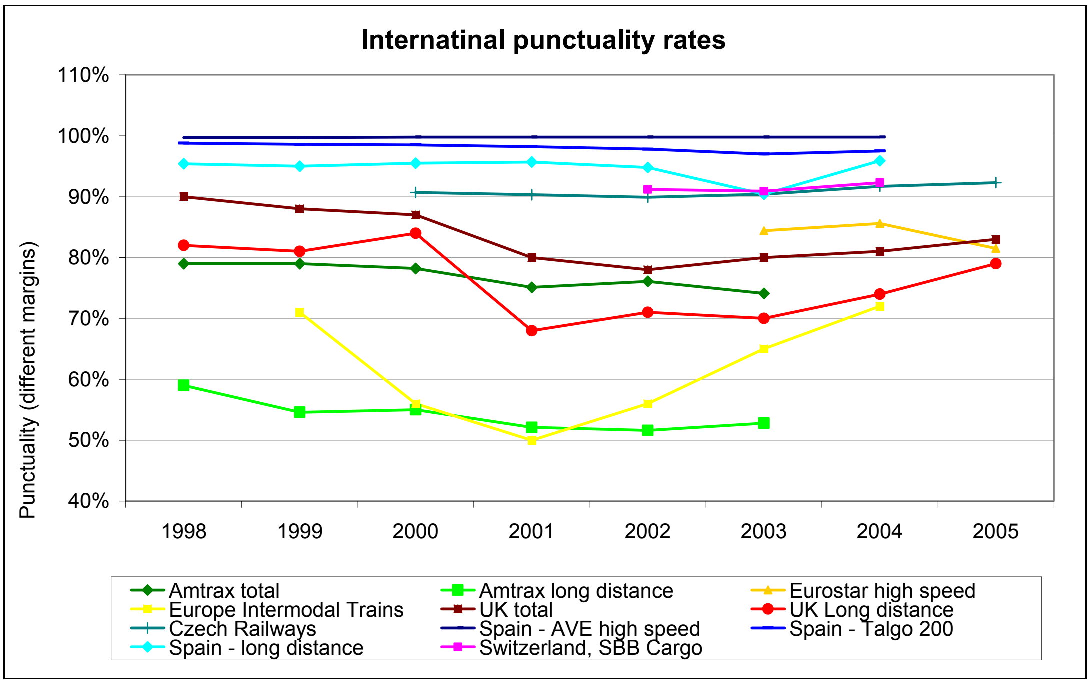


Figure 15: Time series of punctuality data for selected railway undertakings

3.3.3.2 Evidence from Country reviews

Table 23 summarises the reviews of EU Member States, Switzerland and the US on rail congestion. In Europe the major bottlenecks are the French high speed lines and the connections from Dutch seaports to the German border. Further, capacity shortages on the German network reach out to Switzerland and to the Netherlands. The New member states report that the physical quality of the network, of the stations and the rolling stock, incident and track works cause more delays than pure capacity restraints.

Table 23: Synthesis of country reviews - rail transport

Region	**Current state of congestion**	**Expected development of congestion**	**LOS slope**
United States	Freight: Considerable problems due to the lag in grade-separated facilities in the Los Angeles and Chicago regions.	Further increase due to lag of railway companies in funds to finance expensive investments	**D ↘**
Germany and Alpine	Considerable German rail bottlenecks affecting traffic in Switzerland	Major capacity extensions; Alpine routes remain affected by capacity limit in Germany	**A-C ↗**
France and Benelux	High speed and freight lines in France and the Netherlands saturated; relaxed in Belgium	Additional traffic until 2012 +15% which will increase the saturation	**A-D ↘**
UK and Ireland	Current recovery in UK; some minor congestion in Ireland	Additional demand due to economic development and hard coal imports	**B-C →**
Scandinavia and Baltic	Few congested track segments; incidents and low technical standard in Baltic states	Delay reduction through policy and investments; demand driven increases in Latvia	**A-C ↗**
Central Europe	Problems: Old equipment, construction works and incidents; border crossings	Partly solving and partly retaining current problems	**C →**
Southern Europe	Only some minor delays on long-distance lines due to bad infrastructure quality	Improvement for Spain, more delays expected in Athens region	**A- B →**

Source: COMPETE

In contrast, US networks are highly congested. Major bottlenecks are the lag in grade-separated facilities in the Los Angeles and Chicago regions causing considerable problems in freight shipment. This phenomenon is similar to the case of the Dutch seaports.

3.3.3.3 Prospects and policy options

The general prospects for service quality in the European railway market are stable to positive. In particular the huge investment programmes of the Alpine countries and other initiatives manage to accommodate demand increases except for the case of Rotterdam port hinterland transport. Here the newly constructed Betuve Lijn will only be able to serve the additional demand to Germany and not contribute to improve overall railway quality in the Netherlands.

Overall there is no consistent strategy of national network operators and rail carriers to reduce delays. Apart from investment in new capacities, the separation of passenger and freight traffic, construction of high speed lines, peak load pricing and the modernisation of rolling stock and signalling and train control systems are mentioned by the country reviews. The introduction of the European Train Control System (ETCS) could help to make international train operations more efficient and reliable.

The US problem is a financing one. Railway companies lag of sufficient resources to invest in new capacity. Therefore, current capacity problems are expected to further increase. The investments in grade-separated intersections and truck-train interchange facilities by the US SAFETEA-LU policy program will not suffice to reverse this development.

3.3.4 Aviation delays

3.3.4.1 Evidence from available studies

In Europe flight delays are published by Eurocontrol and by the Association of European Airlines (AEA). Eurocontrol delay statistics focus on delays caused by Air Traffic Management (AFTM), but also report total delays due to other reasons. Due to their availability by Airport, the subsequent analyses are based on the results of the annual AEA consumer reports (AEA 2006). Similar consumer reports are available for the US (DOT 2006), which form the basis of the official US transportation statistics (BTS 2006).

Following the detailed analysis concerning delays and capacity per region and airport, subsequently a comparison on delays between the USA and Europe is presented. The long term trends are illustrated by Figure 16. It shows that delay rates in the two regions across all airports are similar, but the EU development appears slightly more dynamic. While until the mid 1990s intra-European flights have been more on time, their punctuality has dropped significantly after the Kosovo conflict in 1999 and since then has remained worse compared to US punctuality figures.

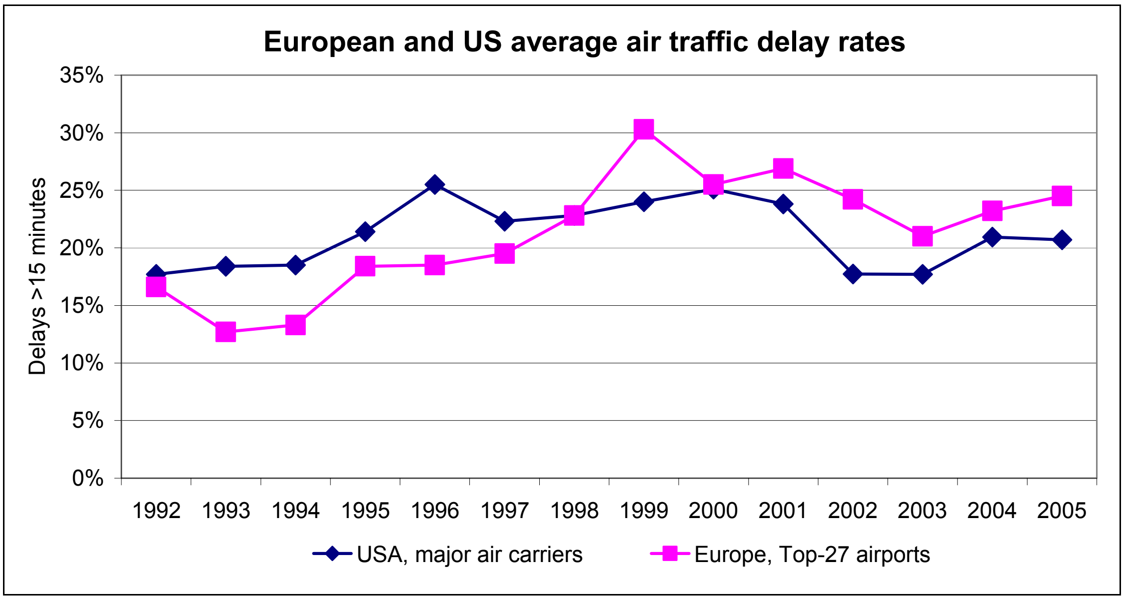


Figure 16: Long-term comparison between delay rates in US and European air transport

Sources: BTS (2006) and AEA (2000 to 2006)

3.3.4.2 Evidence from case studies on selected airports

An analysis of six top European and the five top US airports has been performed by comparing the development of passenger and delays by purpose in the context of past and future investment programmes. It is argued that a parallel growth in passenger numbers and delay rates indicates the airport operates at its capacity limit. But it is acknowledged that, besides airport infrastructure capacity, the efficiency off air traffic management (ATM) and the percentage of systemic reactionary delays are fully or partly out of the airport's responsibility.

For Europe the results show capacity shortages at the London airports, while the Paris airports, Frankfurt and Madrid are not considered to suffer from congestion. Most of the US airports have still not recovered from the 2001 crises. Among the top-5 US airports only Los Angeles urgently suffers from congestion and in Atlanta some problems with ATM delays are indicated. Chicago, Dallas and Las Vegas operate below their capacity limits and show no signs of severe congestion. Table 24 resumes the results of the airport case studies.

Table 24: Summary of European and US airport analyses

Europe	United States
London Heathrow: Highest percentage of delayed flights among top-10 airports; operation close to capacity limits. Current construction of Terminal 5 will reduce delays.	**Atlanta**: Highest share of ATM-caused delays indicates airspace congestion; however sufficient infrastructure capacity due slow demand growth and substantial past investments
London-Gatwick: Single runway; performance similar to Heathrow with even stronger increase in delays, which indicates heavy congestion.	**Chicago**: Demand reduction and significant delay reductions. Unlikely to suffer from congestion.
Paris-Orly: One of the least congested airports among top-10.	**Dallas**: Low delay rates and only slight passenger increase. No congestion problems.
Paris-CDG: Not congested despite the high percentage of ATM delays due to its hub function.	**Los Angeles**: Currently congested; 2005 significant increase in delays with high share of airline related causes. Large 10 year investment plan.
Frankfurt: 3rd largest European hub and best performance of delayed flights. Future large expansions planned in Germany (Frankfurt, Munich and Berlin-Brandenburg International)	**Las Vegas**: Constant delay rate with high share of reactionary delays. No current congestion problems.
Madrid: High passenger growth with significant decline of delayed flights – starting from a high level. Most important ATM and reactionary delays; overall far from congestion.	

Source: Own survey

Table 25 compares annual delay rates over time and by purpose for the top-5 airports in Europe and the US. The currently worse performance of European airports can be a clear indicator of higher congestion in Europe compared to the US. This can be supported by the different contexts of both industries: the USA is going through an important crisis (not yet recovered from the 2001 events) and has a certain level of spare capacity in most airports. On the contrary, the European industry has grown strongly in the last decade and its airports and airspace have been or still are more congested, despite the efforts on investments for capacity expansion.

Table 25 – Resume of percentage of delayed flight and causes by airport and region

Region	Percentage of delays					Sources of delay 2005 (%)			
	2001	2002	2003	2004	2005	Airline	Airport	Weather	Late Arr.
EUROPE									
Average	**26.9**	**24.2**	**21.0**	**23.2**	**24.5**	**6.9**	**7.9**	**0.9**	**8.8**
London Heathrow	24.0	25.7	22.5	27.8	28.4	7.8	9.3	0.7	10.6
Paris CdG	30.3	26	24.4	22.7	25.0	7.9	8.7	0.8	7.6
Frankfurt	20.3	18	16.8	18.3	20.5	4.2	5.5	1.4	9.4
Madrid	32.4	30.2	21.5	23.3	25.3	6.1	10.2	0.5	8.5
Amsterdam	27.3	21.1	19.7	23.7	23.3	8.6	5.9	0.9	7.9
USA									
Average	**23.8**	**17.7**	**17.7**	**20.8**	**20.7**	**4.8**	**9.1**	**0.6**	**6.2**
Atlanta	:	:	:	23.2	24.5	4.3	14.5	0.6	4.6
Chicago	:	:	:	26.1	22.2	4.1	11.5	0.6	6.0
Los Angeles	:	:	:	17.0	18.7	6.3	6.2	0.5	5.7
Dallas	:	:	:	16.1	16.9	3.6	6.4	0.9	6.1
Las Vegas	:	:	:	21.4	21.3	5.5	6.9	0.5	8.4

Source: own elaboration from AEA and BTS data

3.3.4.3 Evidence from Country reviews

The assessment of the COMPETE country reviews on air transport presented by Table 26 reveals the analysis of the airport case studies by showing a higher level of congestion for European than for US airports. Nevertheless, none of the systems can be considered as critically congested.

Table 26: Synthesis of country reviews - aviation

Region	Current state of congestion	Expected development of congestion	LOS slope
United States	Since 1987 no increase in total delayed flights though steady traffic growth; main cause: weather.	Following the past trend average delays will further decrease	B ↗
Germany and Alpine	Currently capacity limits in Frankfurt and Munich; low to medium delay rates	German investment plans will cause over-capacities; possible lag in Switzerland	C →
France and Benelux	Limited infrastructure and airspace capacity	Due to dynamic growth in demand congestion is expected to rise in the future	D ↘
UK and Ireland	No information	No information	
Scandinavia and Baltic	Information on Baltic countries only: no current congestion problems	Congestion problems expected due to economic growth	A ↘
Central Europe	Severe problems in Budapest only; capacity problems in Prague have been solved	Strong demand growth in Warsaw and Budapest will increase capacity problems	A-D ↘
Southern Europe	Large airports approach but have not yet reached capacity limits	All big airports besides Lisbon expect improvement of capacity situation	A-C →

Source: COMPETE

While the analyses coincide for Germany and Spain, a large discrepancy between the two analyses concerns the Paris airports. While the country review states limited infrastructure and airspace capacity, the AEA punctuality figures analysed indicate no major problems. This might be explained by an efficient flight management at the airports and the French Air Traffic Control Centre.

3.3.5 Waterborne transport

3.3.5.1 Evidence from case studies on selected seaports

Within the seaport case study four US and 16 European seaports have been studied. The results show clearly that port congestion is a US problem. Table 27 presents the main statements for each individual port.

Table 27: Results for selected EU and US seaports

Country	Current state of congestion	Expected development of congestion
Long Beach (US Pacific)	Road and rail increasingly congested, terminals equally congested	As traffic increases, problems may worsen
Miami (US Atlantic)	Problem landside: gate, location close to city	Increasing
Tacoma (US Atlantic)	Strong hinterland congestion	Problems may rise without action
Corck (US Atlantic)	Constant inland congestion	Sharp rise
London (UK, inland seaport)	No structural congestion on maritime side	Probable worsening on hinterland
Humber (UK, east coast)	No congestion	No immediate worsening
Felixstowe (UK, south east coast)	No congestion	No worsening expected
Hamburg (Germany, North)	Congestion occurs, but not quantified	No worsening
Rotterdam (Netherl., Atlantic)	Only congestion on hinterland side;	Pessimistic
Antwerp (Belgium, Atlantic)	Sometimes congestion, especially at terminals	Situtatiion will improve: new quays, better rail, inland navigation and trucking system
Zeebruges (Belgium, Atlantic)	Mainly congestioni in hinterland	No immediate worsening
Marseille (France)	Only congestion for tankers	Other commodity types may be affected too
Portuguese ports (Atlantic)	No congestion	No worsening
Rostock (Germany, Baltic)	Congestion at gates and at terminal; peak congestion in hinterland transport	Road situation may get worse
Aarhus (Denmark, Baltic and North Sea)	Minor congestion at terminals	Worsening through overflow from other ports
Kotka (Finland, Baltic))	No real congestion	No worsening expected
Rauma (Finland, Baltic)	No recurrent congestion	No worsening
Gdynia (Poland, Baltic)	No congestion, at least not on maritime side	Worsening if no measures
Barcelona (Spain, Med.)	Some inland congestion	No worsening expected
Genova (Italy, Med.)	Minor congestion in hinterland	No clear view

Source: COMPETE

3.3.5.2 Evidence from country reviews

The results in Table 28 show a clear discrepancy between the highly congested US ports and the European market and thus fully confirm the results of the seaports case study. EU ports and inland navigation networks do not operate under full capacity utilisation and thus are ready to take the strong increase in container movements expected for the coming decades. In contrast, the US faces a strategic problem as most ports are located within urban areas and thus can not be further expanded.

Table 28: Synthesis of country reviews - waterborne transport

Region	Current state of congestion	Expected development of congestion	LOS slope
United States	Considerable congestion at Pacific ports concerning port capacity and congestion hinterland routes	Further increase due to long investment cycles.	D ↘
Germany and Alpine	Inland navigation: No capacity problems	Further decrease as ships get bigger	A →
France and Benelux	Most congested inland terminals (Rheinland, south-west) and seaports (Marseille)	No information	B
Scandinavia and Baltic	Capacity sufficient; but specific needs for certain types of traffic	The situation is considered not to change.	
Central Europe	No problems at seaports; minor problems at locks and opening bridges in inland navigation	Difficult prediction of Russian transit traffic	A-B →
Southern Europe	Land access; minor seaport infrastructure constraints	Only Cyprus some congestion expected; others: no major changes	B →

Source: COMPETE

3.3.6 Conclusions

Table 29 summarises the presentations by mode and draws a direct comparison between Europe and the US. It gets obvious that, besides aviation, the EU consists of less congestion problems than the US. Thus, the EU seems to be better prepared to take the expected rise in international freight transport. In particular the better situation in seaports makes Europe competitive in the fast growing trans-continental logistics market.

Table 29: Synthesis of country reviews - all modes

Mode	Europe		US	
Inter-urban roads	Mainly Randstad and Ruhr areas and urban access	C ↘	Highway intersections and around agglomerations	B ↘
Urban roads	Severe congestion in some cities, no general problem	C ↘	Steadily increasing but not perceived a major problem	D ↘
Rail	Only at port hinterland lines; technical standards	B →	Considerable lag in grade-separated facilities in major lines	D ↘
Aviation	Problems in major hubs (London, Paris); airspace	C ↘	Constant investments and still recovery from 9/11	B ↗
Waterborne transport	Only port hinterland transport (Rotterdam)	B →	Port capacity and congestion hinterland routes	D ↘

Source: COMPETE

3.4 Towards a harmonised approach for Europe

3.4.1 Requirements towards a congestion monitoring system

The review of country practices and international literature shows a variety of different approaches and methodologies, each having their pros and cons. In the following they will be briefly discussed and conclusions towards a harmonised approach for Europe will be drawn.

There are several rationales behind establishing congestion monitoring systems, including user information and the indication of policy action needs. But the most relevant from the perspective of a European approach is assumed to be the monitoring and benchmarking of congestion trends between regions and over time, allowing to assess transport infrastructure quality and policy interventions in order to verify policy targets. Therefore, quality indicators should apply to the following criteria:

1. **Practicability and costs**: The approach should be economical in terms of resource consumption and costs.
2. **Robustness**: Reliable time series are essential and regional comparisons are desirable. The results should not be too sensitive towards methodological details.
3. **Intermodality**: The measure should allow comparisons across modes.
4. **Transparency**: Users and decision-makers should be able to understand what is measured and the final indicators should match their perception of traffic quality.
5. **Significance**: Given the wide range of user information requirements and policy targets the scheme should be comprehensive by covering all congestion causes and it should result in indicators which are meaningful for decision processes.

Further there are several desired properties of congestion indicators, including the differentiation in space and time and the option to set threshold levels in order to indicate the compliance with policy goals. Subsequently, the options for congestion and delay monitoring systems in road, rail and air transport will briefly be discussed and assessed along the above criteria. A main focus is on road transport, since the analysis has shown that there is no comprehensive and comparable indicator across EU MS available.

3.4.2 Methodological options towards a harmonised approach

3.4.2.1 Measuring traffic conditions

The **observation of traffic conditions** (especially for road) is possible by several technical means, including contemporary induction loops, camera based or radar systems. Practical procedures can be distinguished by what is measured (the occurrence of traffic jams or travel speeds) and by their regularity (continuous vs. sampling selected periods).

All variants can be classified as robust and transparent due to their intuitive approach and they are applicable to all modes. Besides the sample measurement of traffic speeds all congestion and delay causes are captured. The costs of automatic observation depend on the availability of modern detectors in road transport, which are usually available in Western Europe for traffic control purposes, while in the new member states detector systems are currently built up. Accordingly, the main components are those costs associated with data processing.

Model based approaches determine travel speeds on the basis of traffic volume data and speed-flow functions in road transport. Contemporary traffic management systems also take into consideration real-time traffic observations to adjust the model results. Modelling congestion in scheduled transport is very difficult due to the time-table dependence of train and aircraft movements.

The information requirements are limited, which makes modelling approaches to congestion possible at low costs. However, the results are strongly depending on model parameters, in particular on speed-flow functions; this has a negative impact on transparency and on robustness. Further, in case only archived flow data is used, the identification of all congestion purposes has to be addressed by other data sources.

Finally, traffic conditions can be assessed by **interviewing** traffic users. This approach is cheap and universal to all modes, but does not deliver quantitative results and varies with the quality of the survey. Overall questionnaire-based indicators are not recommended to build up a European monitoring system. Table 30 gives an overview of the procedures and their assessment.

Eventually, two alternatives for quantifying congestion are recommended: For all modes the observation of travel speeds, delays and traffic conditions provides a robust way of establishing an inter-modal quality monitoring system. In road transport the modelling of congestion based on archived flow and capacity data provides a cost-efficient way to generate time series of recurrent congestion on the TEN network dating back to the early 1990s. Data is available by the UN Economic Commission for Europe, by most member states and most likely by a number of bigger cities.

Table 30: Assessment of traffic congestion measures

Variant	**Practical examples**	**Practicability and costs**	**Robustness**	**Intermodality**	**Transparency**	**Comprehensiveness**	**Overall**
Observation							
Continuous speed measurement	Ile-de-France [1], rail UK [2], air EU [3] US [4]	depends on equipment	robust	all modes	Intuitive	all causes	++
Sample speed measurement	England [5], Switzerland [6]	med. costs, personnel	sample size depend.	all modes	Intuitive	recurrent only	+
Continuous congestion measurement	Netherlands [7], Ile-de-France [1]	depends on equipment	robust	all modes	Intuitive	all causes	++
Archived traffic messages	Switzerland [8]	low costs	robust over time	all modes	Intuitive	all causes	+
Modelling							
Using archived flow data	Switzerland [8], US [9], Scottland [10], Denmark [11], Germany [12]	low costs	Sensitive to model parameters	difficult for non-road	strong assumptions	mainly recurrent	++
Archived plus real time traffic data	Traffic management services [13]	depends on equipment	Sensitive models	all modes	Complex	all causes	+
Questionnaires							
One-off / frequent	Euroe [14]	low costs, personnel	poll size depend.	all modes	Intuitive	all causes, qualitative	0

Sources:
[1] Prefecture d'Ile-de-France (2006) - [2] Network Rail (2005) - AEA (2006) - [4] DOT (2006) - [5] DfT (2005) - [6] Infras (2003) - [7] AVV (2005) - [8] Infras (1998) - [9] TTI (2006) - [10] Scottish Executive (2003) - [11] Hvid 2004 - [12] IVV/Brilon (2004) - [13] E. g. NRW (Germany), Paris - [14] CEDR (2005)

3.4.2.2 Congestion indicators

After travel speed or congestion data has been collected it needs presented by significant indicators, which allow to judge the prevailing situation against social or policy goals. The review of current practice in Europe and the US a large number of indicators has been identified, which are, however, partly derived from one another. Depending on the type of information provided and the scope of the indicators they have been grouped into five types, which are assessed along the above criteria as follows. Details are presented by Table 31.

Total delay based measures (total time losses of all passengers involved compared to a reference speed) are interesting in order to have an overall figure which can be directly translated in economic terms. However, aggregation is difficult (only possible with model input) and costly.

Average delay indicators are easy to compute, robust, comparable and applicable to all modes and significant to benchmark policy targets. The most transparent from the viewpoint of the users seem to be the development of average speeds and the average prolongation of travel times as expressed by the travel time index. In order to derive an indicator, it is important to distinguish between different daytimes (peak; off-peak).

Reliability measures take account of the importance of the unreliability of service levels for transport users. However, they are somewhat more difficult to compute as benchmarks are only in scheduled transport directly available and data over a longer time period has to be used to determine statistical deviation measures from average conditions. Further, they are not always easy to understand for consumers.

Level-of-Service indicators describe traffic conditions by the quality of traffic from free flow to stand-still. Applied categorisations distinguish between six (TRB 2000 and FGSV 2005) or only two (AVV 2005) conditions. LOS measures computed from speed and flow data are criticised as the definition of service levels is somewhat artificial and changes within a class do not appear in the results. The categorisation is less problematic in case observed traffic quality data, e. g. through congestion detectors, are applied. LOS measures allow to categorise networks and thus to describe bottlenecks on a larger geographical, e.g. Trans-European, scale.

Economic efficiency measures determine current congestion externalities and optimal congestion charges per vehicle kilometre and the potential social surplus or delay reduction in case congestion charging, improved operational treatment or better transit services would be applied. The computation of these indicators requires the application of complex traffic models which rely on several sensitive parameters, which are partly difficult to obtain. Due to theoretical reasons the application of these measures is difficult for scheduled transport services.

Table 31: Assessment of congestion indicators

Indicator and description	Application cases	Practicability	Robustness	Intermodality	Transparency	Significance	Over all
Total delay-based measures							
Total annual time lost	4, 5, 8	easy	med.	yes	high	med.	**+**
Total annual time lost by delay cause	13,14,15	easy	med.	yes	high	high	**++**
Total fuel wasted and air emissions	6, 8	cost f..	med	yes	high	high	**+**
Total annual resource costs	4,6,7,8,9	cost f.	med.	yes	med.	low	**+**
Total resource costs related to GDP	6, 7	cost f.	med.	yes	med.	med.	**+**
Annual time lost per traveller	8	easy	med.	yes	high	low	0
Total time lost per network-km	4, 5	easy	high	yes	high	med.	**+**
Annual length of traffic jams	9, 10	easy	high	yes	med.	med.	**+**
Average delay measures							
Average travel speed	1, 2, 11	easy	high	yes	high	high	**++**
Time loss per vkm to free flow conditions	3, 4, 5	easy	high	yes	med.	high	**+**
Average additional time costs	5, 6, 7	easy	med.	yes	med.	med.	**+**
Average additional operating costs	6, 7	med.	med	yes	med.	med.	**+**
Travel time index = current / free flow times	8	easy	high	yes	high	high	**++**
Travel speed index = current / free flow speed	4, 5,10	easy	high	yes	med.	high	**+**
Reliability measures							
Journey time reliability (% trips >115% TTav)	4	difficult	high	yes	med.	med.	0
Buffer time index (TT95 – TTav per km)	7	difficult	high	yes	med.	med.	0
Time loss of 90 percentile network section	1	difficult	high	yes	med.	med.	0
Service-level related indicators							
Capacity utilisation (current volume / capacity)		easy	med.	yes	high	med.	**+**
Share of vkm / pkm / tkm by service level	5	easy	med.	yes	med.	high	**+**
Share of delays by service level	5	med.	med.	yes	med.	med.	**+**
Share of travel time by service level	5	med.	med.	yes	med.	med.	**+**
Share of trips by service level	4	difficult	med.	yes	med.	med.	0
Network length by service level	5, 12	easy	med.	yes	med.	high	**++**
Duration of each service level	4	easy	med.	yes	med.	med.	**+**
Length of traffic jams per network km	10	easy	high	yes	med.	high	**++**
Economic efficiency indicators							
Total deadweight loss	7	difficult	low	no	low	low	0
Expected congestion pricing revenues	7	difficult	low	difficult	med.	low	0
Current marginal external congestion costs	6, 7	med.	med.	principally	med.	low	0
Equilibrium congestion pricing charges	6, 7	difficult	low	difficult	low	med.	**+**
Average deadweight loss per vkm	7	difficult	low	difficult	low	low	0
Delay savings by operational treatments	8	difficult	low	principally	low	low	0
Delay savings by improved public transport	8	difficult	low	no	low	low	0

Sources: [1] DfT (2005) – [2] Infras (2003) – [3] DfT (2000) – [4] Scottish Executive (2003) – [5] Hvid (2004) – [6] Nash et al. (2002) – [7] Maibach et all (2004) – [8] Schrank and Lomax (2006) – [9] Appert, M. – [9] Infras (1998) – [10] AVV (2005) – [11] Infras (2003) – [12] IVV/Brilon (2004) – [13] Prefecture d'Ile-de-France (2006) – [14] Network Rail (2005) – [15] AEA (2006)

Symbols: veh.: vehicles, TTav [seconds]:average annual travel time in the respective time segment, TT95 [seconds]: 95-percentile travel time in the respective time segment

From the perspective of individual traffic users the development of travel speeds and the relative increase of travel timed due to congestion appear intuitive and significant to benchmark policy targets. From the viewpoint of infrastructure operators the classification of network lengths by service levels provides a good overview of where investment or regulation measures might be applied. For all of these indicators similar expressions exist, which might well be used instead. Annual total values are highly relevant concerning the analysis of delay causes and the related emissions of air pollutants and greenhouse gases.

The delay monitoring must be dynamic by providing robust time series and it must reflect the compliance of current traffic quality with policy targets. Therefore the reference travel speed in road transport or the delay margin in air traffic must be held constant over time. For road 60% of free flow or maximum permitted speed are recommended. In rail passenger 5 minutes and in high quality rail freight and in aviation 30 minutes delay margin are recommended. However, local derivations are possible.

3.4.2.3 The scope of a congestion monitoring

Congestion and delay causes: For policy purposes both concepts, recurrent and all-causes delays, can be meaningful as they apply to different policy targets and instruments (investment, demand management, safety programmes, infrastructure management, and others). Table 32 reveals that across all modes capacity shortage in most cases is only one reason of delays. In addition mutual effects between different causes have to be considered. Thus, the above evaluation criteria require monitoring methodologies to address all delay causes.

Table 32: Reasons of congestion according to multiple studies

Mode	Study, area	Congestion / delay cause				
		Capacity	Construction works	Accidents	Weather	Other
Road	TTI Urban Mobility Rep.	30 %-60 %		40 %-70 %		
	CEDR (2005) 1):	40%	41 %	18 %	9 %	9 %
	Hessen, Germany	30 %	30 %	10 %	30%	
	France, Ile de France	85 %	4 %	11 %		
	Netherlands	82 %	5 %	13 %		
Rail	UK Network Rail	32 % 1)	44 % 1)		10 %	14 %
Air	US, DOT	36 %			4 %	60 % 3)
	Europe, AEA	30 %			4 %	66 % 3)
	Europe, Eurocontrol 2)	11 %	-	-	11 %	78 % 3)

1) Number of cases; 2) ATFM En-Route delays; 3) Airlines: 51%, Airport: 19%, security: 4%, miscellaneous: 4%, 3) network management, 4) asset defects,

Congestion effects: Besides time losses, congestion causes increased fuel consumption and additional atmospheric emissions. Wasted fuel and additional pollutants can be quantified via speed-dependent consumption and emission functions in road transport. For time, fuel and atmospheric emissions a variety of unit cost estimates or consumer prices exist, which can be applied to express congestion effects in physical quantities or monetary terms.

Spatial scope: Road congestion assessment may focus on a selected set of links (Dft 2000), estimate total network effects by single link measurements (Scottish Executive 2003) or measure congestion on entire networks (IVV and Brilon 2004). Given the different standards of European roads, for a harmonised approach it seems to be more practicable to analyse selected segments of the TEN and major arterials of selected cities.

Time scope: Traffic quality may be measured continuously over the whole year or be performed at selected time periods only. In case of computing trip- or kilometre-specific indicators of recurrent congestion, such as the relative increase in journey time due to congestion, one-time measurements are totally sufficient. In case annual values are to be produced, continuous measurements or an extrapolation is required. Determining non-recurring congestion eventually demands for a measurement over a longer period of time.

3.4.3 Recommendations by mode

3.4.3.1 Trans-European road network

For road transport in general, it is important to distinguish between comparable measured congestion data and modelled data. In order to have a common starting point, a pragmatic approach to produce comparable speed data seems to be most appropriate. On the Trans-European road network it is proposed to first initiate a simple speed-monitoring system by defining several important interurban links. This speed monitoring should cover a certain section of a road link. The average speed (peak/off peak) can be used to assess time series for different type of roads. This monitoring approach follows the practice of France, the Netherlands and Scotland. In order to enlarge the sample, secondly a modelling study is recommended assessing the development of traffic densities and capacities and their influence on speed on selected links across the Union. Traffic count and road capacity data is available from UNECE (2000) and from national sources. Under consultation of the Member States the study would propose a set of corridors to be surveyed. From a methodological point of view the study would have to propose international speed-flow and fuel consumption functions for different traffic and infrastructure conditions across the EU. A starting point may be FGSV (1997). Further, the study would have to survey the dimension of non-recurrent congestion by monitoring spot. According to the US and UK cases, the study should then be carried out on a regular basis.

An additional approach is the use and regular analysis of existing radio data on road traffic problems on the national motorway network. The establishment of a European road traffic monitoring centre is proposed. This should receive and process information on traffic discontinuities on the Trans-European network from national motorway operators. Respecting the technical equipment in the Member States, the European road traffic control centre would process electronic incident detection information as well as radio messages and traffic volume data.

In the long run a standardisation of incident detection systems is desirable and should be fostered by the Community.

3.4.3.2 Urban networks

As concerns urban transport the monitoring system should start with a limited number of cities of different size. Most of the European capitals and big cities consist of traffic management centres and even provide online-maps on the state of traffic on major roads. The starting point is again a continuous measurement of traffic speed on the main road network entering urban areas. The inter-urban modelling approach could be extended to major urban express ways and arterials in order to obtain a series of comparable indicators across Europe. The local verification of speed flow functions is then, however, of great importance.

Further, a number of cities have recently initiated automatic floating car data systems. From this data the generation of congestion indicators as presented above is easily feasible at low costs and should be fostered by the EC. This de-centralised approach would respect the different geographical and structural conditions of the urban areas, but would make a comparison of the results very difficult.

3.4.3.3 Rail transport

In a first step train delays at selected European stations and the respective number of passengers debarking should be monitored across all day periods at several representative weeks during the year. In the light of the emerging importance of passenger rights agreements across Europe and to understand more clearly the need for policy interventions (e.g. consideration of quality indicator as a basis for the differentiation of public service obligations), the railway companies should be obliged to report regularly on their punctuality and delay causes. A starting point could be the reporting scheme of Network Rail in the UK. It is important to distinguish between interurban and urban railway transport segments.

To provide a better ground for the Communities investment funding the rail network operators should provide data on current capacity utilisation, on construction activities and on the quality of trans-European railway corridors.

In a second step the problem of missed connections should be addressed by monitoring a set of representative international travel relations. The statistical and methodological basis should be provided by a dedicated survey.

3.4.3.4 Aviation

In aviation Eurocontrol statistics on flight regions should be made available by single airports. Alternatively, Eurostat could take over or complement the AEA statistics by non-AEA member airlines.

As for the aviation sector, the problem of missed connections should be addressed by a methodological study in the field, which would select flight relations to be monitored or statistical procedures to assess all missed connections on major European airports.

3.4.3.5 Seaports

Currently there is no common reporting standard on vessel waiting times by European or US maritime ports. As there are certainly capacity problems, which can only be solved by long-run investment programmes such a port congestion monitoring system should be initiated by the EC.

3.4.3.6 Inland navigation

There is certainly no capacity problem in the European inland navigation network. Thus, there is no need for action by the EC.

3.5 Conclusions and research needs

The survey has shown that Europe, compared to the US is more vulnerable to air and inter-urban road congestion, while in the case of rail and maritime shipping the US faces more severe problems. In all cases current forecasts show an increasing tendency, but comprehensive and comparable indicators are only partly available. This is especially true for road transport. Although there are interesting indicators in some Member States, a comparison between countries as a basis for regular congestion and delay monitoring is hardly possible.

The survey of methods has indicated some need for additional research in the field of congestion and delays:

- Elaboration of a European quality monitoring system for road transport, based on traffic speed measurements on specific sections and daytimes.
- Development of representative speed-flow functions across Europe, especially focussed on the TEN-T network and on critical urban access links.
- Analysis of the drivers and magnitudes of non-recurrent congestion on the European road and railway network.
- Ways to equalise the quality standards within European traffic message systems and flow chart data information.
- Statistical methods to account for the passengers missing their connections due to delays in scheduled transport (esp. rail and hub airports).

4 Congestion: Impacts and sector responses

4.1 Economic impacts of congestion: An overview

4.1.1 General impact patterns

Congestion is increasing transport costs and is decreasing transport quality. Due to the various interrelations between transport and the economy, there is an impact on the economy as a whole, with different importance for the various sectors. In order to show impact patterns of congestion, it is necessary to distinguish different dimensions:

- Passenger and freight transport, individual and commercial transport: Whereas freight transport is fully commercial and affects economic sectors according to their transport intensity, passenger transport has to be treated differently. Only parts of passenger transport (esp. professional transport service providers, business transport) are directly linked to economic activities.
- Short and long term reactions: In the short term, mainly reactions to time dependency are relevant (such as changing routings and delivery times), long term reactions also include changes in spatial organisation.

In order to have an economic sound structure, different costs have to be distinguished. At the same time it is important to differentiate between scheduled and non-scheduled transport. The following Table 33 is presenting an overview.

Table 33: Overview of reactions to congestion and their impacts

	Reaction	Impact
Short term		
Non recurring congestion	Infrastructure provider: Traffic management/information Transport user: Waiting	Infrastructure provider: Costs for reorganisation Transport user: Time and operating cost Transport service demand: Additional costs due to less reliability Public: Additional accident and environmental cost
Recurring congestion	Infrastructure provider: Traffic management/information Transport user: Detours and time shift, as long as costs are lower than waiting. For scheduled transport, the reaction is anticipated in the schedule. The costs are hidden as scarcity costs (opportunity cost of non-providing optimal schedule)	Infrastructure provider: Costs for reorganisation Transport user: Avoidance costs, time and operating cost Transport service demand: Additional costs due to less reliability (lower than for non recurring congestion) Public: Additional accident and environmental cost (Scarcity costs for scheduled transport)
Long term	Infrastructure provider: Improved traffic management/pricing and infrastructure enlargement Transport user: Reorganisation of transport demand, change of relations and locations Transport service demand: Change of production structure and location	Infrastructure provider: Additional cost of infrastructure Transport user and service demand: Adaptation cost and benefits of enlarged infrastructure

Source: COMPETE elaboration

The table states that there are different reaction and impact patterns for different actors. Infrastructure supply and demand and transport service supply and demand for scheduled and non scheduled transport are the main dimensions. It has to be considered that - from an operational point of view - only parts of these impacts can be measured in proper terms, such as increased time and operating cost in the short term for the transport users, as the panorama of congestion in the previous Section 3.3 suggests.

Therefore a qualitative analysis of the reactions and impacts of the main actors is the focus of the following analysis.

The following figures illustrate the most important reaction and impact patterns. Figure 17 starts with the reaction patterns within the transport sector itself. Firstly it is important to consider that congestion events or delays only cover a part of the impacts, namely those which are either not anticipated or where reaction costs are higher than the cost to suffer congestion and delays. It is evident that it is hardly possible to measure the additional part of congestion in proper quantitative terms. There will be an important difference between scheduled and non-scheduled transport. A second important issue is the fact that congestion is increasing not only transport costs (time and operating cost), but also external costs such as increased emissions (esp. due to increased detouring and standstill procedures). A third conclusion is that different reasons for congestion have to be considered. The economic consequences of temporary constructions sites on a specific motorway for example will affect economy differently than permanent scarcity of infrastructure.

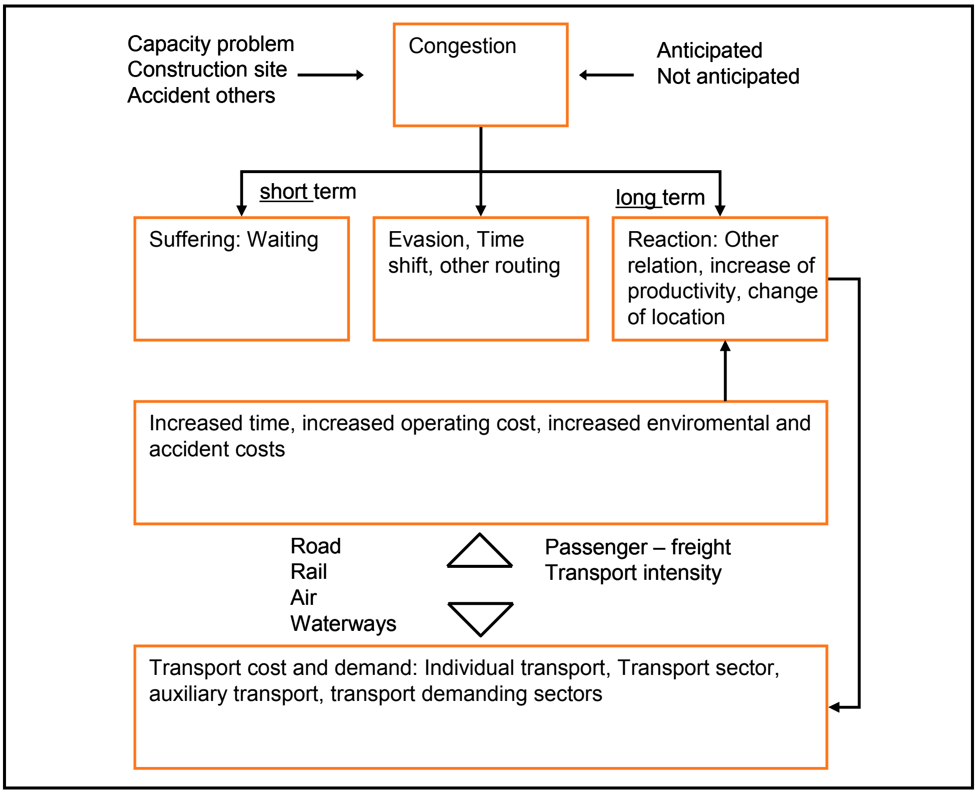


Figure 17: Reaction patterns of the transport sector to congestion and related consequences

Figure 18 illustrates the most important impact patterns in passenger transport. Most of the congestion impacts for the users have an indirect impact to economy. A major part of congestion is related to users of individual transport, such as for commuter, leisure and shopping purposes. Most vulnerable hereby is commuter transport in urban areas, facing daily congestion especially in road transport. The most important reaction is a time shift (earlier start of journey) and a modal shift (e.g. to public transport). This part of congestion is related to the economics of density of urban areas: **Congestion is an inevitable part of urban transport structure**. Spatial development of the settlement area and location of inhabitants and industry is strongly interlinked with this density issues: Congestion or low traffic quality in urban areas might accelerate urban sprawl and thus the loss of economics of density and weakening of the position of public transport. Within leisure and shopping transport, the most important links are related to economic strategies of the food and retail sector (see section 4.2.) and some tourism spots. An important issue are the specific congestion events at the beginning of holidays (e.g. in France, where holidays starts at the same date for all inhabitants) and at specific bottlenecks (e.g. transalpine congestion at weekends). This part of the congestion illustrates specific societal needs and does not affect the economic sectors in general. In contrast to that, transport for business purposes is affecting costs and reliability in all those sectors which are depending on time sensitive activities such as meetings and contacts with clients. This is especially interesting for globally acting service sectors (see section 4.2).

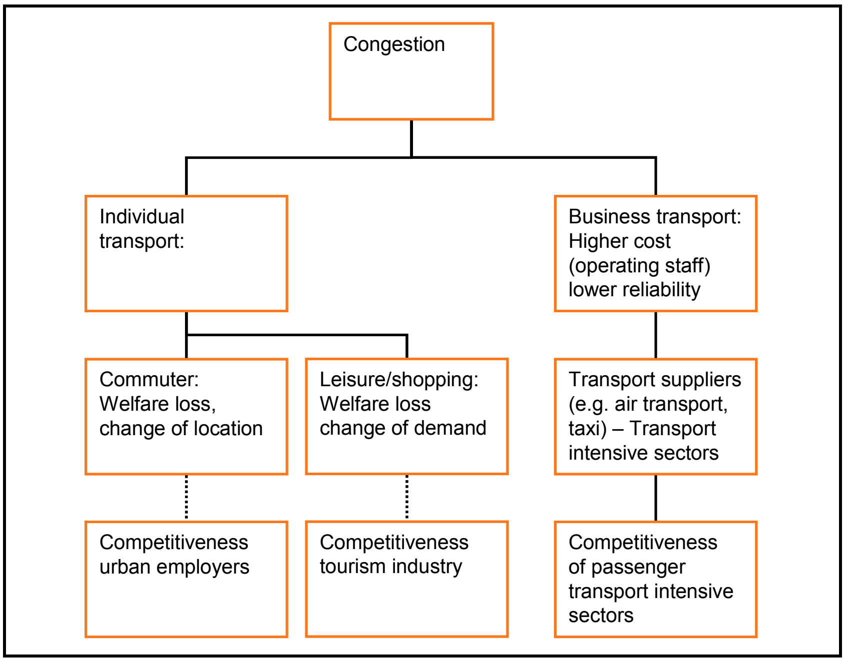


Figure 18: Reaction patterns within passenger transport

Figure 19 relates to freight transport. It is evident that the value added chain may be affected directly due to congestion. The more transport intensive and the more time dependent transport demand, the higher the vulnerability of a sector. This is most important for Just-in-Time production structures where reliability is essential and the transport chain (different modes, e.g. combined transport, different actors involved) must function properly in order to guarantee maximal transport quality as an important precondition of labour division at European or global scale.

Within some sectors there is an interlinkage between passenger and freight transport, usually being a trade off for optimal traffic conditions: Traffic preference in peak hours, delivery times etc.

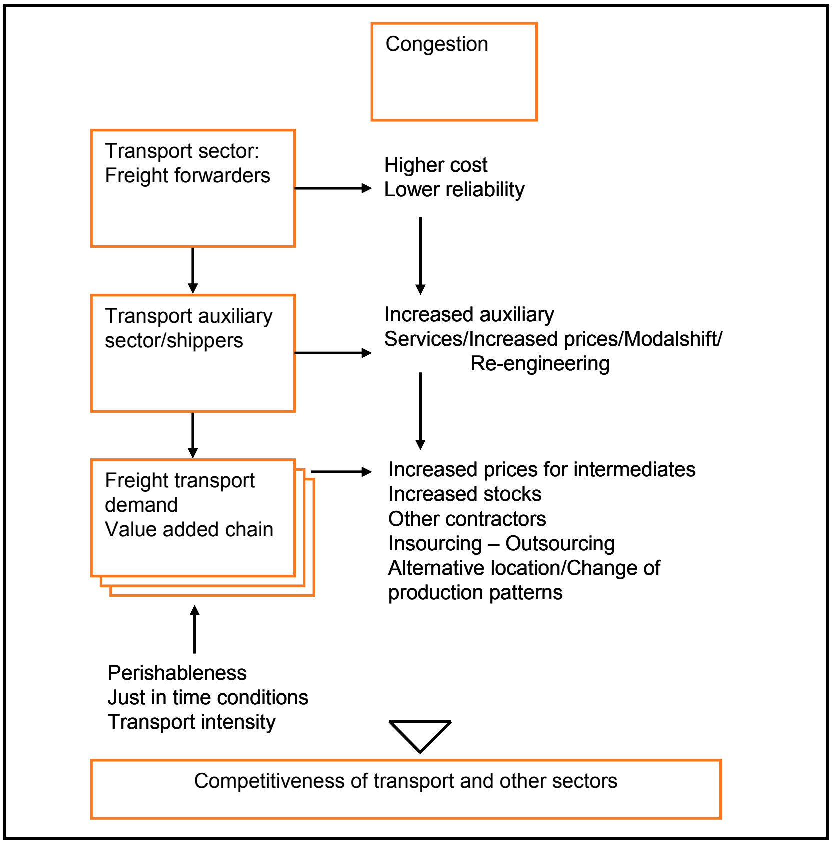


Figure 19: Reaction patterns within freight transport

4.1.2 General empirical evidence

There are quite some reports looking at the overall economic impacts of congestion, based on value of time (VOT) assumptions. This is summarised in our congestion panorama in the previous section 3.3. Of major interest within this section is the differentiation along sectors. The NCHRP report for the US (2001) states the sensitivity of urban congestion (with example for Chicago and Philadelphia) and for industry. The model based approach stated that industries with broader worker requirements and higher levels of truck shipping absorb relatively higher cost associated with congestion. Congestion is reducing agglomeration benefits and thus economics of density. The report suggests that delivery markets in urban areas are most affected in the US. The study summarises general cost approaches for business values of freight delays, based mainly on revealed preference surveys. The willingness to pay to reduce delays for shipper is around 40 to 50 US $ per hour.

A recent study of Cambridge Systematics for the US (2005a) has shown that shippers and carriers value transit time in the range of $25 to $200 per hour. The cost of unexpected delay can add another 20 percent to 250 percent, depending on the time sensitivity of goods. There are also additional costs such as the costs of remaining open for longer hours to process late deliveries; Penalties or lost business revenue associated with missed schedules, costs of spoilage for time-sensitive, perishable deliveries and costs of maintaining greater inventory to cover the undependability of deliveries, Costs of reverting to less efficient production scheduling processes; and the additional costs incurred because of access to reduced markets for labour. The study also states important regional impacts such as urban sprawl and production shifts of congestion sensitive industries.

A study carried out by the Washington Research Council (2001) states that congestion is inflating local cost of living by comparing congestion and consumer price indices: Increases in congestion may have added more than 0.5 percent per year to the Seattle area (congestion is notorious) inflation rate over the last 17 years. The resulting higher prices cost local consumers more than $9 billion in 2000. This figure seems rather high, since it is difficult to analyse the detailed cause-effect relation between costs of congestion and overall growth properly.

Another study from Weisbrod et al. (2003) has stated that the reliability costs (costs due to not reliable delivery) constitute an important part of congestion. The costs per hour for different sectors are as follows:

Table 34: Calculated shipping delay costs, by industry

In US$	Direct user	Reliability cost	Value of shipment
Agriculture	25	7	16’800
Mining	25	0.8	5’500
Manufacturing	26	11	34’700
Service/Other	0	0	135

Source: Weisbrod (2003), figures rounded

4.2 Sector analysis

Most of the available studies on congestion impacts to economy are related to the measurement of congestion for traffic management purposes and to measure time costs. The differentiation of traffic purposes makes clear, that a considerable part of the costs is related to individual passenger transport, as it is for operating costs (where individual transport accounts for more than 30% of costs). There are only few studies available which show the relevance of congestion costs for different economic sectors (impact, relevance, vulnerability, strategies). This might be interpreted as a sign that there is no major straight and critical relevance for the competitiveness of different economic sectors in Europe and in the United States for the time being. An exception is road freight transport and aviation. Fact is, that the issue of congestion will gain importance in the future. Therefore we concentrated the analysis on different interesting sectors with different type and level of vulnerability. Besides desk research a number of qualitative interviews have been carried out with economic stakeholders in various sectors and different countries. In order to have a qualitative overview, we developed a questionnaire containing the following key questions:

- What is the relevance of congestion for your sector (in general, for your input markets, for your output markets)?
- Which types of cost arise and which impacts and reaction patterns are typical for your sector? What are your main strategies to tackle congestion?
- What is the influence of (growing) congestion for your competitiveness?

The following chapters are summarising these findings. The detailed questionnaire and responses are summarised in COMPETE Annex 4.

4.2.1 Transport industry

4.2.1.1 Road transport

Due to dynamic changes in the transport and logistics sectors and liberalisation within the transport markets, there is a widespread range of actors, which are differently affected by congestion: Long range hauliers (partly integrated in bigger logistic suppliers combining different modes of transport), short range hauliers and delivery vans (esp. in urban areas), specialised transport like construction or terminal haulage, bus and coach operators. Road hauliers face increased competition especially in Europe, which leads to efficiency gains, but also to a high vulnerability to congestion, since margins are very low. An important effect of liberalisation is the change of size of firms. According to the German logistics report (2005), the average size of firms increased in the last ten years by 50%, showing the relevance of economies of scale and scope.

Congestion is a very important issue for the road transport sector. The reasons however have to be differentiated: Only parts of congestion are capacity related, as a study commissioned by IRU (IRU 1998a) points out. Total barriers to road transport consist of capacity related traffic congestion, delays at border crossings, traffic bans (e.g. construction sites), blockades, speed limit constraints. In UK and Italy, about 60% to 70% of time losses were stated as capacity related congestion. In other countries of the sample (i.e. France) the share is considerably smaller. About 40 to 50% of time losses is related to congestion in Eastern Europe. The share of congestion of total transport time ranges from 5% (UK, Italy) up to 22% in Poland (IRU 1998a).

The most important impact of congestion is decreased reliability: The bigger the share of non recurring congestion, the higher is the risk of low reliability. All interview partners have highlighted this effect as most important. Since competition is very high, the risk of loosing clients and business is significant. These risks are significantly higher than the direct costs in form of increased personnel and energy costs. The above mentioned study (IRU 1998a) estimated these costs for a set of countries. The study concludes (although based on a rather small sample) that the missed opportunity costs are in the order of 1.2 times of the base transport costs.

Table 35: Cost for impediments (Road freight and busses/coaches)

	UK	France	Italy	Czech Republic	Poland
Road Freight:					
Loss of travel time (monet. terms)					
% of road expenditures	3.2%	2.3%	1.3%	8.3%	28.8%
% of GDP	0.16%	0.14%	0.09%	1.27%	2.6%
Total loss including lost business opportunities (monetary terms)				-	-
% of road expenditures	7.1%	5.0%	2.8%		
% of GDP	0.35%	0.32%	0.19%		
Busses and Coaches					
Loss of travel time (monet. terms)					
% of road expenditures	0.4%	16.3%	6.2%	3.3%	3%
Total loss including lost business opportunities (monetary terms) % of road expenditures	1.2%	45.6%	17.3%	9%	9.1%

Source: IRU (1998a)

The interviews carried out within this study support the thesis, that VOT related estimations underestimate the total costs of travel time. Compared to other studies, the ratio between direct costs and reliability costs seems however quite high, see as well the study of Weisbrod cited above. Another study in the Netherlands (Bozuwa et al. 1999) has estimated the indirect costs of congestion to 8-11% of direct costs. A study from Leeds University has estimated a willingness to pay of 85 pence per minute[8] to increase reliability of transport, which is an even lower share. In the US a survey (Golob/Regan 2000) indicates that for nearly 90% of respondents, schedules are missed because of congestion. For 25% this happens often or very often. Some evidence for that can also be collected by looking at the practice of valuing travel time and reliability.

Within cost benefit analysis, another approach to weigh reliability is used. The reliability ratio is the ratio of the value of one minute of standard deviation (i.e. value of reliability) to the value of one minute of average travel time. The following table summarises the recommendations. The ranges are quite conservative and thus compatible with the scientific studies and show that reliability is not that costly than the IRU study points out. In this regard, the IRU study can be seen as an upper bound (maximal risk).

---

[8] This value comes on top of the general value of time, which has not been analysed in the study.

Table 36: Reliability ratio (relation between value of time and additional value for reliability) for different journey purposes

Journey purpose	Mode	Reliability ratio
Commuting (passenger)	Car	0.8
Business (passenger)	Car	0.8
Other (passenger)	Car	0.8
All (passenger)	Train	1.4
All (passenger)	Bus/tram/metro	1.4
Commercial Goods Traffic	Road	1.2

Source: Hamer et al. (2005), Kouwenhoven et al. (2005a)

The interviews showed that the possibility to shift additional costs to transport prices is very limited since consumers will not accept higher prices and low reliability at the same time. Therefore the road hauliers industry has developed several strategies to avoid congestion. Most important is the shift of transport (bundling, unbundling, long range haul, delivery to urban areas) to off peak situation. This is especially important for the food supply chain (see Mc Kinnon 2003). The additional costs by driving through the night can be seen as long term evasion cost of congestion.

These costs do harm road hauliers competitiveness. According to the interviews, there is however no major intramodal discrimination. An issue in EU15 is the strong competition with road hauliers from Eastern Europe (EU8) due to lower operating cost (e.g. drivers wages). Moreover the competitiveness of the road freight sector as a whole is affected, since it faces a very high level of pressure due to liberalisation and globalisation and the change in logistics markets which has reduced margins. For specific corridors, railways have become an alternative. Big road hauliers therefore use combined transport and railways services as an alternative. Most important in this respect is transalpine transport, where specific measures (such as tolls, night bans etc.) lead to a strong shift towards combined transport road-rail.

The interviews have stated a tendency that vulnerable sectors to congestion (such as just in time-production or food and retail, see further below) tend to insource the transport chain, in order to gain a better overview. Bigger retailers and manufacturers therefore use their own fleet for input or output delivery. In fact, only big freight forwarders are able to supply reliable service packages for the industry independently. The bigger the size of the business model of a logistics provider, the better the internal traffic management systems, the higher the competitiveness and the strategic response to congestion. Interesting examples can be found in Germany (Deutsche Post and DHL) or Stinnes-Schenker-Railion (collective logistics road and rail).

The road freight transport industry has developed an general policy approach to overcome congestion. It consists of several elements, such as modern traffic management and information systems, in order to anticipate recurrent and non recurring congestion, efficiency increase (increased use of off peak, increase of weight limit) and pressure to increase infrastructure. IRU has launched the so called 3I strategy (Infrastructure, Innovation, Incentives). Important elements are own lanes for trucks to overcome passenger car related congestion and delay penalties for construction site managers (infrastructure)[9]. Bonus-malus or quality systems within the sector is however not (yet) common.

A comparison between EU and US makes clear, that the congestion issue is more important for EU-road freight transport, since urban and interurban problems are relevant and transalpine capacity restrictions and competition between Eastern and Western Europe are overlapping the congestion issue. Thus the IRU policy (although generally defined) is mainly relevant for Europe.

With respect to road transport, it is also relevant to have a brief look to passenger transport. Individual car transport is the main transport segment suffering from road congestion (see section 4.2.5). Within an economic sector analysis however, the economic consequences are much less relevant since most of the costs can be expressed as individual losses of consumer rents and welfare which are not directly relevant in monetary terms. Other (professional transport) segments are taxis and urban bus transport. Both are negatively affected in urban road congestion by additional time and operating costs. Whereas taxis can shift time losses to the consumer (by increased prices), the schedules and thus the potential of urban public transport is limited in peak hours. The consequences are however less severe if there is a strong separation of tracks or bus lines.

4.2.1.2 Rail transport

The delay risk in the rail transport industry is depending on different factors such as infrastructure deficits (capacity, security and traffic management systems), traction deficits (rolling stock failures) and operational interlinkages between infrastructure and traction (interoperability problems). Therefore the analysis (reactions, impacts) has to consider different transport segments (with different market positions and different actors), especially the role of infrastructure and train operators.

The most time sensitive segment is **high speed rail**, in competition with short haul air transport. Due to the advantage of own tracks, some operators (e.g. France, Italy, Spain, Germany) are very successful and use specific quality controlling systems; delays are minor. In some countries (such as US, Spain, Germany, Austria), penalties (e.g. reimbursement to passengers in cases of delay) are common, in order to compensate passengers for time losses. According to the interviews, this segment is prioritised by infrastructure operators. The performance might become critical, if network functions (connection to regional trains, passage of highly frequented nods) become important. In such cases, the delay risk is increasing. There is however no major competition between railway operators. Germany (due to its central geographical position and network outline) is slightly more vulnerable than Spain or France. The approaching of major agglomeration areas is also a quality problem in the US (e.g. Chicago region).

The delay risk of **urban rail** has an influence on the competitiveness of public transport versus private car transport. In general the interviews show that there are – although critical rail bottlenecks in urban areas exists – still advantages for the railways. The bottleneck problems

---

[9] There is an interesting trade off while planning road infrastructure maintenance. The shift of maintenance to night hours (in order not to harm passenger transport) leads to barriers for freight transport.

in urban rail systems are mainly limiting the potential to divert road transport (and related congestion). Due to natural monopoly situation of urban public transport however, there is no influence on intermodal competitiveness. Compared to the US, the vulnerability due to increasing rail capacity problems in urban areas is higher in Europe.

The quality problems of railways are most relevant for crossborder **rail freight** services, where additional actors (such as combined transport providers) are involved and competition between railway operators is gaining relevance. Due to low infrastructure quality (capacity) and crossborder interoperability problems, the risk of delays and deterioration of quality and reliability is a major reason for low competitiveness compared to road, especially in countries where transport during the night is possible for road and rail. An interesting market is transalpine transport, where improved quality is essential to divert traffic from road to rail. Since wagon load freight usually is not very time sensitive, the vulnerability in this traditional rail segment is rather low. It is bigger for combined transport with hub and spoke terminal and gateway systems, where rail and road transport chains have to fit together. But crossborder quality problems are harming competitiveness significantly. The Swiss transport policy for instance is using a quality indicator to measure delays of combined transport trains. Although Switzerland has a high level of punctuality in the rail system as a whole (see chapter 3[10]) and is promoting combined transport heavily and improves also infrastructure quality, only some 55% of transalpine combined transport trains are 'punctual' (means have a delay of less than 30 minutes to schedule). 10% of the trains face delays of 6 hours and more. The most important reasons are lack of infrastructure and lack of crossborder organisation (e.g. availability of rolling stock). The increased use of direct traction (no more change of locomotives at the borders and the use of multifunctional locomotives), has improved the situation in the last years, however at low level.

Compared to the situation in Europe, delay problems and related competitiveness of the freight railways industry in the US is less important since there are significantly less interoperability problems and productivity is considerably higher.

The problems in the railway industry are very much quality related affecting the whole system. Thus the quantitative capacity problem (scarcity of tracks) is only one issue and mainly relevant in dense areas where different rail segments (esp. urban and interurban) cannot be separated fully. In general however, other quality deficits such as old train management systems and non-optimal collaboration of actors within the rail system are more important, especially in Eastern Europe. Compared to all other transport sectors, intramodal competition due to railways liberalisation and free access is still a minor issue.

The costs of delays are in general shifted to the train operators (reorganisation of trains, additional trains and personnel, delay management) and to the railways users (time losses, less reliability in freight delivery). As stated above, only high speed passenger transport has developed a system to reimburse losses of passengers.

There are ongoing attempts to overcome these quality problems with a strong role of the EU railpackages aiming at increasing capacity (bottleneck minimisation), interoperability and competition. An important cornerstone is the development of the European train manage-

---

[10] The overall punctuality of passenger trains is above 90%.

ment system (ERTMS) with different levels of train control (ETCS). An additional tendency is the separation of passenger and freight networks, which becomes more and more reality. Proposals to include quality indicators and related bonus-malus systems in the freight sector will gain importance, although the most recent attempts of the EU third railway package have been rejected.

Germany has introduced a quality oriented system within a new track pricing scheme, where infrastructure or traffic related delays are considered within the track price, providing incentives to reduce delays and improve quality. It will be interesting to monitor the effects of this system with respect to quality improvement.

4.2.1.3 Air transport

Air transport has faced a considerable change in the last 10-15 years due to increased liberalisation and competition. Most important is the reaction of the sector to new business models (e.g. Low Cost Carriers, network carriers, regional carriers) and to remarkable growth rates due to liberalisation (lower fares, increased supply) and globalisation (increased demand for intercontinental services and capacity and demand increase in Asia and in the near East such as Saudi Arabia). The delays statistics (see section 3) of ATM-managers and airports show that there are several influence factors to consider: Airport capacity (runways, terminals), ATM-capacity and quality (in the surroundings of major cities, en route, based on technical potentials to bundle air traffic movements in a safe way) and airline oriented issues (aircraft failures, connections). In addition there are several exogenous factors such as weather and increased security problems. The latter has gained significant importance due to increased risk of terror attacks after the events of 9/11.

The existing delays statistics for Europe and the US show considerable differences. Whereas in Europe airline related delays are most important, the influence of the weather (especially in winter times) seems to dominate delay causes in the US. Airports and ATM related problems seem to be a minor issue. However, in order to analyse sector impacts properly, it is important to differentiate these results considering the growth potential and the competitive situation of the air transport industry and the different type of actors and transport segments.

Network carriers are depending on a sound collaboration with their main hub airport. The hub system has to guarantee time sensitive connection flights in order to increase load factors for long haul flights. Delays of connection flights are harming the whole transport chains and are a crucial factor for the competitiveness of the industry. The strategy of global alliancing has formed several major actors where intercontinental competition (between Europe and the US) is an issue. Especially hub systems such as London, Paris, Frankfurt or Milan in Europe and Atlanta, Chicago, New York in the US and related airlines are vulnerable to delays. For network carriers, the capacity situation of their hub airports today and in future is a crucial factor for their competitiveness. In this respect a sound collaboration of airline and airport is vital. Facing the recent developments due to security problems, long realisation times for infrastructure enlargement, increased fuel prices and the high level of competition, a limitation of growth due to limited infrastructure capacity is harming competitiveness heavily. This is true for all network carriers (US and Europe). The interviews have shown that some airports (esp. Eastern US, London, Frankfurt, Milan) face increasing capacity problems.

The direct delay costs in the short run are minor for the airports (reorganisation, terminal limitation). Most of the costs of delays are shifted to the airline and to the passengers. Delay penalties are not common, but reimbursement for cancelled flights. But there are also increased operating costs for the airlines, such as waiting times, costs for holding flights at crowded airports (esp. hub airports) and administrative costs (e.g. rescheduling, re-routing). Due to the increased competition there is a tendency that passengers have to bear the main share of related costs in terms of waiting time. The shift to flight prices however is hardly possible.

A recent survey of IATA (2006) has shown that more than 60% of passengers are judging air transport quality as very important or vital and the reduction of delays is the main concern for network carriers. The study has analysed the airline network benefit showing that these benefits (based on network carriers and alliances) are considerable and important as a competitive factor of regions as a whole.

Regional (intra Europe or US) traffic is affected at a similar level since delays in relation to flight times are considerably higher than for intercontinental flights. An additional element is the high level of competition between network carriers and low cost carriers. The latter are in a more favourable situation with respect to delay risks, since their connectivity is less important and their approach to avoid major hubs and use regional airports[11] is part of the overall strategy to save costs. On the other hand their slots are usually very short. If low cost carriers miss their slots, there is no possibility (while too costly) to reallocate the airline service. In general low cost carriers are less able to bear costs of delays, since there is no potential for additional planes or services. This leads to the fact, that passengers have to bear nearly all costs of delays in form of time losses. Although low cost carriers are in a rather strong competitive situation, delays are affecting the image in due time and have an influence on their competitiveness.

Compared to that, **tourism and charter air transport** is in general not very time sensitive since alternative airports and less critical time slots can be used.

General aviation services and business jets are for a high level business segment an important alternative to avoid deteriorating quality and increased delay risks. According to the interviews, the enormous growth of this segment is related to increased quality problems of major hubs.

Air cargo faces on the one hand similar problems than network carriers, since belly cargo is part of passenger flight. Pure cargo operators are using (like road hauliers) off peak slots to organise their worldwide traffic. This leads to the situation that cargo hub systems are used during the night causing considerable noise at sensitive times for residentials. In Frankfurt for example, more than 100 cargo planes are leaving the airport after midnight. As soon as night bans are discussed to protect densely populated areas, there are increased risks of additional cost for the air cargo industry. The air cargo industry has partly already reacted (especially in Europe) by using road (and combined rail) alternatives for feeder transport with short distances.

---

[11] Such as Standstad in London or Hahn in Frankfurt.

The competitiveness of the industry is weakened especially for hub carriers which are depending on reliable connections. In Europe, the competition between road and high speed rail is visible. Especially for relations with duration below 3 hours, there are strong arguments for high speed trains. According to the interviews however, the potential of using high speed rail for hub services is very limited. Comparing the situation between EU and US, one can state, that in general the US aviation sector – due to its importance and due to the increased security risks for the time being – is more vulnerable to congestion and deterioration of quality. On the other hand there is no major competitive issue to other modes. Europe faces more competition on short distances by terrestrial transport. In addition, it is more difficult to enlarge capacity at major hubs due to limited space and densely populated areas.

The air transport industry has elaborated several reports where the potential losses of not increasing capacities have been quantified. Eurocontrol states in its study "Challenges to Growth" (2004), that today, most airports have some spare capacity. In fact, for the first 133 airports, nearly 30% of existing capacity remains unused at 2003 typical busy hour traffic levels. This situation however will deteriorate quickly due to high growth rates. Eurocontrol concludes that the existing capacity will exhaust and more than 17% of growth (by 2025) cannot be satisfied. An important reason for this high growth rates are the dynamics in Asia and the Near East. The answers of different European airports and Airlines including ACI and AEA to a survey carried out by the European Commission with regard to the capacity, efficiency and safety situation (2005) shows, that there are increased limits for network carriers. The airline industry is very sceptical on the potentials of intermodal approaches to overcome capacity and safety problems.

The air transport industry in the EU and US has recognized these problems a while ago. Nearly all major hub airports are therefore engaged in extension plans, whereas other airports (namely in Italy and Spain) have been enlarged recently. The open sky agreements and the strategies to improve air traffic management are additional corner stones. Modern systems might reduce delays at airports in the LTO cycle by up to 10%, leading also to considerable fuel savings. Whereas the US was leading in modernised CNC/ATM systems in former times, their systems need to be improved in due time. Compared to Europe there is however no single sky problem. In addition, airlines are considering bigger aircraft volumes (esp. Airbus) to increase loading capacity per air traffic movement.

Another possibility to improve capacities is the use of slot allocation and pricing instruments. Peak load pricing at hub airports might flatten daily frequencies. According to the interviews, there is however very limited potential. The experience in London Heathrow shows, that there are only short term effects visible. After the General Aviation has skipped from London Heathrow, the capacity (and the delays) remained stable.

4.2.1.4 Ports

In general ports are facing enormous growth rates for container shipping. There are severe capacity restrictions, especially for terminal capacities, quays to berth and crane capacities. The interviews with port officials in Northern Europe have shown that bottlenecks are most relevant, where port owned terminals are used (e.g. Bremerhaven, Gent, Antwerp). This leads to unpredictability of port usage (user conflicts), to rescheduling and relocation of ships and to time delays. As an example, Bremerhaven states an actual delay of 11 to 36 hour per ship.

In Antwerp and Rotterdam delays of several days are common. The example of Portland in the US shows, that in extreme situation, even a closure of ports is possible. Congestion of road and rail (access to ports) is judged in different ways. Certain ports do not see road and rail access as a major constraint, since port terminals can be used as buffers. Rotterdam for instance uses free road lanes for trucks accessing the port. On other ports, however, land transport connections are a severe problem, since road and rail infrastructure is limited (e.g. Hamburg or certain US ports such as the ports of Los Angeles and Long Beach).

The port industry reacts by time shifts (more terminal handling at night times) and improved planning by early rescheduling of ships. Due to the character of goods (less time sensitive), the costs are mainly directly relevant for port operators (management costs of delays and capacity handling), less for the final shippers, as long the delay can be communicated to end haul transporters and to shippers.

The main mid term reaction is capacity increase with huge investments and the implementation of new models such as hub and spoke systems, using big ports for general handling and smaller ports for feeder transports. This is visible at Italian ports (Gioia Tauro as a hub port, where enough land is available). This concept (due to land scarcity) is more difficult to implement at ports in Northern Europe. There are shifts visible to Eastern Europe, where the Baltic states and the Black Sea ports are quite dynamic. A main difference between EU and US is the role of the ports within general logistics. Whereas in the US, the distribution of hinterland transport is located inland away from ports infrastructure, Europe uses the ports themselves as distribution centres. The major reason is land scarcity. Thus the mid term possibilities to expand capacities are better in the US than in Europe.

4.2.1.5 Logistics and auxiliary transport

The auxiliary transport and logistic sector is covering all modes. Most important is road transport. According to the interviews, the relevance of congestion is big to mean. Due to night time delivery, long distance transport has a punctuality of 90-95%. In contrast to that, railways have a punctuality of 75-85% with an average speed of 25-28 km/h. The most critical bottlenecks in Europe are transalpine corridors and the Ruhr Area. However the delays are quite small compared to the duration for loading/unloading (3 hours per trip). Critical are not anticipated temporal access restrictions, especially in urban areas.

The interviews also stated, that congestion is not part of the planning procedures and not part of cost calculations. But cost increases due to congestion are visible. One hour delay costs around 50-60 EUR per vehicle. Night time deliveries cost 10% more than daytime deliveries. Up to no however, penalties are rarely issued for haulage companies. There are liability payments including the costs for extra transports, which have to be undertaken, but there are no liability payments for haulage companies of carriers in case of production losses. In general economies of scale play a predominant role: The bigger the size of the firm, the more possibilities to react to congestion. In very critical delay cases, there is a shift to combined transport (rail) and to express deliveries by plane (use of KEP services such as DHL). In such cases, where reliability have to be guaranteed, the clients are willing to pay the added value. If there are non recurring congestion events and no short term improvement of quality possible, a shift to the clients is very difficult. In the long term, the logistics industry is changing locations using cargo centres at sites with low congestion risk. However there is a trade off between accessibility and minimal congestion. A major problem is still Eastern Europe. Although transport costs are considerably lower, the low quality and reliability weighs that to some extent out. Hence there is a huge structural change in Eastern Europe (trend to bigger and more professional entities) visible.

Compared to the EU, the US has more favourable conditions due to geographic conditions and settlement patterns with less density. However the quality of the road network is worse than in Western Europe. In general there is less vulnerability to congestion in the US. As we already have seen by comparing operating costs, the transport efficiency of the road sector in (Western) Europe is higher than in the US from the viewpoint of logistics actors.

4.2.2 Delivery and Retail

The food and delivery sector is highly affected by congestion. The ECOTRA report has shown that the supply chain of processed food is very transport intensive: The added value of delivery and retail accounts for around 6% of total production cost for processed food; 43% of this value is related to transport. The overall incidence of transport costs on the final prices of goods is on average in the range of 5-10% for processed food.

As an example (Spain), the retail channel structure for food consists of 81% modern distribution (hypermarkets, supermarkets) and 19% traditional or specialised (increased share of modern).

Most critical is the transport of perishable goods and the delivery for retailers in urban areas. But also customers might suffer (by their individual shopping trips) of congestion. Whereas long distance trips are usually carried out by night road haul or rail transport, the delivery to urban areas uses early morning slots with delivery vans. Late delivery means significant production losses, a critical issue in a very dynamic market with a high level of competition and low margins. The higher the number of logistical processes in the transport chain, the higher the risk of congestion, as the transport survey in UK has shown (UK KPI survey 2002 in McKinnon 2004a). Since delivery has to use several transport legs compared to other sectors, it is specifically vulnerable to congestion. Bigger retail companies therefore tend to control their sensitive transport chains by themselves.

The interviews however showed that there is no directly measurable and explicit cost increase of congestion which could be shifted to consumers. Most of the interviewees stated as well, that the whole sector is affected in the same way and there is no difference between actors.

Besides insourcing of sensitive transport and better planning procedures, a major strategy of retailers is the use of outlets outside of densely urban areas with high congestion risk. A good example is Walmart which – in contrast to other actors- does not state congestion as a major problem. The suburban location outside of cities shift congestion costs to the consumer in form of higher transport costs, due to longer distances. This cannot be seen as an isolated strategy due to congestion however. More important are cheap land prices for huge areas and good accessibility by road.

The retail sector is the only economic sector (besides the transport sector itself) which has carried out own studies. The AEA food miles study (DEFRA 2002) has estimated congestion costs for retail markets of nearly 5 billion Pounds[12] (77% in urban areas; 52% passenger cars of individual shopping transport and 48% of freight delivery, out of that 43% of light duty vehicles). Compared to the interviews carried out, these figures seem rather high, but the tendency and the structure can be supported. Another interesting evidence is the impact of the London Congestion Scheme to the retail sector. Whereas the retail sector claimed losses due to the charge, London Transport (Ernst&Young 2006) came to the conclusion, that there is no major impact. That means: the additional cost for shopping purposes outweighed the advantage of having less congestion in peak hours, making shopping in the central London area more attractive.

Comparing different regions, one can state, that the problem of congestion is more severe in Europe than in the US, since urban patterns are more dense and big retailers (such as Walmart) are located in suburbs.

4.2.3 Manufacturing industry

4.2.3.1 Car manufacturing

The car manufacturing logistics is highly organised with vertical organisation patterns and Just-in-Time production structures. According to the ECOTRA study, the global transport intensity is max. 4% (TRT 2006). The interviews with international players such as VW, BMW or Daimler Chrysler have shown that congestion is not regarded as a major problem. This holds true for up- and downstream transport and the conditions for commuters. In accordance to that the NEI study (2001) stated no considerable influence of transport cost to the automotive sector.

But the sector is – due to its production structures –sensitive to congestion, since reliability plays a predominant role. There are differences between these players due to specific location of the production sites in relation to access motorways and nearby urban areas. The JIT conditions refer to 70% of new production units and to 30% of old units. The suppliers JIT share is around 20%. Depending on that, the time sensitivity is around ½ hour - ½ day.

The industry has used several strategies to overcome congestion. Besides the ones already stated within the road hauliers and logistic sector, the car manufacturing industry is using railway transport for non time sensitive goods, since railways can be used as rolling storehouses. Efficient block trains are preferred for the delivery of cars to customer sites. Train quality (wagon load) is however not always sufficient. Volkswagen for example changed in the Czech Republic from rail to road transport. All manufacturers reported major problems with rail transport through France to Spain. However none of the interviewed manufacturers or suppliers reported a stop of production due to traffic congestion.

Another important strategy to save costs and – in this respect – also to overcome congestion are new production models, where productions process are concentrated at the same location (within specific collaborating production units). An example for that is the SMART fac-

---

[12] According to the input-output tables of UK, the turnover of the food industry in UK (2001) amounts to 58.7 billion pound.

tory in Hambach, Germany. Such production structures are (upstream) very robust towards reliable JIT processes. [13]

Compared to Europe, the situation in the US is even better, since car manufacturers have changed their locations to remote areas (e.g. Chrysler). In general the interviews showed that congestion is only in major agglomerations (e.g. Detroit) an issue for the industry.

4.2.3.2 Electronic industry

The industry is quite broad and entails electronics and electro technics, such as household appliances and media appliances. The relevance of transport therefore varies quite significantly. The interviews have been concentrated on end products, since just in time delivery related congestion is an important issue. Transport plays a big role in the electronic sector. The interviews best guess amounts to 5%. Most relevant are transports from production plants to clients and transports of components to production plants while the output delivery of goods has a 2-3 times higher transport intensity than input delivery of components (Sony). Besides supply transports and delivery to end consumers, the delivery of spare parts is also rather time critical.

Transport in the electronic sector in most cases is outsourced to professional providers. The most important reasons for outsourcing are costs in the first place and professional handling in the second place.

The general impact of congestion is rated as medium. Most important are higher production cost (due to higher time costs) and risk of late delivery (loss of quality). In order to avoid delays, time shift strategies and explicit planning procedures are most relevant. In addition production sites and delivery gates are located in peripheral areas close to motorway connection. Overall, the congestion costs are estimated below 0.1% of transport costs in the electronic industry sector.

4.2.4 Banking and insurance

The service sector is quite different to the other sectors since JIT production and freight transport is no important issue. Due to that general transport intensity is quite low. Transport mainly consists of business travel to clients and between business partners in different locations/segments of the company. On average, according to the interviews, travel costs amount to 1-2% of the total costs. Most important is air transport.

Most global companies in the finance and insurance sector outsource their business travel organisation. The main reason for outsourcing is a higher professionalism of those agencies and economies of scope. According to the interview partners extern travel agencies negotiate better contracts with airlines.

The interviews have shown that congestion in general is no specific issue. Also commuter related congestion (of staff) is not directly relevant. There are no processes like claims for higher wages visible. Bigger organisations however build incentives to use public transport and to avoid building of parking areas.

---

[13] This is no contrast to globalisation trends. Moreover it is a concentration of the value chain (at different production sites worldwide) at one place in order to save transport costs for value added services.

The outsourcing of travel activities however indicates that travel costs and reliability are an issue in business transport, especially in regard to long distance air transport. Another visible strategy is the use of business jets within the high key and very time sensitive management segments of the sector. Hence there is a certain vulnerability of the service sector to increasing capacity constraints and delays in the aviation sector, leading to cancelling of flights and meetings, higher administrative costs and increasing personnel costs. This will be increasingly important in the future since the global service patterns of banking and insurance has led to a significant increase of travel activities. The international travel activities of UBS (Switzerland) for instance have increased by 80% within the last 5 years. This has led to several strategies to decrease transport intensity by video conferencing and bundling of activities in foreign countries. But according to the interviews, these strategies are not directly related to congestion.

The service sector has –due to increased costs in central urban areas – shifted several units into suburban areas, such as less client intensive data processing and controlling activities. This is primarily an answer to increased land costs and not directly related to traffic congestion either. This indicates that urban sprawl can be related to congestion.

Comparing different regions in Europe and the US, one can state that the major problems related to delays are located at the most important hubs, which are at the same time also important headquarters for the banking and insurance sector (such as London, Frankfurt and New York).

4.2.5 Individual transport

In order to mirror the sector analysis it is interesting to look finally at the different segments of individual transport. Commuter transport is related to all sectors and definitely vulnerable to congestion in urban peak hours. No economic sector according to our interviews however stated this as a direct cost issue of economic relevance. The same is true for shopping activities, with respect to the delivery sector. But it can be stated that business strategies tend to overcome peak hours and dense transport infrastructure by shifting the related costs to the commuters and consumers. This accelerates urban sprawl and weakens the advantages of agglomerations density. In this respect, the time losses of commuters and shoppers are not directly GDP relevant, but significant benefit losses on an individual level (in economic terms: loss of consumer rents). A similar statement can be made for leisure and tourism transport where congestion is mainly individual and not directly relevant for GDP related activities (e.g. for the tourism industry).

This is however different for business travels, where specifically air transport (for the service sector, see above) is important and GDP relevant costs are occurring.

4.3 Vulnerability of sectors and countries

4.3.1 An index for economic vulnerability to congestion

The information above is mainly qualitative. Only the transport sector has partly quantitative information on the economic vulnerability and related costs. The analysis however has shown clearly the most relevant elements, such as the transport intensity, the relevance of Just in Time production patterns, the involvement in transport chain issues, the perishableness of goods, the relevance on the demand side such as delivery to clients in urban areas and the quality of infrastructure.

Based on this qualitative information, we compare a set of countries building up a transparent indicator to measure and compare the economic vulnerability of different countries to congestion. The indicator does not show the vulnerability on actual congestion. Furthermore the indicator provides information whether the specific economic structure of a country (mix of sectors and transport intensities per sector) is more or less vulnerable to congestion: Within this respect, **the indicator is showing a potential, not an actual performance.**

Based on this qualitative information, we compare a set of countries building up a transparent indicator to measure and compare the vulnerability to congestion. We base our analysis on the Input-Output-Tables of EU-25 and the US. The following working steps have been carried out:

- Transport intensities of different sectors for each of the countries.
- Qualitative evaluation of the vulnerability of the sectors per country to congestion according to sector specific criteria.
- International comparison of an "**Index on vulnerability of the economy to congestion**" (IVEC) for EU-25 und the US.

Details on the definition of the index and the different variables are shown in the Annex 4.

4.3.2 Results

The IVEC has been calculated for 11 countries with base year 2000. A lower index indicates a lower vulnerability, an IVEC of 100 shows a "medium" vulnerability of congestion. The following Figure 20 shows the overall results for the vulnerability of sectors of the selected countries (on average). Transport intensity shows the level of transport costs in relation to total turnover per sector. The congestion vulnerability index is an aggregate of different criteria.

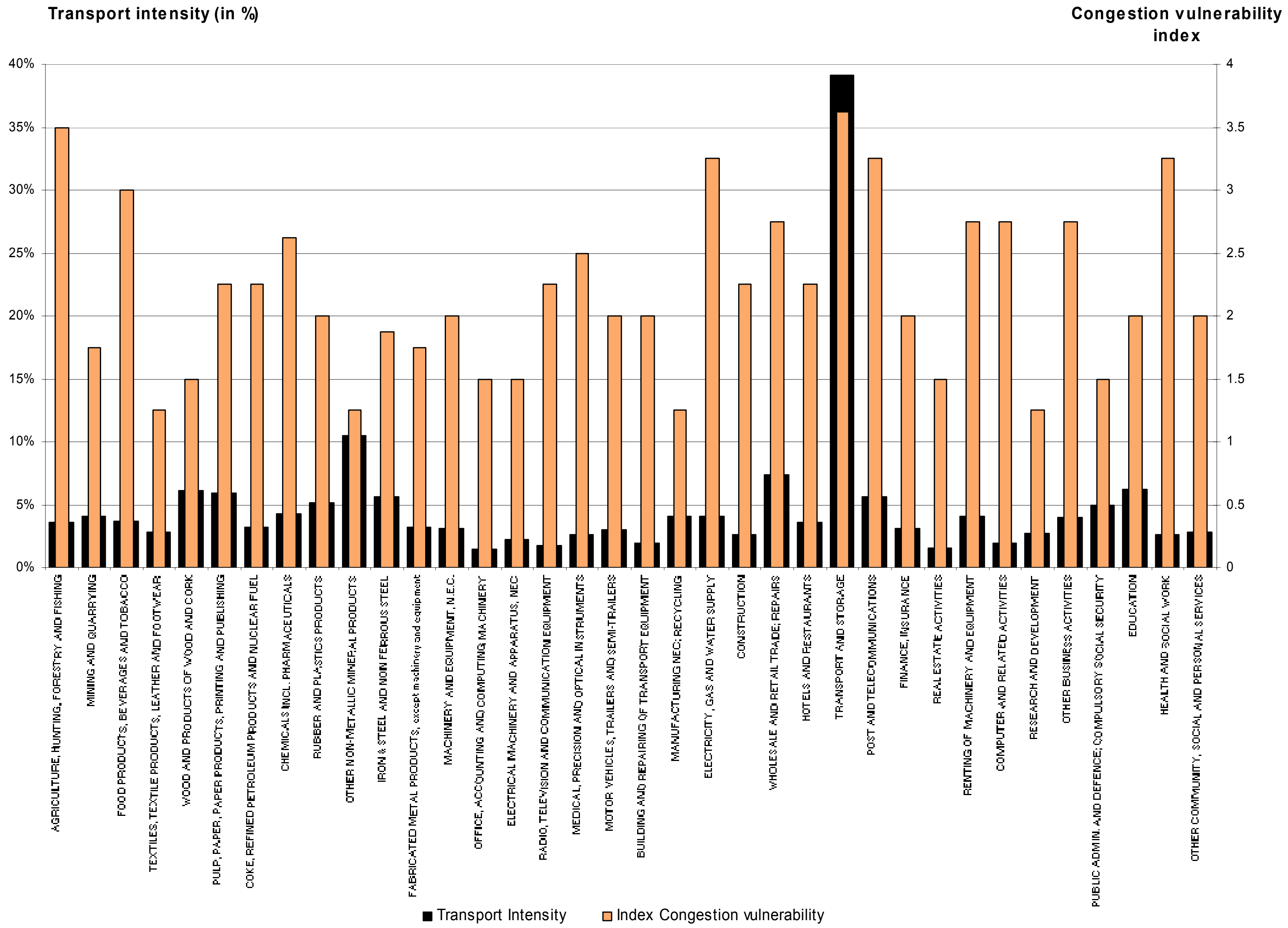


Figure 20: Transport intensity and congestion vulnerability index per sector (average of 11 countries). Index: 1 (not vulnerable) up to 5 (very vulnerable)

The Figure 20 shows the high relevance of the transport sector itself and those sectors with JIT production structures (Food, Manufacturing).

Table 37 shows the results for the index per country. The index related information has been translated to qualitative information. Considering as well the quality of infrastructure, an overall vulnerability of a country can be elaborated.

Table 37: Index on vulnerability on congestion, year 2000

Country	IVEC Index points	IVEC qualitatively	Quality of infrastructure	**Overall vulnerability on congestion**
Czechia	78	++	0	**+**
Denmark	172	--	0	**--**
Finland	167	--	+	**-**
France	120	-	++	**+**
Germany	86	+	+	**++**
Hungary	91	+	+	**++**
Netherlands	156	--	++	**0**
Poland	125	-	--	**--**
Spain	112	-	0	**-**
United Kingdom	143	--	+	**-**
United States	117	-	0	**-**

Source: own calculation based on IOT-information, qualitative congestion impact analysis and information on the quality of infrastructure

Four Groups of countries may be identified:

- Group 1 “Low vulnerability”: Czechia, Germany, Hungary (IVEC < 100)
- Group 2: “Mean vulnerability”: Spain, US, France (IVEC between 101-120)
- Group 3 “Increased vulnerability”: Poland (IVEC between 121-140)
- Group 4 “high vulnerability”: United Kingdom, Netherlands, Finland, Denmark (IVEC > 141)

The analysis of the four group shows, that the different degrees of vulnerability on congestion is not mainly due to the sectoral structures of the countries. The main reason of the different vulnerability is the fact that countries of group 3 and 4 with increased and high vulnerability show higher transport intensities for the country overall and for the single sectors than the countries of group 1 and 2. More than three quarters are explained by the higher transport intensities.

This means that high vulnerability of a country is more due to higher transport intensities of the countries to a large part independent from the sectoral structure. Netherlands, Hungary and Spain are the countries where the sectoral structure explains the highest share of the country’s vulnerability; between 26%-38%.

Adding infrastructure quality, the ratio changes somehow, especially for the Netherlands, UK and Poland.

The IVEC does not show whether a country suffers today from congestion, but whether the economic structure of a country (of sectors and transport intensity per sector) is generally more or less vulnerable on congestion. This means if two countries have already a similar high level of congestion, the country with a higher IVEC will be more negatively influenced in its economic performance due to the specific sectoral structure.

Therefore a comparison of IVEC information with the LOS information from the panorama of congestion in chapter 3 is interesting. It shows in which countries economic development is already burdened with negative impacts from congested (inter-urban) roads. Three examples:

(a) *Finland* has a high vulnerability of congestion (IVEC=167) but the LOS-indicator is "A" for inter urban roads, so Finland has to take care that LOS-indicator does not get worse in order to avoid retarding influence from congestion on economic activity.

(b) *Germany* has a low vulnerability (IVEC=86) but a LOS-indicator of "D" for inter-urban roads, so despite of a low LOS-indicator the German economy is not strongly negatively influenced by congestion because the general structure of the economy is not very vulnerable to congestion.

(c) The *Netherlands* have a quite high IVEC (=156) and a LOS-indicator of "E" on inter-urban roads, so the economic development is already suffering from congestion. Hence, out of these three countries considered, additional investments to improve inter-urban road capacity in the Netherlands would be most effective and efficient.

4.4 Conclusions

Based on our findings, we draw the following conclusions:

- Economic consequences of congestion must be differentiated. GDP relevant are direct costs by suffering and avoiding congestion and indirect costs due to decreased reliability of different economic sectors. Not GDP relevant are the time losses of passenger transport, except for business purposes (e.g. delays in air transport).
- The transport sector is highly affected and vulnerable to congestion, especially road transport and aviation. Both sectors are liberalised and in a strong competitive situation. Besides congestion, other competitive factors (such as fuel costs, wages, and security) are of increasing importance. Congestion (recurring and non recurring) is increasing costs and affecting reliability. For the case of possibly loosing of clients, reliability can be much more important than direct costs. Therefore the transport and logistics sector use several strategies such as night haulage, information and planning instruments to avoid congestion. The aviation sector (especially network carriers) is strongly depending on the possibilities to increase hub capacity in the near future. Besides the transport sector, the food and retail sector with delivery to urban areas is very vulnerable as well.
- For other sectors, congestion is not seen as a major problem, although the relevance is increasing. Congestion is one (amongst many others) factor to induce change of location (e.g. shopping and production sites) leading to urban sprawl.

- It is difficult to pass congestion costs over to consumers. Quality differentiation is only common for specific transport services, such as express delivery and high speed rail and some passenger flights, where penalties for late arrival or reimbursement for cancellation are used.
- Comparing the vulnerability between Europe and the US, one can state that the European economic sectors are more vulnerable to congestion, due to the dense network, the many actors and interoperability problems, and due to smaller land capacities to enlarge transport infrastructure. Within the transport sector, the US aviation industry however is strongly affected by capacity problems, since competition is very strong for network carriers and other factors (such as time losses for passengers due to security measures) are increasingly important.
- In order to quantify economic impacts of congestion costs, the value of time (VOT) approach is useful. It covers however not all related costs. Most important is an additional valuation of reliability. The empirical relevance is quite heterogeneous. Most scientific studies point out that the share or reliability costs is 10 to 20 % of the value of time costs. In maximum – according to road hauliers replies – the ratio can reach more than 100%. A differentiation according to economic sectors might be useful, since the relevance varies between sectors and countries considerably.
- There are influences on competitiveness of the transport sector between modes. In general rail transport is supposed to profit from congestion in urban areas and specific corridors. Intramodal distortion in competitiveness is however not significant. The vulnerability between European countries and the US is quite different, depending on the structure of the economy, the transport intensity and the quality of infrastructure. The vulnerability is higher in Northern European countries with high network density and Eastern European countries with low infrastructure quality. Compared to that the vulnerability of the US transport sector is less significant.
- In order to consider the different economic impacts, measures to overcome congestion must be seen in a broader context. Besides efficient infrastructure pricing, infrastructure capacity and quality enlargement, incentives to shift to public transport in urban areas and sensitive corridors, information systems in order to anticipate congestion properly, quality controlling and penalty systems for fair pricing of transport and maximal conditions for environmentally sound use of off peak situations (esp. night haulage) and increase of load factors are important. The EU policies in regard to improvement of rail interoperability, road management systems and air traffic management play an important role to improve transport infrastructure quality and to minimise economic impacts of congestion.
- In countries with much congestion and a high structural vulnerability of the economy on congestion the economy is most negatively influenced by congestion and suffering from losses in economic competitiveness due to congestion. Additional infrastructure investments seem most effective in countries where the indicator of the economy to congestion is high and the actual level of service (on roads and rail) is low. Whereas UK, the Netherlands and Germany are highly congested, the general impact of congestion to national economy will be more relevant in UK and the Netherlands than in Germany, since these countries face a high vulnerability indicator.

5 Structural change and its implications for transport

5.1 Mega-trends affecting transport

The evolution of the EU economy in general and its transport sector in particular cannot be understood isolated from the context of the globalisation process of the national economies and societies. The globalization process itself must be understood as a set of inter-connected macro-economic world-wide mega-trends, with relevant impacts on logistic processes at micro level and, consequently, in transport systems. The analysis of future transport trends (see section 5.2 and Annex 5 - section 2.6) was framed by the study of these on-going mega-trends. The main macro-trends can be identified as follows (further information concerning each mega-trend can be found in Annex 5):

- **Population change**, that can affect transport sector in several ways, according to its evolutions: the increase in population increases mobility and transport (both for passengers and freight) demand with a potential source of congestion, or the reduction in population can affect negatively, for instance, the sustainability of public transport systems through the revenue side; Additionally, population growth is accompanied by trends affecting its location, particularly its concentration in major urban and costal areas;
- **Opening of national economies**, with the entry of new international economic players like China and India, the creation of multinational free trade areas (like NAFTA or the EU Internal Market) and the subsequent rise of international trade. In parallel, services represent a growing share of the overall economy and are playing an especially important role in developed countries;
- **Increase of international investment**, with the generalisation of the activities of the multinational enterprises that extend their production and distribution activities to several countries throughout the world. Furthermore, the increase in international investment, together with the opening of national economies, is accompanied by an increased division of labour;
- **Advances in technologies**, turning information and communication equipments portable, cheaper and affordable, triggering the emergence of new services and products and allowing a reduction in information and communication costs of transport, stimulating the global interchange of products.

The association of the above presented global mega-trends has triggered or accelerated a set of logistic related trends, more or less internationalised according to the geographical scale where market companies operate. In total the logistic trends considered are 20 and the relationship with the 4 mega-trends is fully developed in Annex 5. The logistic trends are:

- Spatial concentration of production and inventory;
- Development of break-bulk / transhipment systems;
- Creation of hub-satellite networks;
- Concentration of international trade on hub ports;

- Rationalisation of the supply base;
- Vertical disintegration of production;
- Wider geographical sourcing of supplies;
- Wider distribution of finished products;
- Postponement / local customisation;
- Increased direct delivery;
- Time-compression principles applied in retail and manufacturing;
- Increase in retailers' control over supply chain;
- Growth of “nominated day” deliveries and timed delivery systems;
- Changes in freight modal split;
- Reduction in international transport costs;
- Impact of legislation and regulation;
- Increased use of information and communications technology;
- Developments in vehicle and handling technology;
- Complexity, Packaging, Modularity;
- Globalisation, growth of E-commerce and dematerialisation of freight.

Table 38 presents the relationships between the 4 mega-trends and the specific trends detected in logistics. The mega-trends with more weight in triggering the changes in logistics and transport systems are those related to the extension of the global economic activity throughout the world (opening of national economies and increase of international investment) and the one related to the reduction of transport costs due to communication and information activities (advances in technologies).

Table 38: Relation between global economic mega-trends and international logistic trends

	World-wide Economic Mega-trends			
International Logistic Trends	Population Growth	Opening of National Economies	Increase of International Investment	Advances in Technologies
Spatial concentration of production and inventory	🟧	🟧	🟧	🟧
Development of break-bulk / transhipment systems	⬜	🟧	⬜	🟧
Creation of hub-satellite networks	🟧	⬜	🟧	🟧
Concentration of international trade on hub ports	⬜	🟧	🟧	⬜
Rationalisation of the supply base	⬜	⬜	⬜	⬜
Vertical disintegration of production	⬜	🟧	⬜	🟧
Wider geographical sourcing of supplies	⬜	🟧	🟧	🟧
Wider distribution of finished products	⬜	🟧	⬜	🟧
Postponement / local customisation	⬜	🟧	⬜	🟧
Increased direct delivery	🟧	⬜	⬜	🟧
Time-compression principles in retail and manufacturing	⬜	🟧	⬜	🟧
Increase in retailers' control over supply chain	⬜	🟧	⬜	🟧
"Nominated day" deliveries and timed delivery systems	⬜	🟧	⬜	🟧
Changes in freight modal split	🟧	🟧	🟧	⬜
Reduction in international transport costs	⬜	🟧	🟧	🟧
Impact of legislation and regulation	⬜	🟧	🟧	⬜
Use of information and communications technology	⬜	🟧	🟧	🟧
Developments in vehicle and handling technology	⬜	🟧	🟧	🟧
Complexity, Packaging, Modularity	⬜	🟧	🟧	🟧
Growth of E-commerce and dematerialisation of freight	🟧	⬜	⬜	🟧

Source: own elaboration from TRILOG project data (OECD 1999)

5.2 Implications of structural changes for development of logistics

After relating the 4 global mega-trends with the logistic specific trends, the next step is to characterise the impacts on the transport sector of the developments on logistics. For the assessment of such impacts per transport mode we introduce 6 qualitative indicators that provide information on the expected evolution of the modes in the near future. This evaluation process is based in results from state of the art literature and results from previous projects, and was updated and refined based on the research carried out throughout the COMPETE project. The indicators are: variation of modal share, variation of load factor, variation in vehicle size, use of intermodal loading units, variation of the length of haul and variation of the tonne-kilometres transported. The categories of effects on the indicators are 4: positive evolution (expected increase), negative evolution (expected reduction), no expected change and no reliable expectations.

In what concerns **road transport** (see Table 39), road modal share will be positively affected by the "rationalisation of the supply base" and by the "changes in freight modal split" (for past trends regarding modal split see annex 5 – section 2.4.1. Changes in Freight Modal Split). On the other hand, one can expect that the "concentration of international trade in hub ports" and the "impact of legislation and regulation" will contribute to the reduction of road modal share. The overall balance of these opposite effects is not clear and is largely dependent upon technological and political factors. In parallel, the road vehicles load factor will suffer many positive influences by nine of the twenty logistics trends studied, while only two of these trends will contribute to decrease this indicator. In this sense, it is reasonable to expect that the medium/ long term result will be a positive one, i.e. there will be an increase in the road freight transport vehicles load factor. In terms of road fleet vehicle size, it is also reasonably clear that there will be an increase of this indicator in the coming years, since five logistic trends will positively affect it, and only one will contribute to its reduction. Attention should be paid to the fact that this indicator will probably rise within the legal limitations already imposed and that no changes to these restrictions are expected. The use of intermodal loading units is also going to increase. Seven of the logistic trends will influence positively this change, while none will contradict it. Apparently, also the indicator "tonnes-kilometres" will increase in the future, as long as the trends such as: **i)** the concentration of spatial concentration; **ii)** transhipment systems and **iii)** hub-satellite networks, also maintain its evolution (more detailed information is presented in Annex 5). However, this presupposition is highly dependent upon political and technological progress, namely in what concerns energy alternatives.

The organisation of production systems since the early 80s was largely influenced by two major factors: the relative low prices of oil and the absence of internalisation of external costs associated with transport. However, at this moment, both factors seem to be following a path for change. Concerning the internalisation of external transport costs, the issue has been on the political agenda during the last decade, especially in the European Union. Important efforts have been done to calculate the real costs of each transport mode and internalise them in order to reveal the "true modal cost" and reflect it in the transport prices (with a potential effect for modal change, due to the expected changes in prices). Concerning the low prices of oil, after the recent increase in oil prices, all forecasts expect sustained higher prices than during the previous decades, with variable trends to be followed in the future, depending on the source. The United States Energy Information Administration (EIA) provided a forecast in June 2006 for the time horizon of 2030, in which the increase in prices is quite constant, varying prices between near the 60$ per barrel (US EIA 2006).

In this context, it is quite likely that this decade will see some developments in logistics. If transport is not any more a cheap leg of the logistic chain, several trends that have dominated logistics since the 80s could reverse. For instance, the spatial concentration of production in the low labour cost countries of Asia could stop due to the large increase of the overall production price including transport to the markets in Europe and the USA. This could mean that factories would "relocate back" to Europe (strong candidates are the NMSs and the Candidate Countries) or to some locations outside Europe with lower salaries but nearer the consumption countries. The dimension of this undoing of the logistics trends prevailing for the last 20 years will depend after all on the capacity of the logistic and transport system to adapt to the current energy prices trend. In the following figure the evolution between 1985 and 1995 (in percentage) of several road freight transport related indicators are presented for five European countries.

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

Figure 21 – Overview of changes in economic activity and road freight transport 1985-95

Source: Redefine Summary Report

For **rail transport** (see Table 40) the modal share indicator is balanced by five positive influences and four negative. The overall balance will largely depend upon the strength of the "impacts of legislation and regulation". However, it can be argued that most European countries which will modernise their rail infrastructures, adapt their institutional frameworks and allow access to the network of private logistic operators, will, most likely, register an increase in this indicator. No clear estimations can be drawn concerning the final results in the medium and long run concerning the indicators load factor and vehicle size, which are very much dependent upon the evolution of the previous indicator. It is also important to put in perspective the relevance of the indicator load factor in this particular transport mode. In fact, the size of freight trains is easily changeable according to the load volumes to transport; therefore the second indicator ("vehicle size"[14]) is more useful. The use of intermodal load units is also expected to increase in rail transport, as well as the length of haul (rail freight is getting more flexible, but it is in the longer hauls where it is more competitive with the road) and the tonnes-kilometres transported.

In what concerns **air transport** (see Table 41), one can expect a potential increase in the modal share. The separation between passengers and cargo, not only operational but also institutional, has contributed to the better performance of the air freight sector. On the other hand, time to market is an increasingly important variable in most logistic chains. Particularly, freight with a high value and low volume will have significant potential to be transported by air. No reliable forecast can be made regarding the effects of logistic trends in the indicators load factor and vehicle size(for past information - 1990 to 1999 - concerning the load factor and vehicle size indicator please see Annex 5 – section 2.1.2). The high use of intermodal units is already a reality, especially in "belly" transport[15]. On the other hand, the length of haul and the indicator tonnes-kilometres will most likely increase in the air freight transport during the coming years.

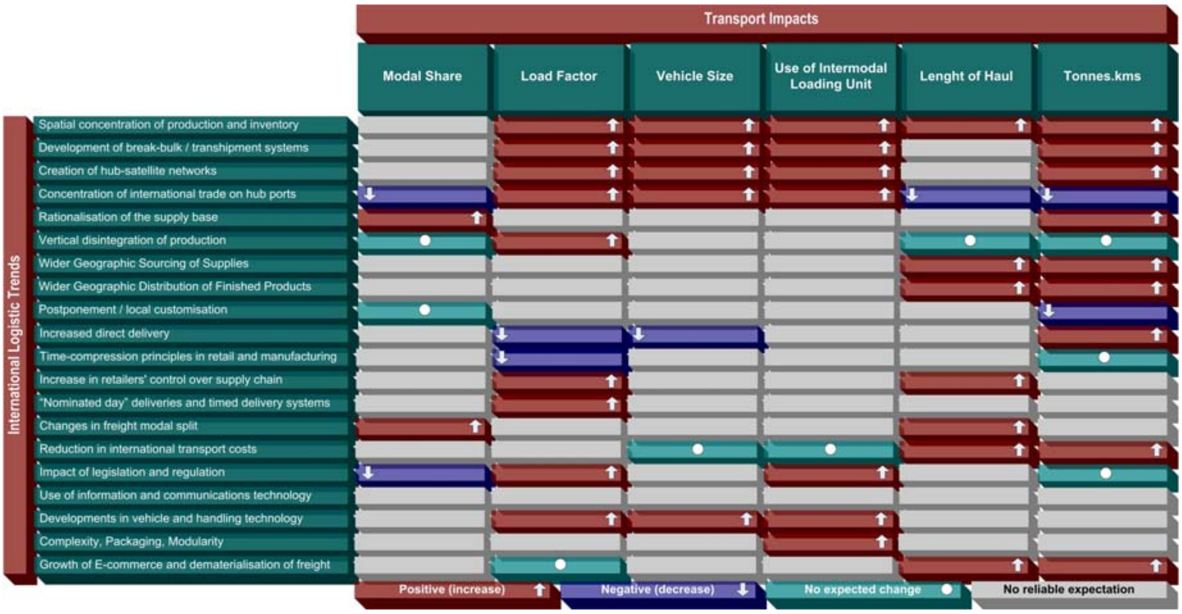
---

[14] Being vehicle size the total length of the train

[15] as oposed to all-cargo airplanes, "belly" transport refers to cargo transport in ULD (unit loading device) in the "belly" of passengers aircrafts.

Finally, in **maritime transport** (see Table 42), although five logistic trends will contribute positively to increase the modal share of this transport mode, the overall final result is not totally clear, and will depend largely upon the configuration of international logistic chains and the evolution of trade agreements and partnerships. The load factor associated with maritime vessels will most likely not suffer any significant change in the coming years, due to the international logistic trends. However, one can expect an increase concerning the indicators vehicle size (for instance, container vessels are continuously increasing its size and cargo capacity; nowadays 6.000 TEUs vessels are quite common in transoceanic routes), use of intermodal loading units (containerisation of cargo), length of haul (the commercial relationships between commercial blocks America-Asia-Europe are scaling) and tonnes-kilometres (longer haul and larger cargo capacities).

Table 39: Road haulage logistical qualitative effects matrix

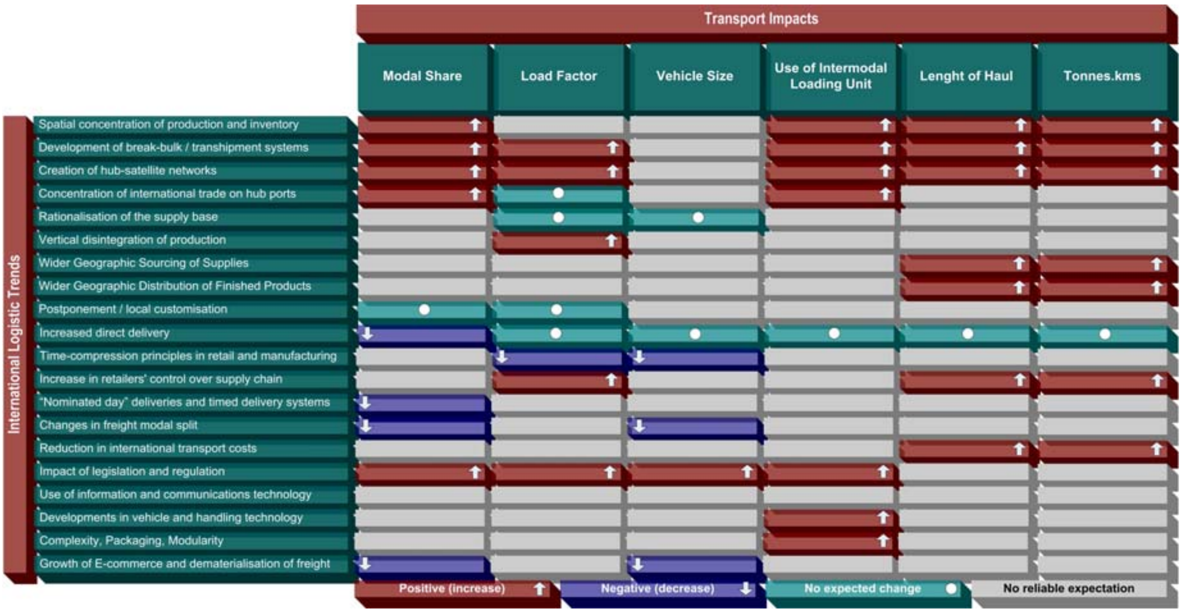


International Logistic Trends	Transport Impacts					
	Modal Share	Load Factor	Vehicle Size	Use of Intermodal Loading Unit	Lenght of Haul	Tonnes.kms
Spatial concentration of production and inventory		↑	↑	↑	↑	↑
Development of break-bulk / transhipment systems		↑	↑	↑		↑
Creation of hub-satellite networks		↑	↑	↑		↑
Concentration of international trade on hub ports	↓	↑	↑	↑	↓	↓
Rationalisation of the supply base	↑					↑
Vertical disintegration of production	●	↑			●	●
Wider Geographic Sourcing of Supplies					↑	↑
Wider Geographic Distribution of Finished Products					↑	↑
Postponement / local customisation	●					↓
Increased direct delivery		↓	↓			↑
Time-compression principles in retail and manufacturing		↓				●
Increase in retailers' control over supply chain		↑			↑	
"Nominated day" deliveries and timed delivery systems		↑				
Changes in freight modal split	↑				↑	
Reduction in international transport costs			●	●	↑	↑
Impact of legislation and regulation	↓	↑		↑		●
Use of information and communications technology						
Developments in vehicle and handling technology		↑	↑	↑		
Complexity, Packaging, Modularity				↑		
Growth of E-commerce and dematerialisation of freight		●			↑	↑

Positive (increase) ↑ Negative (decrease) ↓ No expected change ● No reliable expectation

Source: own elaboration

Table 40: Rail transport logistical qualitative effects matrix



	Transport Impacts					
International Logistic Trends	Modal Share	Load Factor	Vehicle Size	Use of Intermodal Loading Unit	Lenght of Haul	Tonnes.kms
Spatial concentration of production and inventory	↑			↑	↑	↑
Development of break-bulk / transhipment systems	↑	↑		↑	↑	↑
Creation of hub-satellite networks	↑	↑		↑	↑	↑
Concentration of international trade on hub ports	↑	●		↑		
Rationalisation of the supply base		●	●			
Vertical disintegration of production		↑				
Wider Geographic Sourcing of Supplies					↑	↑
Wider Geographic Distribution of Finished Products					↑	↑
Postponement / local customisation	●	●				
Increased direct delivery	↓	●	●	●	●	●
Time-compression principles in retail and manufacturing		↓	↓			
Increase in retailers' control over supply chain		↑			↑	↑
"Nominated day" deliveries and timed delivery systems	↓					
Changes in freight modal split	↓		↓			
Reduction in international transport costs					↑	↑
Impact of legislation and regulation	↑	↑	↑	↑		
Use of information and communications technology						
Developments in vehicle and handling technology				↑		
Complexity, Packaging, Modularity				↑		
Growth of E-commerce and dematerialisation of freight	↓		↓			

Positive (increase) ↑ Negative (decrease) ↓ No expected change ● No reliable expectation

Source: own elaboration

Table 41: Air transport logistical qualitative effects matrix

	Transport Impacts					
International Logistic Trends	Modal Share	Load Factor	Vehicle Size	Use of Intermodal Loading Unit	Lenght of Haul	Tonnes.kms
Spatial concentration of production and inventory	↑				↑	↑
Development of break-bulk / transhipment systems					↑	↑
Creation of hub-satellite networks	↑				↑	↑
Concentration of international trade on hub ports	↓				●	●
Rationalisation of the supply base	●					
Vertical disintegration of production	●					
Wider Geographic Sourcing of Supplies	↑				↑	↑
Wider Geographic Distribution of Finished Products	↑				↑	↑
Postponement / local customisation						
Increased direct delivery	↑	↓			↑	
Time-compression principles in retail and manufacturing	↑					
Increase in retailers' control over supply chain					↑	↑
"Nominated day" deliveries and timed delivery systems	●					
Changes in freight modal split	↑					
Reduction in international transport costs	↑				↑	↑
Impact of legislation and regulation				↑		
Use of information and communications technology						
Developments in vehicle and handling technology				↑		
Complexity, Packaging, Modularity				↑		
Growth of E-commerce and dematerialisation of freight	↑	↓			↑	

Positive (increase) ↑ Negative (decrease) ↓ No expected change ● No reliable expectation

Source: own elaboration

Table 42: Maritime transport logistical qualitative effects matrix

International Logistic Trends	Transport Impacts					
	Modal Share	Load Factor	Vehicle Size	Use of Intermodal Loading Unit	Lenght of Haul	Tonnes.kms
Spatial concentration of production and inventory	↑		↑	↑	↑	↑
Development of break-bulk / transhipment systems			↑	↑	↑	↑
Creation of hub-satellite networks			↑	↑	↑	↑
Concentration of international trade on hub ports	↑		↑	↑	↑	↑
Rationalisation of the supply base	●					
Vertical disintegration of production						
Wider Geographic Sourcing of Supplies	↑				↑	↑
Wider Geographic Distribution of Finished Products	↑				↑	↑
Postponement / local customisation	●					
Increased direct delivery	●					
Time-compression principles in retail and manufacturing	↓					
Increase in retailers' control over supply chain	●					
"Nominated day" deliveries and timed delivery systems	●					
Changes in freight modal split						
Reduction in international transport costs						
Impact of legislation and regulation	↑					
Use of information and communications technology						
Developments in vehicle and handling technology				↑		
Complexity, Packaging, Modularity				↑		
Growth of E-commerce and dematerialisation of freight	●					

Positive (increase) ↑ Negative (decrease) ↓ No expected change ● No reliable expectation

Source: own elaboration

5.3 Changes of trade patterns and trade flows of the EU and US

The following section presents the resume of the analysis of the main commercial flows, their evolution through time and types of transported goods traded. The overall objective is to provide insights of the evolution of the external sector of the national economies and the implications in the transport sector. In more detail, the technical objectives of the analysis are the following:

- To investigate the evolution and changes in commercial partnerships and associated trade flows in order to check changes in transport flows and transport modes handling them;
- To point out the qualitative effects from the changes in the use of the available modes and freight transport shares and forecast the future sign of potential qualitative changes in the use of the available freight modes;
- Provide conclusions concerning the modes, networks or geographic areas with a potential for congestion or with present or future bottlenecks for transport and logistics in the EU.

The data used for the analysis come from different sources: STAN Bilateral Trade Database statistics from the OECD for the analysis of international commercial flows (OECD 2006), Eurostat (2004) and North American Transportation Statistics (2006) concerning transport statistics in Europe and the USA. The period of analysis was in the majority of the countries 1988-2004, being it reduced in several cases due to the unavailability of some data.

Given the time limits for the study, in total 11 countries were analysed, in agreement with the Commission services, concerning specific national case studies. The conclusion per country concerning the trade patterns and their effect in the transport sectors are the following:

1) **Denmark** present a very high level degree of stability on its trade flows, with an economy very integrated in the EU Internal market. The main trends concerning the trade flows since 1988 are: the progressive integration of the Danish external sector in the EU internal market through the reinforcement of the commercial relationships with several EU Member States; and the extension of its trade flows into the global trends, with increased relationships with China. The main effects in the Danish transport sector for the near future according to the present international trade trends are the following:
   - Intensive use of the land modes, due to the preferential partnership with Germany and other growing flows with other EU Member States;
   - Intensive use of the port sector, given the growing trade flows with countries of the Baltic area and North Sea (UK and Norway), and the increasing commercial flows with overseas countries, especially with China. The situation of several European hub ports can soften this pressure, as some are very near to Denmark: Bremen, Hamburg and Rotterdam;
2) **Finland** presents a mixture of commercial partnerships with several changes in the configuration of its main import providers and export purchasers. There are 3 groups of partners that can be highlighted: regional non-EU Member State partners (Russia, Norway) and other Baltic states in lesser degree; EU Member States (Germany, Sweden, France and Netherlands mainly); and overseas partners (USA, China and Japan). The main effects in the near future on the transport sector would be:
   - Strong increase in the land based modes due to the large increase of the trade flows with the Russian Federation. The most likely mode increasing its share would be the road, as the situation of the Russian railway network would determine the capacity for responding to the demand for transport;
   - The port sector will continue its growth path since the early 90s, due to the increase in maritime activity in the Baltic region and the growing partnerships of Finland with several EU Member States and overseas countries. Since 1996, the Finish port sector has a growth rate of 32% of the total transported tonnes;
3) **France** presents very stable commercial partnerships and flows, being the main importers and exporters amongst the same group of countries, mainly EU Member States. The most relevant variations in terms of partnerships are the growing role of Spain both as importer and exporter and the role of China as booming overseas partner. The main effects in the near future on the transport sector would be:
   - Most flows are concentrated on neighbour countries (Germany, Spain, Switzerland, Italy and Belgium), putting more pressure in the land based modes. The most likely effect is a rise in the share of road haulage, due to the shorter distances covered and to the present trend of reduction of the rail freight share;
   - The French port sector will continue to grow, as it concentrates 66% of the total extra-EU French trade and handles also important flows from the Mediterranean and Baltic routes. In this context, the global phenomenon of the rise of the Chinese economy will play a key role in the evolution of the tonnage handled by the port sector;

4) **Germany** can be considered as pivotal in the trade and transport sectors of the EU for two reasons: first, it is the main EU economy, generating very large flows of imports and exports not only with all EU Member States, but also extra-EU trade, and the subsequent transport flows; and second, its geographical situation in the core of Europe means that its networks also support trade between other European countries. The set of German commercial partners has been very stable through the period analysed, with well defined activities as main importer/exporter within the EU and as key global importer/exporter. The main effects in the near future on the transport sector would be:

   - The recovery of the rail share on the total tonnes transported by the land modes depends largely on the evolution of the railway infrastructure in the emerging German partners, the NMSs. If it cannot cope with the expected (and already ongoing) increase in trade, road transport will increase its share and put more pressure on the already congested German network;
   - Maritime transport is key for the extra-EU German relationships and for trade in several long haul intra-EU routes. The strong increases of commercial flows to/from the US and China will rise as potential sources for congestion in the German ports and associated Hinterland networks;

5) **The Netherlands** present an interesting case of “specialisation” concerning the trade flows: exports flows are very EU oriented, having imports a more “global” orientation. This intense process of globalisation started in the late 80s. In both cases the main partnerships are neighbour countries and other EU Member States, with the inclusion of several overseas partners concerning imports. The main effects in the near future on the transport sector would be:

   - The port sector is crucial for the fluent relationships of the Dutch economy, with some of the most important European hubs. The ports sector will suffer from more pressure and a high potential for congestion, not only for the Dutch trade flows, but also due to the concentration of European trade flows passing through them;
   - The strong relationships with neighbour countries and other EU Member States and the commercial flows concentrated in the Dutch hub ports will put increasing pressure in the land based modes as far as they continue to grow. Of special importance will be the extra-EU relationships, that tend to use the Dutch port system.

6) **Spain** is a case study for evolution of the external relationships of its economy and the evolution of the transport sector. As the Netherlands, Spain presents a characteristic of double integration: first, with the strengthening of the intra-EU partnerships; and second with the increasing integration in the global trade relationships. This dual evolution has been handled quite separately by the maritime sector (mainly the global integration, extra-EU trade) and the road haulage (the intra-EU trade). The main effects in the near future on the transport sector would be:

   - The road haulage is so high in Spain because of the interoperability problems of the railways. This mode is suffering from a lack of modernisation, that means that in the near future any increase in the intra-EU trade will be directly translated into a more intensive use of the road network;

  - The port sector in Spain has experienced a large growth in the last decades, being the main mode for the Spanish extra-EU trade and getting increasing importance in intra-EU long haul routes in the Mediterranean and with the North Atlantic and Baltic areas. There are no important congestion problem in the ports (in aggregate terms there is some excess of capacity) but the associated networks are already congested at some points.

7) **The UK** is, of all the European countries analysed, the one with the highest proportion of extra-EU trade over total trade, due to its traditional relationship with the USA. Moreover, both imports and exports have a very similar structure regarding the main partnerships, with a high level of stability in the last decades. The most important new partners are China and Spain, two different trends, globalisation and integration in the EU internal market. The main effects in the near future on the transport sector would be:

   - Of course, the port sector is crucial in the British commercial interchanges. It is evident that the pressure of further increases in imports and exports will put more pressure in the port sector and rise the potential for congestion. Complementary land based networks and their connections to ports must be also taken into account;

   - Concerning the land based modes, the UK has followed since the 90s an interesting trend of reduction of the road freight share over the total volume of transported tonnes using land based modes. This can be due to the process of rail liberalisation in the UK, which is more advanced than in any other EU Member State, and to the highly developed presence in the rail freight market of specialised private operators;

8) **The Czech Republic** trade flows during the period are characterised by the strengthening of relationships with the former EU15 Member States, specially with Germany, a trend that verifies also in Hungary and Poland. Of these three NMSs, the Czech Republic is the one with higher increases in trade and with the most focused commercial flows. The main effects in the near future on the transport sector would be:

   - The preferential Czech trade partnerships determine the transport modes used for commerce: the flows are extremely intense, both imports and exports, with Germany (especially), Austria and the Slovak Republic. Most of these commercial interchanges are performed using the road network. The trend followed by the Czech economy (increase in the average value of imports and exports) suggest further pressure on the road mode with a potential for more congestion;

   - The rise of the road share has been complemented with a fall of the rail freight share due to several reasons, but the most important seems to be that the Czech rail network is lagging in terms of its ability to respond to the needs of the logistics operators, mainly due to its need for modernisation.

9) **Hungary** has a very similar evolution in several aspects to that of the Czech Republic: a common set of partners, a very similar evolution in the composition of imports and exports and a parallel evolution in the transport sectors. Hungary presents (as the Czech Republic) a fast integration in the EU internal market with strong regional partnerships. The main effects in the near future on the transport sector would be:

- The road sector has increased its freight share in the last decade and it is expected that it will continue to grow in the near future, due to the increasing commercial relationships with its neighbour countries, Slovakia, Czech Republic and specially Austria, haul distances where the road is more competitive;
- The railway share has been fairly stable since 1998 but in the near future it is expected more pressure from the road operators (more competence) and from the logistics operators asking for a higher integration of rail freight in the logistic chains as complexity of transport operation rises.

10) **Poland** is undergoing an accelerated process of integration in the EU internal market, as the Czech Republic and Hungary. The evolution of the transport sector and the composition of import and export flows are also very similar to those of the other NMSs studied. It is important to remark the high integration with Germany, first partner concerning imports and exports. The main effects in the near future on the transport sector would be:

    - The land based sectors have followed a trend since 1993 of intense shift from rail to road freight. It seems quite likely that the share of road haulage will continue to grow, putting more pressure in the road network and increasing the potential for congestion, specially in the road connections with Germany, the top supplier and purchaser of the Polish economy;
    - The maritime transport in Poland has grown steadily in Poland, being the mode used by the overseas commercial partnerships and (potentially) in some intra-EU commercial routes of long distance. To this it must be added the increasing integration of the Polish ports in the Baltic region trade. In this context, it is foreseeable a more intensive use of the sector in the near future.

11) **The US** has gone through a process of commercial and trade integration due to the implementation of the NAFTA agreement in 1994, that has meant a significant rise in trade activity between the signing countries, USA, Canada and Mexico. However, in aggregated terms, the effect of the NAFTA agreement in the ranking of Top10 commercial partners for imports and exports has been very limited, mainly because Mexico and Canada where already before the agreement amongst the US preferential trade partners. As first economy of the world, the structure of the US trade partnerships is very complex with three trade blocks quite well defined: NAFTA countries, Canada and Mexico; European countries, all EU Member States; Far East countries, China, Taiwan, Korea and Japan. The main effects in the near future on the transport sector would be:

    - The long distances travelled by the external US trade determines largely the transport mode used. In the commercial relationships with Canada and Mexico, with a trend to reduce the share of road haulage and increase the shares of rail freight and maritime transport. It is expected a similar evolution in the near future;
    - The US port sector is key for handling most of the extra-NAFTA external commerce of the USA. The trade flows through the Pacific towards Japan, Taiwan and China, and through the Atlantic towards the EU. The development of the port sector will be especially important in the Pacific routes given the pattern of high growth rate followed

by the Chinese economy and the increasingly intense relationship with the US economy.

Figure 22 presents a schematic representation of the main variations in the value of trade flows between countries, according to the values of the detailed analysis presented in Annex 5. The objective of such representation is to put together in one figure all the main increases in trade flows (both intra and extra-EU) for the countries analysed and draw some qualitative conclusions concerning the main regions and transport networks affected. The final objective is to set the basis for the analysis of the potential bottlenecks in transport and logistics that serves as conclusion of this chapter.

From Figure 22 we can highlight the high concentration of rising trade flows around Germany, with the former EU15 Member States and the NMSs. Thus, central Europe will face, if trade trends evolve under the same parameters of nowadays, a more intense use of the land based modes. This will be especially important in countries with rail infrastructure needing modernisation, as in such situations road haulage will increase its share steadily. This can be the case of Poland, Czech Republic and Hungary. Another important transport area will be the North Atlantic and Baltic regions, where the increasing trade flows from overseas partners (USA, China, Japan, etc) concentrate. The port sector will be of utmost importance, as well as the accesses to the associated land based networks.

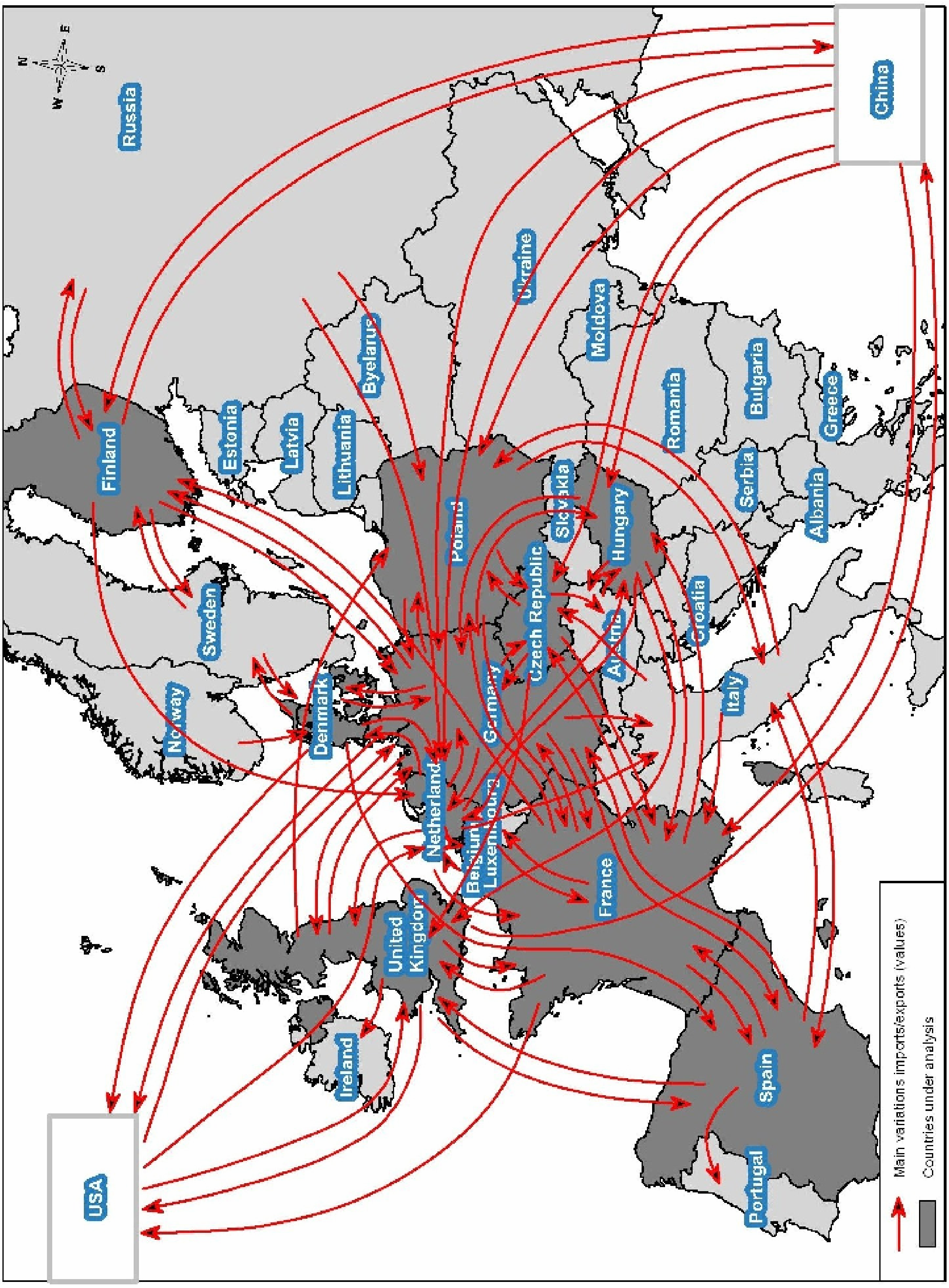


Figure 22: Schematic representation of the main increases in the trade flows for the EU Member States analysed

Source: own elaboration

5.4 Structural change of the economies

From the analysis of the trade flows and types of transported good we can derive important conclusions concerning the structural changes of the national economies. There are two indicators of relevance:

- Evolution of the composition of the main NSTR categories of goods: changes in the shares of the NSTR categories provide an indicator on the evolution of the economy and productive system. For instance, reductions in imports and exports of agricultural goods and an increase in imports and exports of manufactured goods during a period of time might indicate that the secondary sector of the economy is gaining weight against the primary sector;
- Evolution of the composition of imports and exports in terms of the technological level of the traded manufactured goods. This classification presents imports and exports of manufactured goods classified in 4 categories: low technology manufactures, medium-low technology manufactures, medium-high technology manufactures and high technology manufactures. The increase of the share over total transactions of the higher technology categories might indicate an increase in the production with a high value on the ratio value/weight and a specialisation of the national industry in the production of higher value goods.

These two indicators were checked for all the countries under analysis in this section, being the detailed results presented in Annex 5. Following we present a resume of the results per country and the potential effect of the changed observed in the national transport sectors. It is important to remark that the conclusions we present are related with the potential effect of the structural changes on the share of the land based modes, those with a higher tendency to shift modes due to changes of its value per unit.

1) **Denmark**: the composition of Danish imports and exports is quite stable throughout the period, being the manufactured goods the base of both figures. Imports total value presents a percentage of manufactured goods between 88% and 92% for the total value of imports, and between 92% and 94% for exports. The share of the medium and high technology manufactures grew during the period from 47.8% to 51.7% for imports and 40% to 50.5% for exports. The low increase in the average value of manufactured goods and the stability of the share of manufactured goods over total trade does not suggest a relevant change in the economy. There are no relevant changes expected in the transport sector due to structural economic changes;
2) **Finland**: the composition of imports and exports consist mainly of manufactured goods, especially in exports, with a very stable share around 97% of the total value. The share of medium and high technology manufactures over total manufactures exported was 43.7% in 1988 and 49% in 2004. The low increase in the average value of manufactured goods and the stability of the share of manufactured goods over total trade does not suggest a relevant change in the economy. There are no relevant changes expected in the transport sector due to structural economic changes;
3) **France**: the type of goods exported has followed a trend for increasing the value of goods, changing the proportion of medium and high technology manufactures from

56.2% in 1988 to 64.9% in 2004. Over the total value of exports, manufactured goods had an increase on their share from 90.9% in 1988 to 94.7% in 2004, with a reduction for those years of the agricultural goods exported from 6.7% to 3.12% respectively (more than a 50% reduction). This means that there is a significant shift in the value of produced and traded goods, with a potential impact in the increase of the use of road and reduction in the use of rail freight;

4) **Germany**: the share of manufactured goods over total imports and exports has been stable during the period, with values around 94% for exports and 83% for imports. Concerning the value of medium and high technology manufactures, the proportion over total manufactured imports changed from 48.6% in 1988 to 62.1% in 2004, and over manufactured exports from 64.5% to 70.8% respectively. There is a clear trend for specialisation of the German economy in the production of higher value goods. This can have an impact in the increase of the share of road transport and reduction on rail freight, but the impact would be lessened as the German transport sector is a very mature one, with high stability and a high degree of development;

5) **Netherlands**: The share of medium-low technology imports decreased since 1988 from 49%, to 35% in 2004. At the same time, in 1988 the share of medium and high technology exports was 47%, being almost 60% in 2004. Combined to the figures of the imports, these numbers are consistent with the structural trend of the more developed economies that area following a path of specialisation in the production of high value goods. This can have an impact in the increase of the share of road transport and reduction on rail freight, although the effect would be small due to development of the Dutch transport sector;

6) **Spain**: Spanish exports follow the trend of specialisation in medium and high technology goods of most developed economies. The share of manufactured goods over total exports also rose in the period, from 89.3% to 91.5%, with reductions in the share of exports related to agriculture goods, from 9.4% to 6.1%. In terms of its technological level, the types of goods exported have also changed: in 1988 the majority of exports were medium and low technology goods (51.5% of the total manufactured exports), and in 2004 the majority were medium and high technology goods (almost 57% of the total manufactured exports). This increase in the value of transported goods can have an impact in the increase of the share of road transport and reduction on rail freight, which is in fact the trend nowadays;

7) **UK**: The structure of imports and exports has changed since 1988 in the same way as in other developed EU economies: the share of manufactured goods over total imports and exports has increased, as well as the share of the medium and high technology manufactures over total manufactures imported and exported. This means that the UK economy has increased its specialisation, like other European countries, producing more valuable goods. This increase in the value of transported goods can mean an increase of the share of road transport and reduction on rail freight, although the effect would be small due to the maturity and high development of the UK transport sector;

8) **Czech Republic**: Since 1993, the proportion of mining and quarrying products over total imports has fallen 50%, from 10% to 5%. In the same period, the percentage of manu-

factured goods imported changed from 84% to 92%. Second, the structure of exports has changed also, as in 1993 almost 88% of the exports were manufactured goods and in 2004 this number rose up to 96%. The most relevant change however was the shift from medium and low to medium and high technology exports: in 1993, the figures were 40% and 60%, and in 2004 had changed to 60% and 40% respectively. The combination of the changes on imports and exports has a clear origin: the increase in the value of the produced goods by the Czech economy, derived of the changes on its national industry and the relocation of firms. The Czech economy is following an accelerated evolution towards modern production (and transport) structures. This can affect the transport sector increasing the share of road transport and reduction on rail freight;

9) **Hungary**: As in the Czech case, the average aggregated value of the produced goods by the Czech economy has grown, most likely derived of the changes on its national industry and the relocation of firms devoted to manufacture of goods. The trend on imports and exports is to increase the proportion of manufactured goods and to increase the proportion of medium and high technology goods over total manufactures. Again, this can affect the rail share, as it is the mode with a more traditional market in large volume goods and traditionally less flexible than the road;

10) **Poland**: As in the other two NMSs analysed, the evolution of imports and exports in terms of the types of products purchased and produced reveals a pattern of modernisation of the Polish economy. The structure of imports has undertaken a structural change in the period under analysis, increasing the share of manufactured goods and decreasing the shares of mining and agricultural products. For the type of exported manufactures in terms of their technological level, there is observed a significant change: in 1992 31% of the exports were medium and high technology goods, being 44% in 2004. This shift to higher value goods can affect the transport sector increasing the share of road transport and reduction on rail freight;

11) **USA**: The exported goods follow a trend already analysed for several EU Member States: the US economy has increased the technological level (and thus the value per unit) of the produced and exported goods. Between 1990 and 2004, the proportions agricultural product, mining products and manufactured goods over total exports changed from 7.3% to 4.4% (a reduction of 39%), from 1.92% to 1.1% (a reduction of 44%) and from 85.5% to 89.9%, respectively. In terms of the technological level of the exported manufactures, there is an increase in the proportion of medium and high technology manufactures over total exports: in 1990 it was 71.8%, being 75.2% in 2004, an increase of 4.7% during the period.

For Germany a time series of input-output tables comprising 71 sectors exists for the period 1991 until 2000. COMPETE analysed these tables aggregating them to 32 sectors with seperate sectors for road, rail, air, water and auxiliary transport services (including logistics) as well as production of transport equipment to derive the dynamics of the development in particular of and between the transport sectors. The main findings of this analysis were:

- The **transport sectors behave rather cyclical** following closely to the general business cycles of the German economy and to some extent the world economy. This is caused by:

  - The road vehicle sector, which is closely linked to the German economic cycles e.g. demonstrated by the German boom after the reunification (1991-1992) while most of the world was in a recession, and
  - the transport service sectors, which as transport is a derived demand stimulated by other activities including economic activities such that the transport service sectors follow the cycle of the driving economic activities.
  - The export of road vehicles, which is one of the largest export sectors of Germany and which closely follows the trends of world economic development.
- **Intermodality and cooperation between different modes** has significantly increased during that time since the transport service sectors continuously increased the shares of intermediate inputs that they received from other transport service sectors. This was more pronounced for auxiliary services (including logistics), road, air and water transport than for rail transport. For the latter sector some stagnation in terms of intermodality improvements could be observed in the first half of the period, while at the end of the second half of the period it also showed strongly growing involvement in the exchange of intermediate inputs between the transport sectors. This should also be the result of German and European policies promoting intermodality and railway transport.

5.5 Bottlenecks in future logistic systems

Following the structural analysis in the previous sections the main conclusions concerning potential bottlenecks in the European transport system affecting the development of logistics are presented. In general terms, we can separate the national specific effects or local bottlenecks from regional or modal bottlenecks. The first type is out of the scope of the present study, as it requires the analysis of the national and local transport networks in order to identify the “black spots” and circumstances hindering the development of logistics and transport. The second group, regional and modal bottlenecks are presented in the following pages in a synthetic manner, trying to provide a general vision of the most important obstacles for smooth transport and logistics between the countries analysed.

For the presentation of the evaluation of the potential bottlenecks per region, an approach based in three parameters and implemented in two stages was used. The 3 parameters are:

- The evolution of the structure of the transport sectors from the IOT and STAN data, in qualitative terms, taking as base the trends identified in the analysis and the expected evolution in the near future;
- The evolution of the trade flows derived from the analysis undertaken previously;
- The state of the networks in qualitative terms, an issue not analysed in this project and that will be taken as exogenous data.

These three parameters will be combined in an approach with the objective to identify the main regional bottlenecks per transport mode and the main causes underlying them. The two stages of the approach are the following:

1) Clusterisation of the European countries analysed into groups according to criteria concerning their tight commercial relationships, the volume of the trade exchanged, the result from the analysis of the trade flows (see Figure 22 in page 108), their mutual integration of transport networks and the nature of the (potential) common transport problems. The same country can belong to several clusters, as can have with different countries strong commercial links or different "network problems". The clusters selected are: Southwest EU (Spain and France), Central EU (France, Germany and the Netherlands), Eastern EU (Germany, Poland, Hungary and the Czech Republic), Inland Baltic (Finland and the Russian Federation) and Baltic & North Atlantic (all ports in those areas). Afterwards, the description of each cluster is presented, the state of the network and the main expected potential bottlenecks for logistics. Table 43 shows the different clusters for further analysis;

2) Characterisation for the potential for congestion of the national and regional (supranational) networks within each cluster defined previously, attending to two criteria:

   - **Quality of the network** under stake, in terms of overall geographical density, continuity between countries and state of conservation (physical quality). The "quality of the network" will be measured using a 3 degree scale from 1 (high quality) to 3 (low quality), according to the following criteria:

     3 = low quality of the network: some basic connections between major cities, ports or between borders still missing, frequent discontinuity of network in technical terms and frequent conservation problems;

     2 = medium quality: isolated problems concerning missing major connections, continuity, missing links and conservation;

     1 = high quality: uncommon situations regarding missing major connections, continuity and conservation.

   - **Demand for transport services** in the mode under stake, measured with reference to the expected development of the demand in the short term according to the analysis of the national transport sectors evolution. The "demand for transport services" will be measured using a 3 degree scale from 1 (low demand) to 3 (high demand), according to the following criteria:

     1 = low demand: transport mode with no or weak growth expected and/or low modal share;

     2 = medium demand: transport mode with positive growth expected, but its modal share is not amongst the highest;

     3 = high demand: transport mode with a strongly positive growth expected and/or with a high modal share.

The combination of both indicators will produce a third indicator, the **bottleneck potential indicator**, which will be the final synthesis of the expected network congestion and bottleneck problems derived from trade, transport and logistic flows. The indicator will consist as well of a three points scale:

1 = low potential: isolated bottlenecks will occur namely in terms of interoperability problems, some intermodal operations and congestion in high demand links;

2 = medium potential: some bottlenecks in ordinary operations occur in the network;

3 = high potential: frequent bottlenecks in ordinary operations occur in the network, jeopardising the normal flows or goods and passengers in a systematic manner.

The indicator is derived from the results of the "quality of network" and "demand for transport services" indicators. The result is derived calculating the mean of both results. For instance, values 1 and 3 would result in a 2 for the "bottleneck potential indicator". In case the average value has a decimal case (for instance, values 2 and 3 result in a 2.5) the number would be rounded to the upper case (in the example, 3).

The assessment of the situation of the networks in the clusters selected is done through the observation of the situation of the Trans-European Networks in the first place and through expert opinion. The TEN-T were selected as a proxy for the quality of the networks because a high density of TEN-T in a country implies an overall good quality of the transport network and the existence of major links to the most important cities, ports and other connection points. We include the maps of the TEN-T in Table 43,

Table 44 and Figure 23.

Table 43 presents the resume of the values of the "bottleneck potential indicator" for the five clusters considered.

Table 43: Resume of potential bottlenecks per European regional cluster

CLUSTER: Southwest EU		
Network	**Description**	**Bottleneck potential**
Roads	1) Quality of road network (density, continuity, conservation): **1** 2 3 **Observations:** ▪ Will continue to increase length and extension in the short/ medium term, mainly highways in Spain (TENs category); ▪ The conservation state is good (important highway network already in place); ▪ Good international highway links. 2) Demand for road transport services: 1 2 **3** **Observations:** demand will continue to increase (short term) due to: ▪ Overall growth which has characterized this sector in Spain (first transport mode in output value) and France (second transport mode in output value); ▪ Low quality and severe interoperability problems concerning international links.	Potential 1 **2** 3
Railways	1) Quality of rail network (density; continuity; conservation): 1 2 **3**	Potential 1 **2** 3

	Observations: ▪ Low quality of the Spanish network with real improvements concerning freight operations only in the medium term (due to large investments planned); ▪ International interoperability very difficult, with gauge, signaling and power problems. 2) Demand for rail transport services: [✓ 1] 2 3 **Observations:** ▪ Reduced interest of international operators due to network quality and interoperability problems yet to be solved; ▪ Potential rise of demand only in the medium term after significant improvement of the overall quality of the network and respective services.	
Ports	1) Quality of maritime infra-structures (capacity; accessibility and services): 1 [✓ 2] 3 **Observations:** ▪ Some accessibility problems persist in some ports concerning the links to land transport networks; ▪ In general, the operational capacity is good and has grown in the last decade, specially in Spain, with large investments underway concerning handling capacity (quays, warehousing facilities, etc). 2) Demand for maritime transport services: 1 [✓ 2] 3 **Observations:** ▪ Mode highly devoted to international trade and long intra-EU connections, being the first mode for external trade of both Spain and France; ▪ With a potential to grow, due to the environmental issues and transport policy agenda of the EC; ▪ Still, maritime not amongst the main transport modes in terms of tones transported and output value.	Potential 1 [✓ 2] 3
	CLUSTER: Central EU	
Network	**Description**	**Bottleneck potential**
Roads	1) Quality of road network (density, continuity, conservation): [✓ 1] 2 3 **Observations:** ▪ Very good quality and continuity of the network, with no missing links and with high density in geographical terms. 2) Demand for road transport services: 1 2 [✓ 3] **Observations:** ▪ Will continue to grow in the short term taking into account the overall growth of the sector in the countries of the area; ▪ Important international transport activities mostly carried out by road; ▪ Intermodal transport highly developed (high output value figure in all countries) with intensive use of road legs.	Potential 1 [✓ 2] 3
Railways	1) Quality of rail network (density; continuity; conservation): [✓ 1] 2 3 **Observations:** ▪ The quality of the network is good in terms of density, continuity and conservation; ▪ Some interoperability problems persist, especially for long course transnational trains (power, signaling, etc). 2) Demand for rail transport services: 1 2 [✓ 3] **Observations:** ▪ High demand both for passenger and freight services, with special demand on the latter; ▪ Countries with well developed logistic sectors and intermodal specialized operators integrating rail legs in their operations; ▪ Demand expected to grow due to increasing use of rail freight.	Potential 1 [✓ 2] 3

CLUSTER: Eastern EU		
Network	**Description**	**Bottleneck potential**
Roads	1) Quality of road network (density, continuity, conservation): 1 [✓ 2] 3 **Observations:** ▪ Quality of network quite variable, with some links still missing in the NMSs and a low density network, compared to the EU15; ▪ Some local bottlenecks exist. 2) Demand for road transport services: 1 2 [✓ 3] **Observations:** demand will continue to grow due to: ▪ Overall growth of the sector in the NMSs; ▪ Increasing commercial flows between the countries of the cluster.	Potential 1 2 [✓ 3]
Railways	1) Quality of rail network (density; continuity; conservation): 1 [✓ 2] 3 **Observations:** ▪ Good quality network in Germany but rather variable in the NMSs; ▪ Interoperability can be difficult but it is expected an improvement in the short term due to investments underway. 2) Demand for rail transport services: 1 [✓ 2] 3 **Observations:** ▪ Overall demand is growing in the NMSs due to the increasing trade flows between the countries forming the cluster; ▪ Increasing involvement of private multimodal and logistics operators; ▪ Traditional high use of rail transport with high shares in some countries of the cluster, although decreasing in some cases;	Potential 1 [✓ 2] 3

CLUSTER: Inland Baltic		
Network	**Description**	**Bottleneck potential**
Roads	1) Quality of road network (density, continuity, conservation): 1 [✓ 2] 3 **Observations:** ▪ Quality of the network is variable as well as the network density; ▪ Continuity of networks is high but local bottlenecks exist; ▪ Winter condition have strong negative influence. 2) Demand for road transport services: [✓ 1] 2 3 **Observations:** ▪ Growing international trade in the area (especially Finland-Russia) but flows still not too high.	Potential 1 [✓ 2] 3
Railways	1) Quality of rail network (density; continuity; conservation): 1 2 [✓ 3] **Observations:** ▪ Low quality of the network is in some areas; ▪ Expected increase of quality and interoperability in the medium term due to large EU investments (including EC's Priority Projects). 2) Demand for rail transport services: [✓ 1] 2 3 **Observations:** ▪ Growing international trade in the area (especially Finland-Russia) but flows still not too high.	Potential 1 [✓ 2] 3

CLUSTER: Baltic & North Atlantic		
Network	**Description**	**Bottleneck potential**
Ports	1) Quality of maritime infra-structures (capacity; accessibility and services): [✓ 1] 2 3 **Observations:** ▪ Good capacity of ports with on-going investments in some to improve handling and storage capacity (keeping up with demand	Potential 1 [✓ 2] 3

	growth); ▪ In general, well developed links to road and rail networks with only specific or local bottlenecks. 2) Demand for maritime transport services: 1 2 [✓ 3] **Observations:** ▪ Mode highly devoted to international trade and intra-EU connections, traditionally strong in the area in all countries of the cluster; ▪ Some ports are real gateways for Europeans trade flows and entry door for imports, concentrating large amounts of cargo; ▪ Increases in extra-EU trade (both imports and exports) will provoke immediate increases of the demand.	

Source: COMPETE

Table 44: Resume of potential bottlenecks per US regional cluster

USA		
Network	**Description**	**Bottleneck potential**
Roads	1) Quality of road network (density, continuity, conservation): [✓ 1] 2 3 **Observations:** ▪ Road network completed, punctual capacity improvements and maintenance works; 2) Demand for road transport services: 1 2 [✓ 3] **Observations:** demand will continue to increase; capacity improvement constrained by environmental concerns;	Potential 1 [✓ 2] 3
Railways	1) Quality of rail network (density; continuity; conservation): 1 [✓ 2] 3 **Observations:** ▪ Bottlenecks in the form of overpasses and bridges with single tracks, sidings too short to accommodate 7000 foot trains and at-grade road crossing without proper warning devices 2) Demand for rail transport services: 1 [✓ 2] 3 **Observations:** ▪ On some major routea trunk line capacity is a problem because some parts of the major routes are single track; ▪ Road acess congestion remains a significant problem whenerver trucks need to access truck/rail interchange facilities; ▪ Acessibility improvements are a key component of many state transportation programmes;	Potential 1 [✓ 2] 3
Ports	1) Quality of maritime infra-structures (capacity; accessibility and services): 1 [✓ 2] 3 **Observations:** ▪ At present, there are proposals to build major new ports in British Columbia and Baja California and additional terminal space in other main ports; ▪ If trans-pacific container flow even remotely approach the levels projected for them in 2020, the main ports of Los Angeles, Oakland and Seattle will require major operational improvements; 2) Demand for maritime transport services: 1 [✓ 2] 3 **Observations:** ▪ Congestion at and around the nations's seaports is a problem primarily because of the concentration of maritime traffic at a small number of locations; ▪ At the ports of Gulf of mexico and the Atlantic Ocean, congestion is somewhat less problemeatic than on the Pacific; ▪ The huge volumes of vehicle traffic make land accessibility a serious problem on greater New York and other major urban areas;	Potential 1 [✓ 2] 3

Source: COMPETE

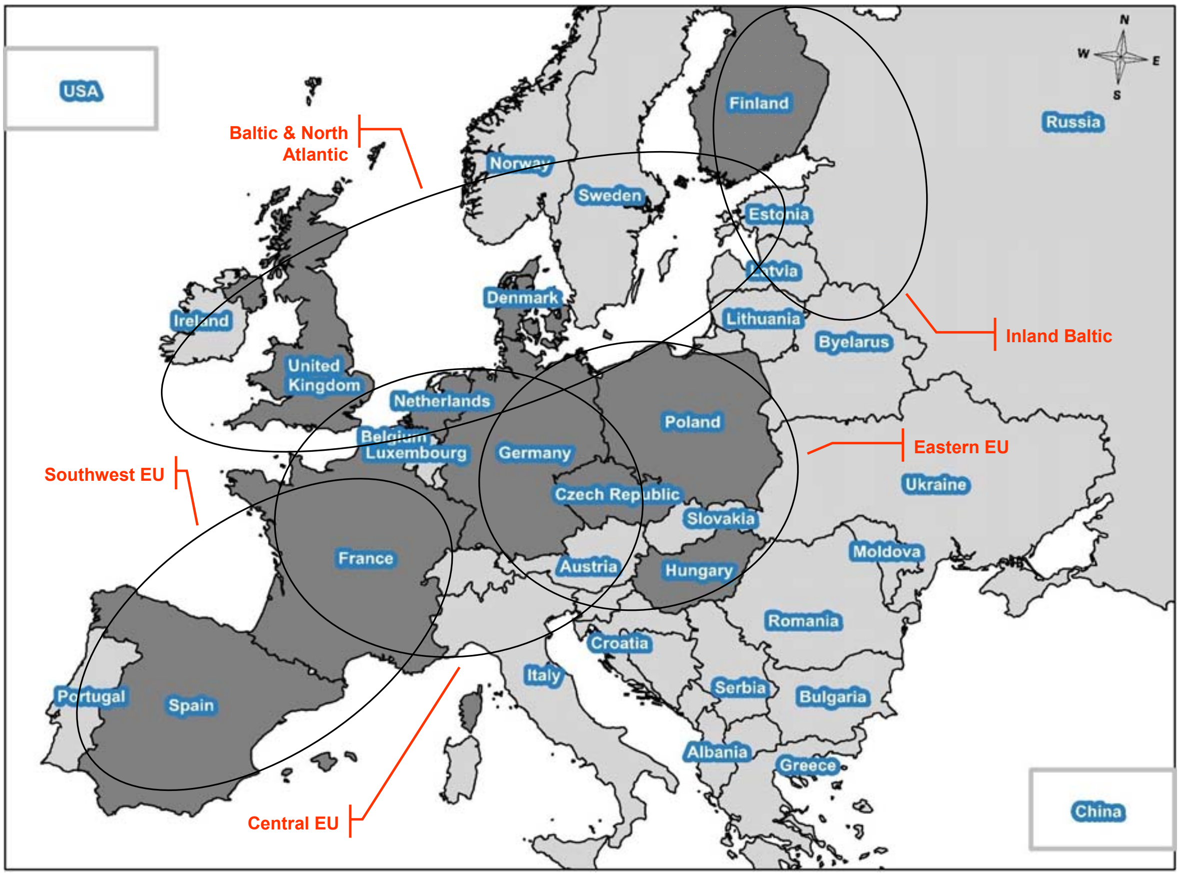


Figure 23: Clusters of regions for analysis of potential congestion and bottleneck in transport and logistics

Source: COMPETE

6 Impact of transport infrastructure on economic growth

6.1 Background of the economic analysis

The theoretical literature on growth models exhibits a broad consensus on the mechanisms through which, at the microeconomic level, transport infrastructure might affect economic and productivity growth: transport infrastructure might reduce transportation costs, which allows a reduction in private sector costs and an increase in specialisation and the degree of division of labour. In addition, transport infrastructure may bring about changes in factor markets and firm location decisions that allow the development of spatial clusters of economic sectors, which in turn affects innovation and allows further reduction in costs.

The literature also implies that non-linearities in the effects of transport infrastructure on economic growth may be important: for instance, additions to an under - developed transport network, or new investments in low - quality stock, or investments aimed to alleviate congestion problems eliminating bottlenecks would all be likely to generate relatively larger benefits, ceteris paribus, than if these were a developed high quality transport network or a network with no congestion problems. However, the literature is as yet not able to offer a robust explanation of the links between transport investment, the network dimension of transport infrastructure and economic growth.

The empirical literature developed fairly independently of the theoretical work. While the theoretical literature has sought to apply microeconomic considerations to model the transport infrastructure-economic growth relation, empirical studies –especially the studies which adopted the production function approach- have mainly followed a "macroeconomic black box" approach which does not spell out in detail the mechanisms that drive the effects of transport infrastructure on productivity growth. This is rather unfortunate, as, often, the aggregate impact of public infrastructure might be a poor proxy for the impact that specific transport projects might have on aggregate growth.

Having said that, the empirical evidence surveyed for this report (see COMPETE Annex 6 for the complete literature review) seems to suggest that public capital in general might have a positive effect on the level of economic activity, though perhaps not as large as suggested by some of early production functions based studies.

For both the US and the EU, production function studies have tended to identify quite large returns for public capital and for transportation infrastructure in particular.

For the US, most of the recent empirical evidence based on production function studies has, in general, identified positive elasticities of output with respect to public capital: for instance, Boarnet et al (1996) found elasticities in the 0.16-0.22[16] range, Duggal (1999) found an elasticity of about 0.27 and Shioji (2001) reports an elasticity of about 0.27.

The average magnitude of the elasticities identified in the most recent studies contrasts with both the seminal contribution of Aschauer (1989) – who identified an elasticity of output

---

[16] In other words, a one percent increase in public capital stock would lead to about 0.16-0.22 percent increase in output.

with respect to public capital of about 0.35- and with most of the papers that immediately followed the Aschauer's study and that in general found very small elasticities or even no impact of public infrastructure on output (see, for instance, Tatom (1991), Holtz-Eakin (1994) and Kelejian and Robinson (1997)).

The evidence for the EU seems to provide a similar picture to that we have just briefly sketched for the US: most studies estimating production functions (or employing the related total factor productivity regression approach) in fact identify a positive effect of public infrastructure on output and productivity.

With some notable exceptions (for instance, Sturm and de Haan (1995) and Stephan (2003) who find elasticities in the range of 0.6-0.8 and 0.38-0.65[17], respectively and Delgado and Alvarez (2000), Evans and Carras (1994) and a few others studies which reported insignificant elasticities) the elasticities of output with respect to the stock of public capital tend to range between 0.10 and 0.20, a far smaller value than the 0.35 originally identified by Aschauer (1989) and more in line with the findings of Munnell (1990) who found an elasticity of about 0.15.

For example, Bajo Rubio and Sosvilla-Rivero (1993) estimated a production function using time series data for the Spanish economy using the Phillips and Hansen procedure and found an elasticity of output with respect to public capital of about 0.2, depending on the exact specification of the production function.[18]

Kamps (2005) followed Aschauer (2000)[19] and estimated an endogenous growth model which allows exploring the non linear link that might exist between economic growth and infrastructure capital (the non linearity arising from the government financing public capital through a tax levied on the private sector) and deriving the growth maximising public capital stock: he found that, for a panel made up of the EU15, the elasticity of output with respect to public capital was about 0.20, a very similar result from Kamps (2004) who reported an elasticity of about 0.22 from a production function for a panel of OECD countries.

Picci (1999) estimated a production function for the Italian regions and found, after first differencing the variables to take into account possible non stationarity, an elasticity of about 0.18.[20]

Stephan (2001) estimated a production function for a panel of German and French regions and found a positive elasticity of about 0.08-0.11.

Similar results have also been identified by Kemmerling and Stephan (2002) who built a political economy model in which a production function with public capital was estimated together with two equations explaining the investment decisions by German local authorities and the allocation of funds from higher tier governments in Germany. Estimating the model

---

[17] This would correspond, in his sample, to a rate of return of about 43-73 per cent and 26-45 per cent, depending on the output to public capital ratio.

[18] They also found that the marginal productivity of public capital was slightly higher than that of private capital (0.61 versus 0.36, respectively), which they interpreted as a suggestion that even in the presence of a complete crowding out of private capital, private output would still be increased by increasing public capital.

[19] Who built on Barro (1990).

[20] It is interesting to note that the regressions in levels yield a much higher value (about 0.5).

using appropriate econometric techniques, they found that the elasticity of output with respect to public capital was positive and significant.

A similar approach was followed by Cadot et al (1999 and 2004) for a panel of French regions: they in fact estimated a production function together with an equation to explain the infrastructure investment decisions and found positive and significant elasticities, in the order of about 0.08 and 0.10.

It is difficult to comment on the overall reliability and "quality" of the results. However, in general, we might observe that the largest results for the elasticity of output with respect to private capital could cast some doubts on the overall reliability of the econometric exercise that produced them. For instance, Sturm and de Haan (1995) observed that their "large" elasticity of public capital is associated to a really low or even negative elasticity of output with respect to private capital, a result which is difficult to reconcile with standard economic theory. In fact, if we make the standard assumptions that private firms combine capital and labour to maximize profits, we expect, as formally shown, for instance, in standard economic growth models a la Ramsey that the marginal product of capital will be equal to the real interest rate, which depends, among the other things, on the rate of time preference and the risk-profile of the investment. A negative of nearly zero elasticity of output with respect to private capital would therefore be difficult to reconcile with standard economic theory.

In Table 45 we have reported the elasticities of output with respect to private capital, labour and public capital for some of the studies we have discussed above. It is difficult to identify a clear pattern between private and public capital elasticities from the results shown in Table 45.

However, the two studies with the highest public capital elasticities tend to find private capital elasticities which are either negative (Sturm and de Haan, 1995) or substantially lower than public capital elasticities, while those studies which report the lowest public capital elasticity also find, in general, much higher private capital elasticities[21]

We noted above that the finding of a negative or nearly zero elasticity of private capital is not easy to reconcile with neoclassical economic theory. In general, a natural expectation might be that private capital should command a higher return than public capital, unless there are serious shortages of public infrastructure in the economy, because it would seem reasonable to assume that the risk profile of private investments is generally higher than that of public investment. However, in financial economics it is not risk per se, but systematic risk (i.e. non-diversifiable risks, arising, for example, because of a correlation between the risks and the general economic cycle) that is the driver of returns. Following this insight, it might be expected that, in fact, public infrastructure expenditure returns should be greater than those from private capital — for example if transport infrastructure using sectors such as freight tended to produce high returns when the economy in general is doing well but low returns in recessions, which usually is the case.

---

[21] An exception is Cadot et al (2004) who find a private capital elasticity which is higher than that of public capital but who also find a perhaps unrealistic elasticity of labour which, according to standard marginal productivity theory, it should reflect the share of labour in total income.

Table 45: Elasticities of Output with respect to Public and Private Capital and Labour

	Public capital	**Private capital**	**Labour**
Bajo-Rubio and Sosvilla-Rivero (1993)	**0.18**	**0.43**	**0.39**
Sturm and de Haan (1995)	**0.63 to 0.80**	**-0.61to 0.82**	**0.93 to**
Picci (1999)	**0.18 to 0.36**	**0.07 to .17**	**0.46 to .83**
Stephan (20003)	**0.38 to 0.65**	**0.10 to .30**	**0.26 to .50**
Cadot et al (2004)	**0.08**	**0.18**	**0.77**
Kemmerling and Stephen (2002)	**0.17**	**0.57**	**0.32**
Percoco (2004)	**0.14 to 0.18**	**0.16 to 0.28**	**0.62 to 0.72**
Delgado and Alvarez (1999)	**-0.03**	**0.63**	**0.25**

A careful analysis of both the theoretical and empirical literature seems to suggest that the relationship between public capital and production might be too complex to be tackled from the oversimplified perspective of the production function approach.

The cost function approach –based on a behavioural model of production which permits the identification of the direct and indirect effects that public infrastructure might have on the cost structure and productivity growth of the private sector- as well as studies that adopt a more "structural" approach (whereby infrastructure effects are incorporated into more general models of the economy) seem to back the theoretical insights that public capital and transport infrastructure might have a beneficial effect in fostering economic growth and the level of output.

However, they also seem to suggest that the returns of public infrastructure are positive, but somewhat lower than those identified by production function studies.

For instance, the US evidence (see e.g. Morrison et al (1996), Nadiri et al (1998), Cohen et al. (2003a and 2003b)) seems to suggest that public infrastructure tends to reduce private sector production costs and that the returns to public infrastructure are in general positive.

The empirical studies based on EU samples which adopted the cost function approach display some variability, with some which find elasticities very close to zero (see, for instance, Moreno et al. (2003) and Bosca et al. (2002) and La Ferrara and Marcellino (2000)), with other studies finding elasticities in the order of about -0.05/-0.1 (which means that an increase of 1 per cent in the capital stock would lead, on average, to a reduction of private costs in the order of 0.05-0.1 per cent), such as Zugasti et al. (2003) or Canaleta et al. (1998) and Rovolis and Spence (2002) and, finally, a minority finding cost elasticities of about 0.20, such as Seitz and Licht (1995).

Even if it is difficult to find a consistent pattern across studies, it seems fair to conclude that, with some notable exceptions, there is evidence that, for the EU, cost function based studies seem to identify quite small elasticities of cost with respect to public capital. Although the elasticities as well as the returns identified in cost function studies are not directly comparable to these derived using a production function approach there seems to be some evidence that the former tend to be fairly smaller than the latter.

Furthermore, cost function studies show that aggregate results often exhibit considerable variability across regions and across sectors, although a consistent pattern does not seem to have emerged yet: for instance, it is not clear whether more developed regions are more likely, on average, to gain from public capital or whether a particular sector is likely to benefit more from public infrastructure than others. A robust answer to this issue would require perhaps better information on the stock of public infrastructure than is provided by the use of monetary values: for instance, virtually all the studies are silent on very relevant issues such as the quality of the infrastructure stock, or the levels of congestion.

The other main approach that we have identified in the literature review, namely the Vector Auto Regression (VAR) models, tends to provide a broadly similar picture for both the US and the EU, with public capital displaying small albeit positive effects on output.

The literature review reported in COMPETE Annex 6 and that we have briefly summarised here seems to suggest that public infrastructure capital tends to display positive effects on private output and production costs.

However, in our view, a precise quantification of the effects of public infrastructure on output and economic and productivity growth is difficult to make, for a series of reasons.

First of all, some studies (see, for instance, Canaleta et al. (1998), Pereira and Roca (1999) and Zugasti et al. (2001) in the case of Spain or Mamatzakis (1999) in the case of Greece) have suggested that there is significant variability of infrastructure returns and elasticities across regions and sectors and that it is extremely difficult to rationalise this variability: in other words, there is not consistent evidence suggesting that some sectors or regions are more likely to gain (or to loose) more than others.

Second, there is fairly robust empirical evidence that seems to support the insights offered by the theoretical literature that public infrastructure might have non-linear effects on the level of economic activity and growth: this is often picked up in cost and production function studies by positive -but declining over time- returns to public capital and transportation infrastructure.

Furthermore, the role that quality and network aspects of transport infrastructure (as well as congestion effects) might play in “driving” the overall effect of public infrastructure on output, even if quite clear from a theoretical perspective, have not yet been investigated in much depth in the empirical literature.

Having said that, our conclusion is that the evidence of small albeit positive benefits -in terms of higher output and economic growth stemming from public capital and, especially, from transport infrastructure - seems to find a broad support in the empirical literature. (Note that this differs from the conclusions of the earlier literature, e.g. Gramlich (1994) or Sturm and de Haan (1998))

There are some further qualifications.

The first is that there is some evidence suggesting that empirical studies that have used samples at regional level have identified lower impacts of public and transport infrastructure on economic growth than studies based on aggregate national data, the reason being that the former neglect the spill over effects of public infrastructure across regions.

This could be one of the possible explanations for the lower estimates that are generally found in the cost function approach, which relied almost exclusively on regional level data, with respect to the time series studies which adopted a production function approach. Some studies (e.g. Cohen et al, 2003a, 2003b) have indeed identified the existence of spill over effects of transport infrastructure and have concluded that neglecting them would lead to underestimating the overall impact of transport infrastructure on private sector costs and productivity.

In second place, while many studies have reported rates of returns from public infrastructure investment, very few have actually compared them with the costs incurred by the governments (one notable exception being Morrison et al. (1996)). In other words, it should be remarked that even if a positive rate of return is a necessary condition for public infrastructure investment to be "productive", it is not a sufficient condition for it to be also worthwhile.

In fact, it would first be necessary to compute a user cost of public funds which should consider depreciation, the opportunity costs and the marginal cost of public funds: if the user cost were higher than the rate of return, then public infrastructure investment would be consuming more resources than it would be generating. [22]

Finally, it should be observed that, even if the return of transport infrastructure were higher than its user cost, it would not necessarily follow that the government should invest in transport infrastructure. Given limited resources, the government might well decide to invest in other kinds of public investments. Put it simply, the gross rate of return of transport infrastructure should be compared to that of other types of public investment expenditures.

Unfortunately, the empirical literature that we have reviewed is not very helpful on this. There is some evidence that core infrastructure (which is closely related to the concept of transport infrastructure) seems to generate higher returns than other forms of public infrastructure, such as offices and buildings. However, there does not seem to be, to the best of our knowledge, any robust theoretical and empirical attempt to compare returns to transport infrastructure to these of other non infrastructure public investments, such as public expenditure in education, R&D or health care.

6.2 The impact of infrastructure policy in the EU and the US

6.2.1 Introduction

Developing on the foundation given by the theoretical models presented in the literature review and in order to analyse the impact of transport infrastructure on growth in the EU and

---

[22] We can note that the few studies that have compared the return of public infrastructure with its cost have generally found that the rates of return were actually higher than the user cost, even if the difference was falling over time.

US economies, we present here the results of simulations of two growth models dealing with transport infrastructure. Two different approaches to modelling the effect of transport infrastructure on growth will be used.

The first approach assumes that transport infrastructure has two purposes: a) improving the productivity of labour and therefore making the economy more productive and; b) making it easier for people to spend time in leisure activities by reducing the travel time from individuals' residences to leisure locations. The second approach has been derived by the analysis of Barro and Sala i Martin (1992 and 2004) that take into account the fact that transport infrastructure (as many other publicly-provided services) is subject to congestion, i.e. for a given quantity of infrastructure the quantity available to a single individual declines as other individuals use the facility.

The two approaches attempt to analyse two different aspects of the effects of transport infrastructure on economic growth: the first focuses on the effects of infrastructure on labour supply (via its influence on leisure) and given the particular form of the production function will not be capable of generating positive growth rates in the long run. It will therefore be used mainly to analyse what the transitional dynamics towards the balanced growth path look like according to different values of the parameters. The second will be capable of generating positive growth rates even in the long run. Although the model will not be capable of giving a deep understanding of the effects of congestion on productivity, given its level of aggregation, it will be useful to understand some of the perverse effects that congestion can have on the production process. For brevity we label the two different approaches as *leisure* and *BSIM* respectively.

As in all models the results would depend on the approach chosen, on the particular form of the functions used as well as on the assumption on the magnitude of the parameters. Therefore it is difficult to draw general conclusions based only on a few models. However we believe that they do provide interesting insights on the likely effects of transport infrastructure on economic growth.

6.2.2 The results of the simulated models

6.2.2.1 Main features and parameters of the two models

In this section of the report we will present the main results of the simulations of the two modelling approaches that we described above. Table 46 presents the basic equations for the two models. The analytical results of the model along with a more detailed description of how the models are developed can be found in the COMPETE Annex 6. The production function describes how output (Y) is produced using the available capital stock (K), the amount of time spent in labour (L), the number of workers (N)[23], the stock of transport infrastructure (TI), the amount of transport costs (T) and a technological parameter (A). In the first model the amount of transport infrastructure influences total output reducing transport costs, as described by the last set of equations.

---

[23] We will assume that total number of workers is normalized to unity so that all variables can be thought as per-capita values.

The utility function describes how economic agents derive their utility from consumption (*C*) and leisure (*1-L*) i.e. the share of time spent in non-working activities. In the BSIM model agents only derive utility from consumption so there is no possibility of choosing between work and leisure. The capital and infrastructure accumulation functions state that the variation in capital and infrastructure from one period to another (indicated by a dot over the variables) is given by the amount of investment (*I* and *IT* respectively) minus the share of the stock that depreciates over time (δ_1 and δ_2). Finally, the allocation function states that output can be consumed, invested in capital or invested in transport infrastructure.

Given the level of aggregation of the model and our interest in the effects of transport infrastructure our definition of the initial value of the variables is slightly different from the standard of economics textbooks. Capital is defined as the sum of private and public capital minus transport infrastructure capital. Therefore it includes public infrastructures that are not related to transport (e.g. hospitals) as well as private capital. The detailed procedure to calculate the initial value of transport infrastructure is described in COMPETE Annex 6

Consumption is the sum of private and public consumption and transport infrastructure is the value of infrastructure capital.

Table 46: Basic equations for the model with leisure (leisure) and the model of Barro and Sala I Martin (BSIM)

	Leisure	BSIM
Production function	$Y = AK^b\left[(1-T)LN\right]^{1-b}$	$Y = AK\left(\frac{TI}{Y}\right)^{\alpha}$
Utility function	$u\left(C,(1-L)\right)=\ln(C)+\vartheta\frac{[(1-\tau)(1-L)]^{1-\gamma}}{1-\gamma}$	$u(C)=\frac{C^{1-\eta}-1}{1-\eta}$
Capital accumulation	$\dot{K} = I - \delta_1 K$	$\dot{K} = I - \delta_1 K$
Infrastructure accumulation	$\dot{TI} = IT - \delta_2 TI$	$\dot{TI} = IT - \delta_2 TI$
Allocation function	$Y = C + I + IT$	$Y = C + I + IT$
Effects of infrastructure	$T = TI^{-\phi}$; $\tau = TI^{-\psi}$	-

Table 47 reports the values of some of the most important parameters and initial values for both the EU15 and the US economies. COMPETE Annex 6 describes in detail under what assumption and how these values can be obtained. Per capita transport infrastructure is higher in the US than in the EU15, since we do not have separate data on the time wasted due to the presence of transport costs this automatically implies that the elasticity of transport costs with respect to the level of transport infrastructure in the US will be lower than in the EU15.

While the procedure used for the calibration of all the parameters and the initial values will be discussed in the Annex 6 we shall mention here how we have calibrated the novel parameters in the two models, i.e. *Φ*, *Ψ* and *α*, and under what assumptions. The first two represent the elasticity of transport costs (respectively in the production and utility function) with respect to transport infrastructure. The last (which is assumed to be smaller than unity) measures the relative weight of the effect of transport infrastructure per unit of output on total output relative to the effect of the capital stock. Given that in the production function *L* represents the share of time that individuals spend working and in the utility function (*1-L*) the share of time spent in leisure activities[24] it is possible to interpret *T* and *τ* as the amount of time that is lost due to the presence of transport costs[25].

Table 47: Transport-related parameters and initial values. EU15 and USA

	TI	*IT*	δ_2	*Φ*	*ψ*	*α*
EU15	7.72	0.73	0.05	0.93	0.93	0.1
USA	11.03	1.04	0.05	0.79	0.79	0.1

The effects of transport costs on leisure *τ* are analogous, but not exactly equal, to those on labour productivity in the production function. We believe that it is useful to think of transport costs as a factor that reduces the time available to be spent in leisure activities. We could think of many examples of transport costs influencing leisure activities: an inefficient airport that retards the departure for a week-end, the absence of motorways to reach a village in the countryside, the lack of train connections that makes it difficult to reach a ski resort and so on. We can use the equations in the two models to describe the procedure to derive the values of the parameters *Φ*, *Ψ* and *α*. Starting from the production function of the leisure model it is possible to calculate the elasticity of output with respect to transport infrastructure as:

$$\frac{\frac{dY}{Y}}{\frac{dTI}{TI}} = (1-b)\phi TI^{-\phi}(1-TI^{-\phi})^{-1}$$

We know the initial value of the transport infrastructure from previous calibration. Thus two unknowns remain in the equation: the first is *Φ* and the second is the value of the elasticity itself. We now have two alternative ways to estimate the value of *Φ*. The first possibility is to plug a value of the elasticity into the equation and solve the equation numerically for *Φ*. In COMPETE Annex 6 we show that econometric estimates of $\frac{dy/Y}{dTI/TI}$ are around the value of 0.1 so that such a calculation is feasible. The second possibility stems from the interpretation that

---

[24] We are assuming that the total amount of time that an individual can use is normalised to unity.

[25] For practical purposes we can think of *T* as a combination of two different parts i.e. the share of the workforce employed in the transport sector that could be employed in other activities and the share of commuting time that is necessary to go to and come back from the workplace. The former component recognizes that the workers employed in the transport sector could be working in different sectors and therefore producing more consumption goods while the latter component simply states that the time spent commuting between the workplace and people's residences could be used in productive activities so that the overall productivity of the economy is reduced.

we suggested for transport costs as time subtracted from other productive activities. Once we have an estimate of this value we can simplify the equation and calculate *Φ*. We decided to exploit both these possibilities and used a two step iterative procedure to get a value for *Φ*. The first step estimates *Φ* using a value of the elasticity as close as possible to 0.1. We then use this estimate coupled with an estimate for the amount of time lost due to transport (that can be calculated via the formula $TI^{-\phi}$) and calculate the implied value *Φ* from the second possibility. We iterate this process modifying the elasticity so that the two estimates of *Φ* converge[26],[27]. The assumption that all time spent commuting could be used for productive activity may be criticized as it contradicts the evidence that in general it is taken from leisure, increasing the disutility of working and taking people out from the workforce. However transport infrastructure also affects leisure through the parameter *Ψ. W*e believe that a large commuting time makes an economy less productive and therefore has effect on production. It would be wrong to assume that an improvement in the transport infrastructure of an economy would only increase the share of time spent in non-working activities. It will affect both production and leisure activities.

Using the production function of the BSIM model it is possible to get an estimate of the value of α in a way that is analogous to the procedure we used to calculate *Φ.* To do this we calculate the elasticity of output with respect to transport infrastructure as:

$$\frac{\frac{dY}{Y}}{\frac{dTI}{TI}} = \frac{\alpha}{1+\alpha}\left(\frac{TI}{Y}\right)^{-1}\frac{TI}{Y} = \frac{\alpha}{1+\alpha}$$

We can therefore calculate *α* and get the calibrated parameter as 0.1. *Φ*, *Ψ* and *α* are the most important parameters since they determine the effect of transport infrastructure on output and utility in the different models.

6.2.2.2 The leisure model

In this section we report the main results of the simulations of the leisure model for both the EU15 and the US economy. Before we turn to discussing the results it is worth spending a few words on a simple use of the leisure model using the elasticity equation of the previous paragraph. The equation that we used to get an estimate of *Φ* can also be used to get an estimate of the elasticity of output with respect of transport infrastructure. While in the previous paragraph we assumed to know the value of the elasticity (from econometric estimates) and the value of *TI* to get an estimate of *Φ* we can assume to have an estimate of the time wasted due to the presence of transport costs and get a value for the elasticity. We can write the simple equation: $\frac{\frac{dY}{Y}}{\frac{dTI}{TI}} = (1-b)\phi T(1-T)$ and use the calibrated values of the parameters to get an estimate of the elasticity. This procedure seems to support estimates towards (or

---

[26] See the appendix for the other assumptions that need to be made for this process to be feasible.

[27] From a purely theoretical point of view this procedure could be replicated to get an estimate of ψ using the elasticity of utility with respect to transport. Unfortunately there is no easy way to get an econometric estimate of the utility since it is not directly measurable. We are therefore forced to assume that the value of the two parameters is the same. This is equivalent to assuming that, for a given level of transport infrastructure, the same percentage of leisure as work is lost. In the simulations however we analyze the effects of changes in ψ on growth.

even below) the lower end of the econometric estimates of this variable — around 0.1. Our result is derived using an estimate of about 13% for the amount of total labour time in the economy used in transport costs[28].

From a comparison of the results for the US and the EU, it is clear that the model predicts (unsurprisingly) very similar patterns for the US and the EU15.[29] However, the differences in the level of the variables that are present at the initial point grow at the end of the simulation. The US has a higher level of output, consumption, capital stock and transport infrastructure. The result that there is no catching-up is a positive feature of the model: even now growth seems more robust in the US and it is unlikely that this trend will be reversed soon for the EU15. The difference in levels of consumption, capital, infrastructure and output are persistent, however their magnitude seem too high given that in forty years the US economy should be twice the size (in per capita terms) the EU15 economy. Another interesting characteristic of the model is that it predicts a constantly decreasing labour effort apart from the very first periods. A reduction of the time dedicated to work activities is a well known empirical regularity. The initial increase in labour effort might be due to a wrong estimation of the weight that agents give to leisure or to a wrong calibration of the initial value of this variable. It is also positive, since it is a well known empirical regularity that labour effort in the EU15 is constantly below the US level.

An interesting point to be analyzed is the composition of the economies simulated by the model. The initial values that we calibrated are roughly 82% for consumption, 17% for investments and 1% for investment in transport infrastructure for both the US and the EU15 economies. The values of these variables in the quasi-equilibrium of the last periods are again very similar for both economies but significantly different from the initial values. Consumption represents roughly 68% of total product while the two kinds of investment are respectively 29% and 3%. The highest increase in both cases is therefore represented by the amount invested in transport infrastructure that triples its share.

Given the focus of this study we are interested in the effects of the modifications of the parameters related to transport infrastructure. There are two parameters that are related to transport infrastructure that we modified: the first one is its depreciation rate (that we assumed equal to the depreciation rate of capital) and the second the elasticity of transport costs in the utility function that we assumed equal to the elasticity in the production function. With regards to the depreciation rate we ran a simulation where δ_2 equals 0.021 (so that after thirty years the value of transport infrastructure would be 1/1000 of the initial value) while all other parameters are unchanged. Both in the EU and the US the effects on the performance of the system are minimal: only minor changes to output and consumption growth take place. However, effects on consumption are positive while on output negative. Gross investment in transport infrastructure declines since the share of infrastructure that needs to be replaced due to depreciation is lower; however there are no particular differences in net investments. Therefore the share of output allocated to investment in transport declines while both consumption and investment in capital rise.

---

[28] Backed by the data presented in the COMPETE Annex 6.

[29] Refer to COMPETE Annex 6 for graphs that compare the results.

While we have empirical reasons to believe that the rate of depreciation δ_2 is roughly equal to 0.021 we cannot rely on estimates to have alternative values of Ψ. We have therefore been forced to carry out a purely speculative analysis. We ran two simulations: the first with a value of Ψ which is twice as much as the value of Φ; the second with Ψ half the value of Φ. In the first scenario then a 1% increase in the transport infrastructure would reduce the time wasted due to the presence of transport costs in leisure activities by a double amount with respect to the reduction that it would have in production activity. In the second scenario the effectiveness of transport infrastructure in the reduction of costs would be double in the production activities. In the first scenario output and consumption growth would decline. What drives the result is the fact that leisure activities become much less costly in terms of time wasted and therefore economic agents substitute consumption for leisure given that transport infrastructure is growing. Furthermore, given the specific form of the production function the gap in the effects on transport costs is increasing in the value of transport infrastructure so that transport costs are less pervasive in leisure activities as times passes. An opposite result emerges when we run the second scenario with output and growth growing sharply. Labour effort is at a higher level than in other scenarios. Leisure activities are very expensive due to the presence of very high transport costs since the increase in transport infrastructure is not effective enough in reducing costs.

One issue of interest concerns the effects of changes in transport infrastructure (stock or investment): Is the amount of infrastructure in the EU15 optimal, i.e. the one that maximizes growth and total welfare? The answer to this question would obviously have potential policy implications.[30] To address this, we modified the initial value of transport infrastructure and analysed the effects on growth and welfare. As we know that many parameters depend on the value of TI, we re-calibrated the model according to fictitious values of initial transport infrastructure and tested whether the highest growth rates for output and consumption are obtained for the current level of infrastructure. The results of the simulations in this case suggest that there is no evidence of a large gap in transport infrastructure in the EU15 or in the US if the objective is to maximize consumption and output growth. By changing the value of initial transport infrastructure (and all the parameters that depend on it) in the EU15 it is not possible to get higher growth for consumption and output, while in the US a 10% increase in initial infrastructure would lead to higher growth. The latter result is surprising given that the per capita stock in the US is higher than in Europe, however it is likely that the non-linearities in the production and utility function are driving the result.

As a further check we also analyzed the effects of changes in the initial transport infrastructure on welfare, i.e. on the sum of utilities of economic agents. We ran a number of simulations and checked the relationship between these two variables. At very low levels of initial TI there is a positive effect on total welfare of increases in the stock. At lower levels of transport infrastructure there is a positive and significant effect on welfare, however at current levels of infrastructure the effects are minimal. Thus, although the model does predict that higher welfare would be achieved at higher transport infrastructure levels, uncertainties associated

---

[30] We note again that if a level of initial transport infrastructure, higher than that currently in the EU15, is optimal, one direct implication is that the marginal benefit of additional transport infrastructure expenditure exceeds the cost of funds.

with the many approximations of the model due to the presence of parameters, initial values and numerical rounding (illustrated in Figure 24) our view is that this result does not support the conclusion that there is currently any material under-provision of transport infrastructure in the EU15.

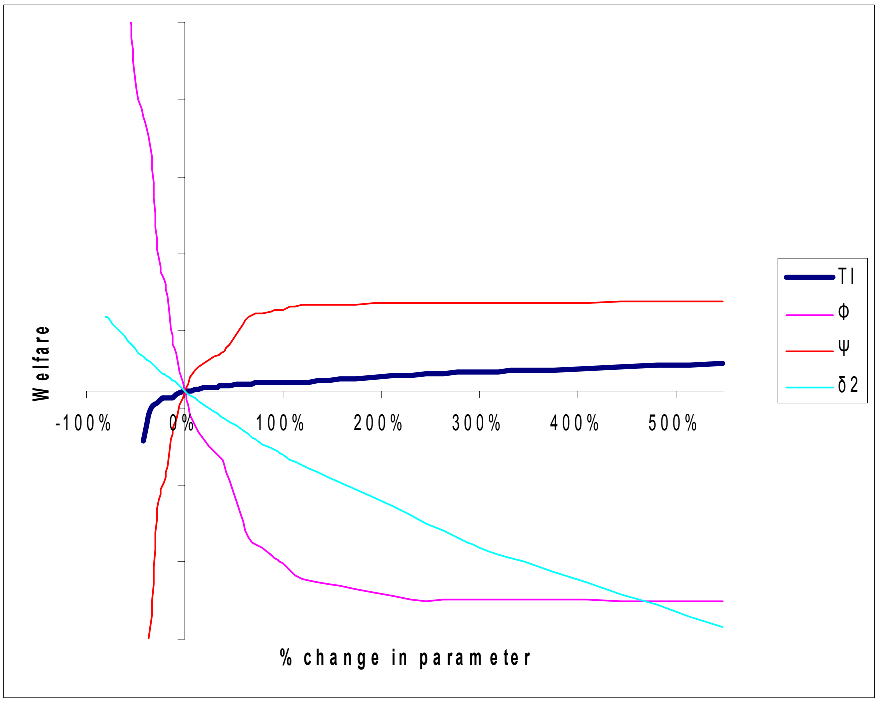


Figure 24: Welfare Effects of changes in parameters

6.2.2.3 The BSIM model

The peculiar characteristic of the BSIM model is that it can take into account congestion effects[31]. However since total output depends on its own value, this creates problems in the numerical calculation that lead to instability in the results, and small changes in the value of the parameters have a big impact on the path that the economy follows. Therefore we use this model only to illustrate that congestion could, in principle, have detrimental effects on growth but it is impossible for such a model to be used for policy recommendations. The main analytical result of the model is that the market outcome can be inefficient from a welfare perspective: single agents have the incentive to use the infrastructure more than its optimal level as they do not take into account the negative congestion effect. An advantage of the BSIM over the leisure model is that, given the particular form of the production function it can provide constant and positive growth rates on the balanced growth path. The results of the model confirm the better performance of the US economy with respect to the EU15. However, predicted growth rates are unreasonably high (23% and 11% per period respectively) notwithstanding the fact that we have increased the discount rate sensibly. According to the measure of congestion that Barro and Sala i Martin use, i.e. the share of infrastructure over output, the EU15 is more congested than the USA, both at the beginning of the period

---

[31] See the appendix for a discussion of the analytical characteristics of the BSIM model and for a discussion of its features.

(0.15 and 0.14 respectively) and on the balanced growth path, where the difference becomes even larger (0.27 and 0.19 respectively). The difference in congestion is clearly one factor that drives the higher growth of the American economy.

Barro and Sala I Martin (1992 and 2004) model congestion in a particular way, i.e. the ratio between transport infrastructure[32] and output. In the general presentation of their research they assume a general functional form such as $f(G/Y)$ where G is the amount of public spending in the economy. They assume that *f* has a positive first derivative and a negative second derivative. What these assumptions mean is simply that an increase of *G* with respect to *Y* increases total output but the amount of the increase tends to zero as *G* grows. An increase in *G* therefore implies an increase in total output, but an increase in total output also implies a more congested economy and a subsequent decrease in total output. It is therefore difficult to simulate numerically a model of this kind as the variable *Y* depends on its own value. In a number of alternative simulations that we tried a number of non-linearities with a high variability of the rates of growth emerged. It can be proved[33] that the optimal ratio *G/Y* in this model must satisfy the condition $\frac{f'(G/Y)}{f(G/Y)} = \frac{1}{1-(G/Y)}$. With the Cobb Douglas functional form that we used in the numerical simulations, that is equivalent to what Barro and Sala I Martin have used in their 1992 paper, the condition becomes: $\alpha\left(\frac{G}{Y}\right)^{-1} = \frac{1}{1-(G/Y)}$[34]. This ratio is the one that maximises overall growth. There are three solutions to this equation, namely $(G/Y) = \frac{\alpha}{\alpha+1}$ and $(G/Y) = \pm\infty$. Therefore it is optimal either to have a low share[35] of public capital (or transport infrastructure in our case) or to have an infinitely high level of infrastructure. In the first case transport infrastructure would be highly congested but the marginal product of infrastructure would be high. In the second case the marginal product would be negligible but there would be no congestion. Of course the only value that is economically significant is the first one as it can be calibrated. It might naturally be assumed that an initial value of transport infrastructure that satisfied this condition would maximise growth and welfare. Unfortunately when such a value is used the system cannot reach a steady state.

6.3 Conclusions

The main results of this section can be summarized as:

The existence of small albeit positive benefits - in terms of higher output and economic growth - stemming from public capital and, especially, from transport infrastructure-seems to

---

[32] They think that also other publicly provided goods such as water systems, police and fire services and courts are subject to congestion, therefore they use G to define public expenditure as a whole.

[33] See Barro and Sala I Martin (2004) p. 225 for details.

[34] Starting from $f(G/Y) = (G/Y)^{\alpha}$ we get $f'(G/Y) = \alpha(G/Y)^{\alpha-1}$ and therefore $\frac{f'(G/Y)}{f(G/Y)} = \frac{\alpha(G/Y)^{\alpha-1}}{(G/Y)^{\alpha}} = \alpha(G/Y)^{-1}$

[35] The value of G with the parameters calibrated in our EU15 and US model is 0.1.

find a broad support in the empirical literature, unlike what earlier literature reviews e.g. Gramlich (1994) or Sturm and de Haan (1998) seemed to suggest.

Production function studies seem to identify elasticities of output with respect to public capital of about 0.10-0.20, while cost function-based studies seem to identify somewhat smaller effects.

The literature review has identified the existence of variability in the effects of public infrastructure on private output and costs across regions and sectors.

A few studies have also identified the existence of important spillover effects, although the research in this area still seems to be at an early stage of development.

The leisure model predicts well the reduction of time spent in working activities as well as the relative position of the EU15 with respect to the US.

The model works well also in showing no catching up of the EU15 towards the US levels. Growth seems more robust in the US and it is unlikely that this trend will be reversed soon. However, the difference in growth seems too high as it implies that the US economy should be twice the size (in per capita terms) of the EU15 in forty years.

The leisure model supports estimates towards (or even below) the lower end of the econometric estimates of the elasticity of output with respect to transport infrastructure — around 0.1. Our result is derived using an estimate of about 13% for the amount of total labour time in the economy used in transport costs.

The model suggests that there is no evidence of a lack of transport infrastructure in the EU15. An increase in the value of this parameter would not lead to any significant effect on growth or welfare. However, this result is obtained using national aggregates without any regional differentiation e.g. in urban areas and rural areas. Such a differentiation seems to be reasonable as the congestion analysis (see Section 3.3) revealed that congestion is mainly a problem of large urban areas in Europe.

7 Developments of productivity in the transport sector

7.1 Background of the economic analysis

The transport sector is an important contributor to value added. In 2003 the contribution of EU transport total value added ranged from about 2.2 per cent in Ireland to 7.2 per cent in Finland. The figures are similar for the new member states of Czech Republic, Hungary and Poland. Across the EU, transport services contribute to about 4.3 per cent of total value added, while in the US the contribution is slightly lower, at about 3 per cent.

The importance of the transport sector for the efficient functioning of the wider economy should not be undervalued, given that the transport sector operates the networks over which goods are delivered and people can travel. Better functioning transport sectors might in fact stimulate long run output growth in the economy by allowing for an increase in market size, which in turn might make it easier for private firms to exploit scale economies and specialisation and the creation of industrial clusters and agglomeration economies (see section 6.1.)

Differences in the relative productivities of the transport sectors and/or the different dynamics in the patterns of transport productivity growth might have a role to play in explaining different growth patterns across countries.

It is therefore important to evaluate the productivity levels and growth rates in the transport sectors of the EU countries, as well as to compare the overall EU situation with that of the US.

One of the aims of this section of the COMPETE report is precisely to analyse and discuss such evidence.

In section 7.2 we will use the available empirical evidence as well as our own estimates to discuss the productivity levels as well as growth rates in the transport sectors of the EU countries and the US. Given data availability problems, the analysis will be mainly centred on labour productivity, rather than on the more theoretically robust total factor productivity. One of the main results of our analysis is that the EU has experienced higher rates of labour productivity growth over the 1979-2002 period than the US and that, from the second half of the 1980s onwards, the level of labour productivity in the EU transport sector has been consistently higher than in the US.

However, it should be recognised the higher labour productivity in the EU might be due to higher capital investment, rather than by inherently higher efficiency in the production process. The evidence which we report for the transport and communication sector confirms in part this analysis, which shows that, in terms of total factor productivity levels, the US consistently had one of the three most productive transport and communication sectors in the group of EU15 plus US in terms of total factor productivity.

The second goal of this section is to analyse the impact that selected transport policies had on productivity growth in the transport sector. The transport sector productivity growth might be in fact explained by congestion problems and associated policies, infrastructure and liberalisation policies, R&D expenditure and so forth. In section 7.3 we will seek to use econometric analysis to evaluate the impact that some policies might have had in the past in stimulating productivity growth in the EU (and US) transport sectors.

In section 7.4 we will instead present some additional evidence on the importance of the transport sector for the total economy in the EU countries, by computing the indirect employment effects of the transport sector, i.e. the number of jobs created by the transport sector in the wider economy, using standard input-output analysis.

7.2 Productivity of transport in the EU and the US

The main aim of section 7.2 is to provide the reader with a background of the developments of productivity levels and productivity growth in the transport sectors of the EU member states and the US.

For reasons related to data availability, productivity will be mainly analysed in terms of labour productivity, which in this report has been defined as value added divided by the number of hours worked. In particular, we will analyse the behaviour of labour productivity growth rates (section 7.2.1), as well as the evidence related to labour productivity levels (section 7.2.2) in the transport sector. In section 7.2.3 we will repeat the analysis at a finer level of disaggregation, discussing the evidence on labour productivity growth and levels in four transport sub-sectors: water, land, air and support transport. Finally, section 7.2.4 will provide some evidence related to total factor productivity growth rate which avoids the major shortcoming of using labour productivity to compare the relative “competitiveness” of different sectors at a single point in time or the behaviour of a sector through time, namely the fact that labour productivity might increase (or it may be higher in a country with respect to others) just because of capital accumulation, rather than because of inherently more advanced technology, higher managerial skills and so forth.[36]

7.2.1 Labour productivity growth rates

Below we present selected average LP growth rates for the EU15 member states and selected new member states within the total transport sector.

It is noticeable that the average rate of LP growth differs significantly between the periods 1979-1990 and 1990-2003. These differences are also between countries which one might expect to exhibit similar behaviour, for example Luxembourg and Belgium. However, one should be aware that differences may refer to underlying structural differences between countries and between transport sub-sectors. For example, labour market conditions, the size of the labour force involved in the activity, and demand patterns might all be used to explain why apparently similarly sized countries exhibit fluctuations in LP growth. Further, countries might show different levels of resilience in LP growth to common external shocks – or these shocks might not be common at all.

---

[36] In this work we have broadly followed the same methodology as deployed by O’Mahony and van Ark (eds.) in *EU Productivity and Competitiveness: an industry perspective – can Europe resume the catching-up process?*. Further details of our methodological and full data results can be found in Annex 7.

In the latter period, for most countries, LP growth declines (though remaining positive). This may because "easy" gains in LP were made during the 1980s (perhaps through more hours worked on labour market deregulation), and subsequent gains are harder to make. The exceptions are Germany, Italy and Greece. In the case of Ireland the drop is steep from 8.8 per cent during 1979-1990 to 2.3 per cent in 1990-2003.

Over the entire period, all EU15 countries exhibit positive LP growth. Most countries' overall growth rate does not deviate far from the mean average of 2.84 per cent. Outliers include Luxembourg (which consistently experiences high LP growth rates) and Greece. The large deviation from Greece may be a reflection of joining the EU and rapid catching-up (see the econometric results discussed in COMPETE Annex 7).

The three new Member State countries have experiences of both positive and negative LP growth. In the case of Poland, since 1996 LP has been continuously rising, with an overall compounded rate of 5.33 per cent. There has been more fluctuation in the cases of the Czech Republic and Hungary and this is reflected in lower overall growth. Indeed, on average, the Czech Republic experienced falls in LP. The divergence in LP growth trends both inter-country and intra-country in the new Member State countries is perhaps not surprising, given the huge structural changes made to their economies during this period. One might expect, that the immediate reaction to market liberalisation is for LP rates to fall temporarily, then rise consistently. The fact that Hungary and Poland both demonstrate overall positive LP growth suggests this line of argument might be relevant. The negative LP growth rate recorded in the Czech Republic may be evidence of country specific shocks.

The figures mask considerable variation in year-by-year LP growth rates. For example, in 2000, at the height of the technology boom one might expect that most countries receive a positive labour productivity shock. This is indeed the case for some countries such as Denmark and Portugal, which record growth rates of 8.96 per cent and 9.43 per cent respectively. The biggest growth comes in Greece at 20.90 per cent. However, there remain some member states that record negative growth rates, namely: France, Ireland, Sweden and the UK. This might because these four countries already had a high utilisation of IT by workers, so there was less productivity to be gained.

Table 48 Compounded LP growth for EU15 and new member states and US in the transport sector, 1979 - 2003

Member State	1979-2003	1979-1990	1990-2003
Austria	2.15%	3.17%	1.46%
Belgium	2.00%	3.42%	0.98%
Denmark	2.99%	4.35%	2.09%
Finland	2.41%	2.60%	2.44%
France	2.08%	3.25%	1.27%
Germany	2.73%	1.94%	3.62%
Greece	5.23%	4.06%	6.05%
Ireland	1.34%	8.83%	2.26%
Italy	2.18%	1.25%	1.52%
Luxembourg	6.74%	6.80%	7.22%
Netherlands	1.82%	2.09%	1.73%
Portugal	3.74%	4.28%	2.55%
Spain	2.25%	3.32%	1.52%
Sweden	2.20%	4.28%	3.58%
UK	2.68%	3.73%	2.01%
Czech Republic*	-	-	-2.36%
Hungary*	-	-	1.85%
Poland*	-	-	5.33%
US	1.42%	1.51%	1.59%

** For the new member states, the first year of calculated LP is 1996. Source: Europe Economics calculations.*

The graph below compares LP growth rates between the EU15 and the US.

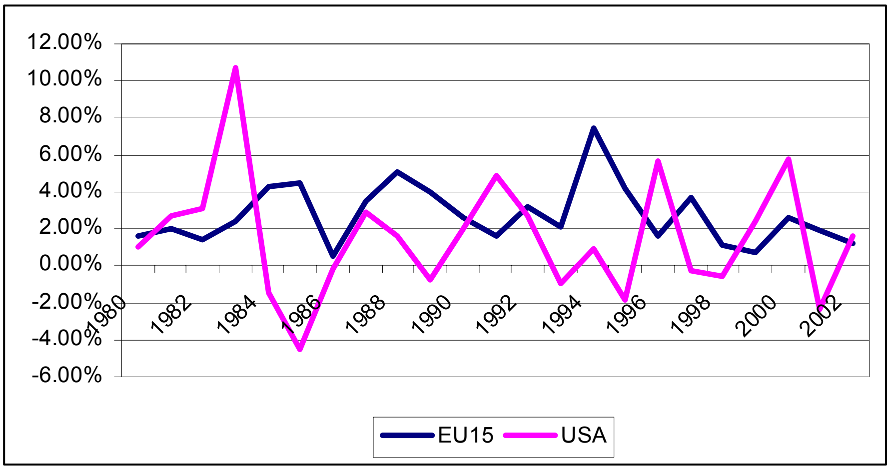


Figure 25: LP growth compared in EU15 and US: 1980 – 2003 (complete transport sector)

What the graph shows is that the US has experienced somewhat greater LP growth rate fluctuations, especially in the early 1980s. Unlike the EU15, in some years, LP actually declined in the USA, albeit only slightly in the years 1997 and 1998. In contrast, the EU15 consistently enjoys positive LP growth.[37] However, from the above graph, one cannot conclusively say that the EU15 has a higher level of LP than the US – instead it has a higher LP growth rate, which might be evidence of catching up to the US's higher starting point.

7.2.2 Labour productivity levels

A further interesting point of comparison between countries and between the EU15 and the US is that of LP levels. By estimating levels one can make statements as to whether particular countries are more productive than others. Table 49 sets out a comparison of transport sector productivity levels. Here it is given in € per hour – that is to say, the value added in Euros for each hour of work. The conversion rates for non-Euro countries are taken from the IMF's International Financial Statistics, using an average for 1995.[38]

If one begins by looking at the end of the period, one can see that there remains a large disparity in the levels of LP in EU15 countries. The highest levels can be found in Luxembourg, Italy, Sweden, Denmark, Finland, the Netherlands and Belgium at over €30 per hour. In contrast, Greece only has an LP of about €11 an hour. These figures intuitively correspond to the states of the respective economies at the time. One is not surprised to see low levels of productivity in the UK in 1980 given its economic situation at the time.

What is also interesting to investigate are the levels at which each country started and ended. A number of countries that began the period with the highest levels of LP also end the period with highest levels of LP. The most conspicuous exception is Luxembourg, which in 1980 had an LP of about €9 per hour but by 2003 had reached €47 – the highest in any country. This would seem to indicate that, in general, the countries with the highest LP levels at the beginning of the period kept their lead by capitalising on their productive sectors. However, there appears to be some evidence of convergence in the levels of labour productivity (perhaps to a common production frontier of efficiency): some more robust results will however be provided with the econometric models discussed in section 7.3.

As might have been expected, the new Member States have far lower levels of LP when compared to the older EU15 member states. In fact, overall LP levels for the transport sector in these new Member States in 2003 is lower than was the case in old Member States in 1993 (except for Greece). However, given past LP growth one might reasonably conjecture that these new Member States will catch up to have levels of LP similar to those of EU15 countries. From the calculated results, LP level growth slows between 2000 and 2003, so the absolute difference between new Member States and old ones should narrow.

---

[37] Our results for LP growth rates are comparable to those of O'Mahoney and Ark (2003) in EU Productivity and Competitiveness: an industry perspective – can Europe resume the catching-up process.

[38] These figures are not converted into purchasing power parity.

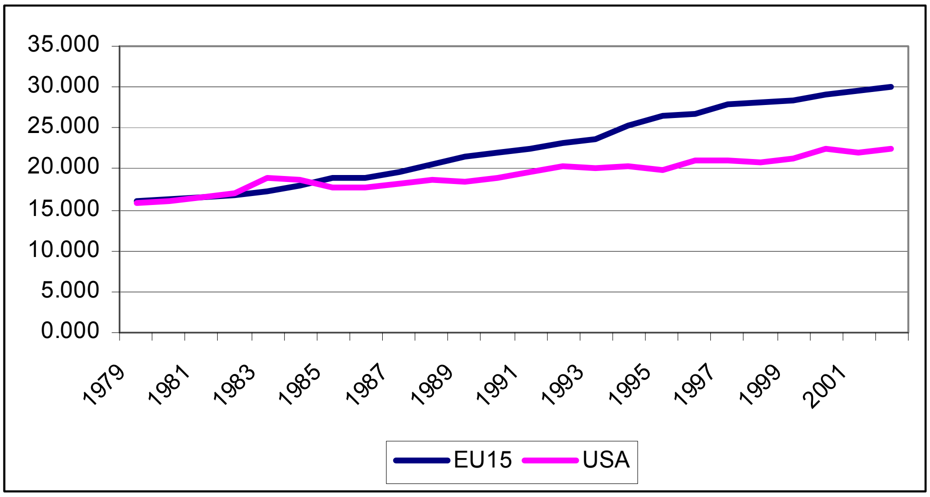


Figure 26: Labour productivity levels in the EU and the US transport sectors (1979-2002) € per hour

Figure 26 compares LP levels between the EU15 and the US in the transport sector. At the beginning of the period, LP levels in the EU15 and US are quite similar, €16.06 and €15.96 respectively. During the early 1980s, US LP levels grow faster than those of the EU15, and so by 1984 the US is actually slightly more productive than the EU15. However, this situation does not last and from the mid-1980s, the EU15 records uniformly positive growth in LP translating into a steadily increasing LP level. In contrast, growth in the US is more variable and actually negative in some instances. The result of these divergent growth paths means that by the end of the period in 2002, despite starting with broadly equal LP levels in the transport sector, the EU15 is significantly more productive in the transport sector than the US: €30 per hour compared to €22. This corresponds to faster LP growth rates in the EU15 compared to the US. Explanations might include a more than proportional growth in hours worked in the US than in the EU, but also differences in exogenous variables such as changing population densities and size.

Table 49: Selected LP levels (1995 € per hour) for EU15 and new member states and US in the transport sector, 1980 - 2003

Member State	1980	1984	1988	1992	1996	2000	2003
Austria	18	20	23	28	26	30	30
Belgium	21	24	27	31	30	30	33
Denmark	16	17	24	28	31	34	36
Finland	18	19	21	25	30	32	32
France	19	21	24	26	27	30	29
Germany	13	14	14	17	23	26	25
Greece	3	4	5	5	6	10	11
Ireland	12	11	11	14	17	19	16
Italy	21	23	25	29	34	33	35
Luxembourg	9	11	17	23	36	42	47
Netherlands	21	24	24	25	29	32	32
Portugal	8	9	11	13	13	16	18
Spain	12	14	16	18	20	21	21
Sweden	20	19	23	26	29	31	34
UK	11	12	16	17	20	20	21
Czech Republic	-	-	-	-	5	3	4
Hungary	-	-	-	-	3	4	4
Poland	-	-	-	-	3	4	5
US	16	19	19	20	21	23	-

Source: own computations

It should be remembered, however, that despite the above data results, when one examines total value added growth aggregated across the economy, the US is stronger than the EU15 (4.25 per cent for the period 1996-2000 compared to 2.72 per cent). The transport sector is only one of many components of total value added.

7.2.3 Labour productivity in the transport sector: a finer disaggregation

The transport sector consists of four sub-sectors: land, water, air and supporting services. Supporting services to transport include activities such as travel agents, travel caterers and logistics. In this section we focus on comparing these different sub-sectors' LP levels in the EU15 and the USA.

Our results indicate that whilst the US had a LP advantage in the land and water sectors at the beginning of the period, by 2002 the EU15 had overtaken the US in all sectors. In the water sector, the EU in 2002 was over 2.5 times more productive. The US also lags significantly in supporting and air industries. The fact that the EU15 overtakes the US is consistent with its higher LP growth rates.[39]

These large differences may be explained by two reasons: first, exogenous structural factors like a larger population, greater urban density and, possibly, higher capital accumulation in the EU than in the US, and, second, European policy in particular the creation of a single market increasing the market size for transport companies and the transport policy itself fostering e.g. competition in the transport sector, intermodality, supra-national infrastructures and by all that providing higher quality transport services, which would then be reflected in higher labour productivity as shown in Table 50.

Table 50: LP levels (1995€ per hour) in transport sub-sectors in the EU15 and USA

	EU15				USA			
Sector	Land	Water	Air	Support	Land	Water	Air	Support
1980	13.25	17.65	20.32	17.86	15.20	20.21	18.01	17.11
1984	15.44	20.53	26.44	21.42	17.33	19.38	23.06	20.97
1988	17.66	25.64	29.79	24.16	17.60	19.20	20.73	20.83
1992	19.64	30.31	34.21	27.02	19.44	23.44	21.80	20.60
1996	22.37	42.70	44.86	31.49	18.96	24.62	25.52	21.28
2000	22.93	55.96	52.22	32.51	19.84	26.40	28.23	25.05
2002	24.32	63.93	53.93	35.22	19.14	24.09	31.08	25.99

Source: own computations

7.2.4 TFP in the transport and communication sector.

Output in the transport sector does not solely depend on labour input; there is a significant capital contribution as well. The transport sector has large capital components in the form of transport infrastructure and transport equipment. Thus it is important to consider all factors of production, as differences in LP levels might simply reflect different capital intensities.[40] However, due to data constraints (namely missing data on capital stocks in the transport sector)[41] it was only possible to calculate Total factor productivity (TFP) for the transport and communication sector. Essentially, TFP refers to the change in output which is not explained

---

[39] We can note that these results are broadly consistent with those of Denis, McMorrow and Röger (2004) in *An analysis of EU and US productivity developments (a total economy and industry level perspective)* (DG ECOFIN)

[40] An example might be the UK, which performs quite poorly in terms of labour productivity levels but, as of 2002, was one of the countries with the highest TFP level in the transport and communication sector.

[41] Here, the trade-off has to be taken into account between not making this analysis to consider the capital intensity of transport, because of lack of data, or to make the analysis knowing base on the transport&communication sector accepting that this has limited comparability with the other results for the transport sector only. However, we took the choice that it is more important to analyse the influence of the capital intensity on labour productivity and hence used the transport&communication sector for this analysis.

by the change in all inputs. In this case inputs encompass both labour and capital goods. The main data source for capital stocks was the STAN database.[42]

Before discussing the TFP results, we should bear in mind that they relate to the wider transport and communication sector and that for some countries we had to construct the capital stock series, which involved some unavoidable assumptions. The implications of including the communications sector is discussed below with the analysis of the results.

TFP growth is computed using a Tornqvist index approach, as explained in some more detail in section 7.3 and in COMPETE Annex 7.

Our computations suggest that TFP growth rates in the US compare favourably with a number of EU member states. However, year on year there are large fluctuations between the EU15 countries. Further, while in the stage of the period investigated (1980-1995), European countries record higher rates of TFP growth, in the later periods the US enjoys higher levels of TFP growth (1996-2000). For example, in 2000 the US registered faster growth in TFP than the economies of France, Germany, Italy, Spain and the UK. This may be because of greater growth of the capital stock in the EU15 compared to the US.

Nonetheless, it should be recalled that these figures should be treated with care because they include the communication sector – the higher US figures may actually be biased by the presence of ICT growth, which is quite plausible given the technology boom of the late 1990s.

We also computed a multilateral index of total factor productivity following the Caves et al (1982) methodology. The results (shown in the COMPETE Annex 7) suggest that Belgium and Italy had been the “frontier” country (i.e. the country with the highest relative TFP level) in the 1980s and 1990s, respectively, for most of the time, but that the US have often been in the group of three countries with the highest relative TFP in the transport and communication sector. Our computations also suggest that a convergence process in relative TFP levels has been taking place within the EU, as the falling value of the standard deviation of relative TFP level seems to suggest.

7.2.5 Conclusions

In conclusion, this section has summarised our results for LP and TFP calculations. The picture that emerged was similar to that of existing studies, i.e. LP growth in the EU15 has been greater than that of the USA. We also calculated LP levels in the transport sector as a whole and in individual sub-sectors. These calculations confirmed that the higher LP growth rates have led to the EU15 enjoying a significant LP advantage of the US.

In contrast, the picture for TFP is not so clear-cut. One must stress here again that the results are based on transport and communications sector and that we had to make some quite strong assumptions to build the gross capital stock used to compute the TFP for some countries. A comparison of TFP relative levels show that, indeed, the US performed pretty well as compared with the EU, as in most years they rank among the first three countries with the

---

[42] The methodology for estimating the capital stock is described in the annexes.

highest relative TFP level. Furthermore, there is some evidence that countries that started the sample period with low relative TFP levels have been experiencing faster TFP growth over the entire sample period.

7.3 Impact of transport policies on productivity

In this section we summarise the main results of the econometric analysis of the impact of some transport policies on productivity growth.

There are potentially many policies and variables that might have had an impact on productivity growth in the EU transport sector, such as expenditure on infrastructure, liberalisation policies, measures aimed to alleviate congestion problems, and so forth.

For instance, liberalisation policies might foster productivity growth in the transport sector because they might provide managers the right incentives to cut slacks and inefficiency and to introduce both product and process innovations[43]. There are different liberalisation policies that have been introduced over the recent years. These are referred to the degree of public ownership in the sector, the existence of price regulation, the existence of third party access to the network in the case of essential facilities like the railways network, and so forth. The degree of liberalisation in the transport sectors of all OECD countries increased over the 1979-2003 period. For instance, the index of liberalisation, as measured by the liberalisation indices built by the OECD, in the EU15 and the US was about 5.7 and 3.2, respectively, in 1980 but it fall to 2.3 and 1.2 in the EU15 and the US, respectively, in 2002.[44]

It is reasonable to expect that the increased levels of liberalisation in the transport sector should be associated, ceteris paribus, with higher productivity growth which in turn should lead to lower prices for both passengers and for transport user sectors.

Other policies that might be expected to affect the competitiveness of the transport sector are infrastructure expenditure policies and policies aimed to alleviate and fight congestion. In fact, new and improved transport infrastructure as well as policies aimed to alleviate congestion and bottlenecks in urban as well as non-urban areas could reduce transportation costs and increase the scope for inter-modal competition (e.g. train-air) which in turn could lead to faster productivity growth in the transport sector.

While, in principle, it would have been desirable to include in the empirical analysis as many variables as possible that could proxy for the main policies introduced by EU countries over the last twenty years or so, data constraints for most of the countries on one side, and the necessity to include as many countries as possible into the analysis on the other –to give an as broad as possible overview of the EU- have forced us to mainly focus on two sets of policies, namely infrastructure and liberalisation.[45]

---

[43] See, for a review of the theoretical issues related to the effects of competition on productivity growth, Griffith et al (2006).

[44] The OECD indices of liberalisation go from 0 to 6, with 0 indicating a fully liberalised sector.

[45] Another transport-related policy that we have considered in the econometric analysis was referred to the existence of inter-city road pricing in each country and in each year of our sample (the variable took the value of one when an inter-city road pricing policy was applied and zero otherwise). However, it was always largely insignificant and therefore it has been omitted from the final version of our econometric models.

Although it might have been preferable to be able to include other variables into the analysis, especially these proxyng for the levels of congestion, indicators related to the expansion of infrastructure and the degree of liberalisation are perhaps the two most important and might therefore provide at least some useful insights in our attempt to explain productivity growth developments in the EU and US transport sectors.

For the infrastructure policies, the only data available were a monetary value of the total public capital stock in the economy as a whole, or physical indicators like length of motorways, roads and railways. Both types of variables have drawbacks: the public capital stock covers not just transport infrastructure, but also capital items such as hospital and schools. There is however some evidence in the economic literature on the macroeconomic effects of public infrastructure on economic growth we have surveyed, that the wider public capital stock tends to have lower effects on economic growth than public infrastructure aggregates more intimately related to transport infrastructure. Therefore our estimates based on the public capital stock can be thought of as providing a conscious underestimate of the "true" effect of transport infrastructure on the productivity growth rates of the transport sector.

The physical measures of infrastructure, though more closely related to the concept of transport infrastructure, suffer from many drawbacks, namely the large measurement errors and the missing data in some years for many EU countries. Therefore, although we have used the physical infrastructure variables in our analysis (mainly to cross-check some findings) the results we will discuss will be based on the public capital stock growth rates as the main "infrastructure policy" variable that we have used in the econometric analysis.

The liberalisation policy variables that we have considered have been based on recently released OECD indices which seek to measure the level of liberalisation in some transport subsectors, namely airlines, roads and the railways.

The remainder of this section is organised as follows: in section 7.3.1 we will present our main findings on the effects of public capital stock on productivity growth rate in the transport sector, while in section 7.3.2 we will discuss a rather different issue, namely the role played by productivity growth in the transport sector in productivity developments in some transport-user sectors.

7.3.1 Econometric analysis of transport policies on transport productivity growth

As we argued in section 7.2.4, TFP growth is a better indicator than LP growth. In fact, LP might grow because of technological innovations and product innovations, managerial improvements, but also because of an increase in the capital deepening of the sector, i.e. an increase in the capital to labour ratio. Therefore, higher LP levels might be the result of a higher capital stock rather than an inherently more efficient production process. TFP is supposed to address this shortcoming of LP and it is therefore a theoretically more rigorous method to assess productivity levels and productivity growth in a sector.

However, due to data availability problems, it has not been possible to measure TFP growth in the transport sector for many EU countries. The data problems were however not insurmountable in the case of the wider transport and communication sector, for which we have been able to compute TFP growth for the EU 15 countries (with the exception of Luxemburg) and the US. We therefore decided to undertake our econometric analysis using as the relevant productivity indicator the TFP growth in the transport and communication sectors of the EU15 countries (with the exception of Luxembourg) and the US for the period 1979-2003.[46]. We however cross checked the main results using LP growth in the transport sectors as the dependent variable of the econometric analysis (the results are discussed in Annex 7).

7.3.1.1 Econometric analysis: TFP growth regressions in the transport and communication sector

The main econometric specification we have estimated was based on equations 1 and 2 as follows:

(1) $$\Delta \ln TFP_{i,t} = \alpha_0 + \alpha_1 Gap_{i,t-1} + \alpha_2 \Delta \ln Kg_{i,t} + \alpha_4 \Delta Transp_{i,t} + \alpha_5 \Delta Tel_{i.t} + Outgap_{it} + v_{it}$$

(2) $$v_{it} = e_i + \lambda_t + u_{i.t}$$

Where $\Delta \ln TFP_{i,t}$ is the rate of growth of total factor productivity for the transport and communication sector of country i at time t[47]; $\Delta \ln Kg_{i,t}$ is the rate of growth of the public capital stock in the economy as a whole of country i at time t. $\Delta \ln Kg_{i,t}$ will have two kinds of effect on $\Delta \ln TFP_{i,t}$. First, because of the definition of $\Delta \ln TFP_{i,t}$, there is a purely *mathematical* effect (witch we might term, a "bias")[48]. Second, there is the *economic* effect – which is what we are interested in. To isolate the economic effect, which we called α_2^*, we adjust α_2 by "adding back" the mathematical effect (correcting for the bias). This correction is country-specific, but the average bias is about 0.06, i.e. α_2^* = α_2 +0.06.

$\Delta Transp_{i,t}$ is the change in the liberalisation index in the transport sector of country i between the years t and t-1 and it was computed as the average of the OECD indices for the road, airlines and railways sectors; $\Delta Tel_{i.t}$ is the change in the liberalisation index for the communication sector between years t and and t-1, $GAP_{i,t-1}$ is the distance from the technological frontier of country i in time t-1 and $Outgap_{it}$ is the output gap in the economy as a whole of country i at time t which is aimed to proxy for the impact of country-specific business cycles on TFP growth.

---

[46] For some countries, the full time series of data was, unfortunately, not available. See COMPETE Annex 7 for details.

[47] The rate of growth of Total Factor Productivity has been computed using a Tornqvist index: $\Delta \ln TFP_{it} = \Delta \ln VA_{it} - \frac{1}{2}(\alpha_{it} + \alpha_{it-1})\Delta \ln H_{it} - (1 - \frac{1}{2}(\alpha_{it} + \alpha_{it-1}))\Delta \ln K_{it}$, where H and K are the hours of work and the gross capital stock employed in the sector and α is the labour share in value added. Value added and the gross capital stock have been converted in US dollars using GDP PPP exchange rates. For this and other details see COMPETE Annex 7.

[48] Referring to COMPETE Annex 7 for a more exhaustive explanation, the bias stems from the fact that the capital stock we have used to compute TFP growth in the transport sector is the sum of private capital stock (e.g. vehicles, buildings, software) and the public infrastructure capital (e.g. roads). In this case, the effect of the public capital stock (as a proxy for transport infrastructure) is likely to provide a downwards biased estimate of the effect of its true effect on "private sector" TFP growth (i.e. computed using only the private capital stock as the capital input).

Table 51[49] summarises our main results for the TFP growth regressions in the transport and communication sectors.[50]

One of the main results that is robust across all the specifications reported in Table 51 –and which is consistent with the findings of some recent literature- is the negative coefficient for $GAP_{i,t-1}$, which says that countries that lag further behind the frontier tend to have faster TFP growth rates than countries that already operate near the industry technology frontier, perhaps because in the former countries there is more scope for imitation of new processes and products already introduced in more technology advanced countries.

Column 1 of Table 51 shows that the rate of growth of the public capital stock has a positive impact on the rate of growth of TFP in the transport and communication sector and that the coefficient is significant at exactly the 10 per cent level of confidence. The point estimate suggests that an additional one percentage point increase in the rate of growth of the public capital stock in the economy as a whole would add about 0.34 percentage points to the rate of growth of TFP in the transport and communication sector. Recalling that 0.34 is likely to provide a downwards biased estimate of α_2^*, we might say that α_2^* is approximately equal to 0.40. However, we should also take into account that our measure of the public infrastructure capital includes other public capital items that are not related to the transport and communication sectors, like hospitals and schools. In this case, a one per cent increases in the total economy public capital amounts to less than one percent increase in the stock of public capital in the transport and communication sector. In particular, we have assumed that the ratio between transport and communication public infrastructure and total public infrastructure is about 0.5-.0.6[51] the overall effect of a one per cent increase in the stock of transport and communication public infrastructure should be approximately an additional 0.67-0.80 (0.40/0.6; 0.40/0.5) percentage points to the TFP growth rate in the transport and communication sector. This result (see COMPETE Annex 7 for details) would approximately correspond to an additional 0.05-0.06 percentage points in the rate of growth of TFP in the economy as a whole, which would also correspond to an elasticity of output with respect to the public capital stock, in the economy as a whole, of about 0.05-0.06. Our literature review on the macroeconomic effects of the public capital stock on aggregate output generally identifies an elasticity of output with respect to public capital of about 0.10/0.20. In our own growth model discussed in section 6.2 of the COMPETE report suggests that an elasticity in the 0.05-0.10 range would appear to be a reasonable estimate. Our findings for the transport and communication sector therefore generates a result which, “transferred” to the economy as a whole, would suggest a value which is just at the lower bound of this range.

---

[49] In each table we have reported the coefficients point estimates as well as (in parenthesis) the p value for the t test of significance.

[50] The full sets of results as well as a discussion of the econometric methodology are reported and discussed in the COMPETE Annex 7.

[51] Picci (1999) has reported data for Italy which show that core infrastructure (defined as roads, airports, railroads, subways, ports, telecommunication infrastructure, electrical lines and water) amount to about 60 per cent of total government infrastructure. We therefore have assumed that a range of 50 per cent to 60 per cent for the ratio between transport and communication public infrastructure stock and total public infrastructure stock could provide a reasonable approximation.

In column 2 we explored the linkages that might exist between productivity growth, liberalisation and infrastructure allowing the impact of the rate of growth of public capital on TFP growth to vary with the degree of liberalisation in the transport sector: the results seem to provide some evidence (statistically significant at the 10 per cent level) that the impact of infrastructure tends to be higher in more liberalised sectors ($\Delta \ln kg_{i,t}$ *Tr1): in more liberalised transport sectors, an additional percentage point in the rate of growth of the public capital stock would add about 0.7 percentage points to TFP growth in the transport and communication sector, while we can not reject the null hypothesis that in the less liberalised sectors the impact of the public capital stock is not significantly different from zero. Considering the biases of the α_2 coefficient discussed above and performing similar computations,, we might say that in more liberalised transport sectors an additional percentage point of the rate of growth of the public capital stock would tend to add 1.3-1.5 percentage points to TFP growth in the transport and communication sector, while we can not reject the null hypothesis that the overall effect is zero in the less liberalised transport sectors. For instance, in the US, the average value of liberalisation in the transport sector was about 1.2; while in the EU it was about 2.2[52]: this would mean that in the US the impact of an additional percentage point of the rate of growth of the public capital stock would tend to add 1.3-1.5 percentage points to TFP growth in the transport and communication sector, while for many EU countries we could not reject the null hypothesis that it would not have any effect.

Liberalisation thus would seem to operate through the effectiveness of infrastructure rather than directly on the rate of TFP growth, as can be seen from the insignificant coefficient of $\Delta Transp_{i,t}$.

In column three we tested the robustness of these main findings by inserting in the regression the level of liberalisation in the airlines, railways and road transport sectors separately. As we can see, the coefficient of the public capital stock is lower than in column one and it is no longer significant[53]. Furthermore, we can see that higher degrees of liberalisation in the airlines sector would seem to reduce TFP growth in the transport and communication sector, while there is some (statistically weak) evidence that higher levels of liberalisation in the railways would tend to increase TFP growth in the transport and communication sector.[54] We have however some concerns that including the levels of the sub-transport indices rather than an aggregate one is a correct procedure to follow, given the low share of value added covered by some of these sub-transport indices, and the possibility of identifying a chance correlation in the data: this is especially the case for the airlines, which amount to just about 6 per cent of the transport and communication sector value added in the EU.

Our results in the transport and communication sector therefore would seem to provide some evidence that higher growth rates of the public capital stock might have a small albeit positive effect on the TFP growth rate of the sector. The evidence does not however appear

---

[52] The value for the EU was obtained through a weighted average of the EU15 member states.

[53] Furthermore, the inclusion of the airlines, road and railways sector liberalisation indices drives down to insignificant the effect of the rate of growth of the public capital stock also when we allow the impact to vary with the degree of liberalisation.

[54] The labour productivity growth regression confirms that the degree of liberalisation has a positive impact on LP growth, while the negative impact of airlines liberalisation is not confirmed.

to be particularly robust: as the result in column 1 shows, the coefficient is marginally significant. Furthermore, the results displayed in column 2, as well as the results (not shown) using labour productivity growth in the transport sector only as the dependent variable do still find a positive impact on productivity growth, but the significance level declines substantially. Therefore our result about the effect of the rate of growth of the public capital stock on productivity growth rates should be taken with extreme caution.

Unlike previous studies that can be found in the economic literature, there would not seem to be robust evidence that liberalisation directly affects TFP growth in the transport and communication sector, although there is some evidence that it might affect it indirectly.

For instance, Nicoletti and Scarpetta (2003) have used a panel of OECD industries to assess the impact that product market regulation had on total factor productivity growth and find that, in general, liberalisation tends to increase productivity growth, especially fostering the pace of productivity catch-up for countries that lag behind the industries' technological frontiers.

Alesina et al (2005) analysed the impact that regulation had on investment in the transport, communication and utility sectors, using OECD panel data. Their main results were that liberalisation -and, in particular, entry liberalisation- had a positive impact on private investment and that the marginal effect of liberalisation tends to be higher when the policy reform is "large", when the change in the policy took place at an already high level of liberalisation and especially for these countries that were early liberalisers.

Griffith et al. (2006) in a report for DG Economic and Financial Affairs examined the impact of competition (measured by the mark-up) and liberalisation had in labour and total factor productivity growth in a panel of EU countries.[55] For the service sector, which includes transport, they found that higher mark-ups – taken as a proxy for the degree of competition - tends to reduce total factor productivity growth, even if their failure to control for its possible endogeneity, does not allow the authors to interpret their finding as a causation rather than simple correlation.

Finally, Griffith and Harrison (2004), in what seems to be the study most similar to ours, especially in terms of sample size and focus on a single sector, were not able to identify any positive effect of the degree of liberalisation on TFP growth on OECD data for the water, gas and electricity sector.

A possible explanation for our finding could be that liberalisation does not play a major role in driving productivity growth in the transport sector, and that other variables, like R&D expenditure, or the degree of congestion, which we have not controlled for in the analysis, play a far larger role: if that were indeed the case, the error term would capture the effect of these omitted variables and the standard error would tend to be larger, making it difficult to precisely measure the effect of the included variables.[56]

---

[55] They also looked at the determinants of investments, employment and R&D.

[56] Furthermore, if some of these variables, like the congestion levels were in fact correlated with the degree of liberalisation, we might expect some bias in the liberalisation coefficients.

There would however appear to be some evidence that liberalisation operates mainly through its impact on the effectiveness of the public capital stock in stimulating higher TFP growth rates rather than directly. Furthermore, the regressions that are based on labour productivity growth in the transport sector only provide some evidence that the "technology" gap effect tends to be stronger for these countries with a more liberalised transport sector.

Table 51: TFP growth regression. Transp&Comm. sector

Dependent variable $\Delta \ln TFP$	**1**	**2**	**3**
Indep. variable			
$GAP_{i,t-1}$	-0.047 (0.03)	-0.045 (0.05)	-0.054 (0.01)
$\Delta \ln kg_{i,t}$	0.345 (0.10)		0.204 (0.36)
$\Delta Transp_{i,t}$	-0.007 (0.38)	-0.007 (0.43)	
$\Delta Tel_{i.t}$	0.005 (0.44)	0.004 (0.47)	
$Tel_{i.t}$			-0.002 (0.71)
$Road_{i.t}$			-0.004 (0.24)
$Rail_{i.t}$			-0.004 (0.12)
$Airl_{i.t}$			
$\Delta \ln kg_{i,t}$ *Tr1		0.700 (0.09)	
$\Delta \ln kg_{i,t}$ *Tr2		0.414 (0.21)	
$\Delta \ln kg_{i,t}$ *Tr2		0.441 (0.19)	
$\Delta \ln kg_{i,t}$ *Tr4		0.284 (0.26)	
Time eff	yes		
Fix eff	yes		
F test (p value)	0.0000		

Source: own calculations

7.3.1.2 Conclusions

The aim of this section is to briefly summarise the main results of the econometric analysis discussed in the previous section.

One of the most robust results of the econometric analysis is that we have found that countries that lag further behind the industry technological frontier experience faster TFP growth[57]: the regression coefficient is in fact remarkably stable and highly significant across all the regression specification in 7.3.1. This result confirms, for the transport and communication sector, the findings of Griffith et al (2004) and Nicoletti and Scarpetta (2003) who also find broadly similar results for a panel of OECD manufacturing and manufacturing and services sectors, respectively.

A similar result is also obtained in the case of the labour productivity growth regressions, where we found that countries with lower levels of LP tend to experience faster LP growth.

The TFP as well as the LP growth regressions do not provide convincing evidence that liberalisation (or changes in the degree of liberalisation) tends to clearly increase productivity growth in the transport sector.

There is some weak evidence that increases in the degree of liberalisation directly increase labour productivity growth, but the coefficients are poorly determined, and the significance level is never lower than 0.10-0.12 (with the exception of the railways-specific index, which is significant at the 10 per cent level and which could therefore suggest that liberalisation in the railways might have had a positive impact on LP growth in the transport sector).

In the case of the TFP growth regression in the transport and communication sector, the inclusion of an aggregate transport sector liberalisation index suggests that liberalisation is beneficial to TFP growth, but the coefficient is never significant or nearly significant; furthermore, the inclusion of individual sub-sector indices provides some evidence that railways liberalisation tends to increase TFP growth – thus confirming the LP growth analysis in the transport sector - while airlines liberalisation tends to decrease it.

A possible explanation for these findings could be that liberalisation does not play a major role in driving productivity growth in the transport sector, and that other variables, like R&D expenditure, or the degree of congestion, which we have not controlled for in the analysis, play a far larger role: if that were indeed the case, the error term would capture the effect of these omitted variables and the standard error would tend to be larger, making it difficult to precisely measure the effect of the included variables.[58]

Furthermore, the fact that our TFP growth measure is based on the composite Transport and Communication sector might have included some noise in the estimations and, therefore, standard errors might have been inflated. Finally, it is possible that the effects of liberalisation needs more time to materialise, for instance because of the existence of adjustment costs.

---

[57] This result provides some further support to our empirical finding, discussed in section 7.2, that there has been a convergence process in the TFP levels within the EU transport and communication sector.

[58] Furthermore, if some of these variables, like the congestion levels were in fact correlated with the degree of liberalisation, we might expect some bias in the liberalisation coefficients.

This does not, however, means that liberalisation does not have material effects. We have seen that liberalisation might operate indirectly through other channels. In particular, in more liberalised sectors the impact of increases of the rate of changes of the public capital stock (which we used as a proxy for the transport infrastructure capital) was magnified: an additional percentage point of the rate of growth of the public capital stock would tend to add 1.3-1.5 percentage points to TFP growth in the transport and communication sector in the most liberalised transport sectors. Furthermore, in more liberalised sectors, the convergence towards the industry frontier (measured as the country with the highest transport labour productivity level) tends to be slightly faster than in the most intensively regulated countries.

The evidence regarding the direct impact of infrastructure is mixed. We discussed in COMPETE Annex 7 the drawbacks of our proxy for the stock of transport infrastructure, the most important being that it is only loosely connected with the stock of transport infrastructure, as it accounts for also of such items as hospitals, schools, etc. However it has been widely used in the literature on the macroeconomic effects of infrastructure on economic growth and, above all, there is some evidence that it tends to provide somewhat smaller effects than core infrastructure capital, which is more closely associated with transport infrastructure: therefore it should be possible to argue that our result is a lower bound of the "true" effect of transport infrastructure. Furthermore, alternative variables[59] like km of roads, motorways or railway tracks are measured with substantial error and they do not provide year on year variation, within each country, sufficiently large to allow the researcher to identify the parameter of interest.

Having said that, our results do not show strong evidence that the rate of growth of the public capital stock has a positive impact on the rate of growth of TFP in the transport and communication sector, as the coefficient of $\Delta \ln kg_{i,t}$ is indeed positive but poorly determined (it is significant, even in the best TFP growth regression, exactly at 10 per cent). However, this result is not confirmed when we focus the analysis on the labour productivity growth in the transport sector: in this case, although the coefficient for the rate of growth of the public capital stock is positive, it is never significantly different form zero at the usual levels of confidence.

Which of the two sets of results is more "reliable" as an indicator of the likely effects of infrastructure expenditure programs on productivity growth in the transport sector is not immediately clear. For instance, we are not in a position to argue that the failure of the labour productivity model to show a significant positive effect of the public capital stock on labour productivity growth is due to the fact that the latter is the wrong indicator to consider or that, instead, the positive effect in the TFP model is due to the inclusion of the communication sector activities.

What would be required to provide more robust result would be the expansion of databases like the Groningen Growth Accounting Database or the STAN database and, above all, the

---

[59] Which we used in the regressions but that always turned out to be highly insignificant, with t values close to zero.

estimation of sufficiently long time series of the infrastructure capital for as many as possible EU countries.

7.3.2 Econometric analysis of the linkages between productivity growth in the transport sector and productivity growth in some transport using sectors.

Developments in productivity growth in the transport sectors are important because the sector produces intermediate inputs that will be then purchased by other sectors (transport user sectors): high rates of growth of labour or total factor productivity might have important implications for the economic development of some sectors that make an intensive use of transport. The sectors that we have considered in this report are financial intermediation; transport equipment; chemicals, rubber and plastics; food, drinks and tobacco and retail and wholesale. The main goal of the analysis has been to explore whether and to what extent productivity growth in the transport sector might have led to productivity growth in transport user sectors.

The econometric model we have estimated for the five sectors mentioned above in the EU 15 (less Luxembourg) and the US, for the period 1979-2003[60], is the following[61]:

(1) $\Delta \ln TFP_{ijt} = \alpha_0 + \alpha_j \Delta \ln TP_{it} + Outgap_{it} + v_{it}$

$\Delta \ln TFP_{ijt}$ is the rate of growth of total factor productivity in country i, sector j at time t; $\Delta \ln TP_{it}$ is the productivity growth in the transport sector in country i at time t, which could be either the rate of growth of total factor productivity in the transport and communication sector or the rate of growth of labour productivity in the transport sector. The coefficient of $\Delta \ln TP_{it}$ has been allowed to vary over the sectors, so that we are able to estimate the impact of transport productivity growth in each of the five transport user sectors.[62]

The results (not shown) suggest that the impact of TFP growth in the transport and communication sector (or of labour productivity growth in the transport sector only) is never significant: this would imply that higher productivity growth within the transport sector does not seem to be correlated with higher TFP growth rates in the five transport user sectors.

There can be different reasons for this result, the first one being the very stylised nature of the econometric model of equation 1.

First of all, it might be the case that productivity gains in the transport sector could lead to higher productivity in the transport user sectors but not to higher growth rates.

Secondly, our TFP growth refers to the Transport and Communication sector, and therefore we have to acknowledge that our findings might have been driven by productivity developments in the Communication rather than in the Transport sector.

---

[60] As explained in Annex 7, for some countries the full time series 1979-2003 was not available.

[61] Full details of the econometric estimation, as well as the drawbacks of such a model have been reported in annex 7.

[62] FI stands for financial intermediation, RW stands for the retail and wholesale sector, CRP stands for chemicals, rubber and plastics and FBT stands for food, beverages and tobacco.

Furthermore, it is possible that in these sectors-although they have been selected because, a priori, it was considered reasonable to assume that they might be more affected than others from productivity developments in the transport sector - transport costs represent a small share of costs. This, in turn, could make it difficult to identify the effects that productivity developments in the transport sector might have had on the productivity growth of these transport user sectors.

Finally, we could expect a positive and significant impact of higher TFP growth in the transport sector on the TFP growth of transport user sectors only in the presence of increasing returns to scale and/or positive mark-ups in the transport user sectors.

In fact, the Solow residual can be decomposed in three components which can be decomposed in three components which can be attributed to technical change, scale economies and mark-up. Assuming that it might be difficult to capture the technical change in the transport user sectors induced by producitvity growth in the transport sector, the scale economies and mark-up channels would appear to be the most likely channels through which productivity growth in the transport sector can impact on the productivity growth of transport user sectors.

In the case of scale economies, we can note that if a sector is producing with a technology that exhibits increasing returns to scale, then an increase in production, brought about by the cheaper inputs made available by productivity developments in the transport sector, would be associated with a less than proportional increase in inputs and with an increase in productivity growth (as measured by the Solow residual).

As for the mark-up, if the transport user sectors were perfectly competitive, the higher productivity in the transport sector would be passed on to the transport user sectors that would pay lower prices for some of their inputs, which, in turn, would be passed to the final consumers: given the degree of scale economies, that should not affect the rate of growth of the transport users' Solow residual. However, when output prices depart significantly from marginal costs (i.e. in the presence of substantial positive mark-ups) the lower input prices would not be entirely passed on to consumers, and, as a result, we could expect a higher Solow residual.

Our results could therefore suggest that either economies of scale are approximately constant in the five transport user sectors or that their mark ups are reasonably small and these five sectors are therefore approximately competitive.[63]

7.4 Indirect employment effects of the transport sector

In this section, we summarise the additional employment effects that arise due to direct employment in the transport sector. Detailed results are presented in COMPETE Annex 7.

---

[63] However, given the very stylized nature of the analysis, one should not interpret these results to argue that in particular markets within the five transport user sectors we have considered there are not significant competition problems.

Two types of employment effects arise from direct employment: linkage effects and induced effects. Linkage effects refer to the jobs created in the supply or distribution chain, while induced employment or the income multiplier effect is that which arises due to expenditure of the incomes that employees in the transport sector earn. This additional expenditure creates further jobs as the money is spent on goods and services – a ripple effect.

In the absence of availability of a computable general equilibrium model (CGE) or alternative fully specified economic models like econometric or system dynamics models the method that we consider to be the most suitable for assessing sector level change is to use multipliers derived from Input-Output tables. The Input-Output tables allow us to derive the Leontief inverse, which provides information on how much input is required from all other sectors to provide a €1 of output in the sector of interest. We derive output effects from the Leontief inverse tables, and then use industry level output-employment ratios to determine gross employment effects.

The model provides gross estimates of employment i.e. it does not take into account that some employment is displaced from other productive uses, and therefore the results are biased upwards. We adjust these estimates to present net employment effects, which subtracts from the total those employees who might have been displaced from other productive uses. The last data we have available to us to provide a possible adjustment to gross employment is a set of four case-studies conducted by the DfEE (now known as the DfES)[64], which calculates an average re-absorption rate of 52%. In the absence of better data, we use the figure of 52% as a benchmark, and present both gross and net estimates.

An important caveat is that the use of Leontief multipliers in the I-O tables is intended for marginal changes in the output of a particular sector. The multipliers we have calculated can be used to estimate the effects of other potential changes in the transport sector, for example, an increase in output in the rail transport sector of €10m. We would suggest caution in extending these results to very large changes[65]: the effect of transport on the economy is likely to be non-linear and therefore it is not generally acceptable to apply marginal results to the entire sector, or to changes that are very large as compared to the sector as a whole.

In addition the model does not give general equilibrium effects, i.e. it does not take into account possible changes in other industries and the resultant shifts in employment that would arise as the transport sector expands or contracts. The model also does not take account of movements in unemployment in entirely unrelated industries, and so did not involve any prediction about aggregate employment or unemployment levels.

<u>National Income multipliers:</u>

The techniques used to estimate the induced employment that arises from the expenditure of income created by an injection to the economy is more straightforward. A national income multiplier of 1.1 is widely used and accepted.[66] This multiplier suggests that 10 direct jobs in

---

[64] Moore, Barry and David O'Neill (1996) *The Impact of redundancies on local labour markets and the post redundancy experience* Research Studies RS23, Department for Education and Employment

[65] The size of the change can be judged in proportion to the size of the sector. Clearly a change which would double the size of the sector, for example, would not be considered marginal.

[66] For example, in the English Partnerships (September 2004) "Additionality Guide: A Standard Approach for Assessing the Additional Impact of Projects".

the transport sector lead to an additional one job in the wider economy. The table below summarises the results

Table 52: Summary of multiplier effects

		Railways[67]	Land Transport	Water Transport	Air transport	Supporting and auxiliary transport activities	**Weighted average[68]**
Gross Linkage effect	UK	2.27	1.54	3.02	3.02	3.34	**2.69**
	Finland		1.28	1.61	2.08	1.92	**1.51**
	Germany		1.35	2.28	3.20	2.26	**1.91**
	USA	2.56	1.85	4.67	2.32	1.2	**1.73**
Net Linkage Effect	UK	1.09	0.74	1.45	1.45	1.60	**1.29**
	Finland		0.61	0.78	1.00	0.92	**0.73**
	Germany		0.65	1.10	1.54	1.08	**0.92**
	USA	1.23	0.89	2.24	1.11	0.58	**0.83**
Income multiplier effect	All countries	1.1	1.1	1.1	1.1	1.1	**1.1**
Cumulative multiplier (gross)	UK	2.50	1.69	3.32	3.32	3.67	**2.96**
	Finland		1.41	1.77	2.29	2.11	**1.67**
	Germany		1.49	2.51	3.52	2.49	**2.10**
	USA	2.82	2.04	5.14	2.55	1.32	**1.90**

Source: own calculations

The interpretation of the multipliers in the table above is, for example, in the UK, for every 100 jobs created directly in the transport sector, a total of 269 jobs are created in the economy as a whole, out of which 169 are external to the transport sector.

In summary, the table indicates that there are substantial indirect effects, with variation both across sub-sectors and countries. The air and water transport sectors appear to have the strongest external effects while land transport seems to have the lowest. These effects are likely to be key in conducting cost-benefit analysis of additional transport investment as it gives a more accurate picture of employment created than direct effects alone.

---

[67] Consistent data for the Leontief inverse, output and employment in the transport sub-sector was only available for the UK. For the remaining countries, transport is included in the Land Transport sector.

[68] Weighted on the basis of proportion of revenue.

7.5 Conclusions

The main results of this section can be summarized as:

Labour productivity growth in the transport sector over the period 1979/2002 has been, on average, stronger in the EU than in the US.

While in 1979 the US and the EU had similar levels of labour productivity in the transport sector, in 2002 the EU labour productivity was significantly higher than in the US.

TFP levels in the transport and communication sector show a somewhat different picture, with the US being in most years among the three countries with the highest TFP level.

The econometric analysis found some evidence that countries with lower levels of TFP or LP tended to experience higher LP and TFP growth rates over the sample period.

The econometric analysis has also provided some, admittedly weak, evidence that public infrastructure might stimulate TFP growth in the transport and communication sector, especially in countries with more liberalised transport sectors.

Higher degrees of liberalisation in the railway sector seems to be associated with faster rates of growth of TFP in the transport and communication sector and higher rates of growth of LP in the transport sector.

Our input/output analysis seems to suggest that there are substantial indirect employment effects, with variation both across sub-sectors and countries. The air and water transport sectors appear to have the strongest external effects while land transport seems to have the lowest.

8 Importance of transport for competitiveness in the economies of the EU and the US

The economic importance of transport can be measured in several different ways. Four options have been presented throughout this report:

- By estimating the contribution to macroeconomic totals like output, production value or employment.
- By estimating the total expenditures spent for transport i.e. the operating costs of transport.
- By estimating the role of transport in the exchange of intermediate products between sectors.
- By modelling transport productivity and its impacts on the productivity of other sectors.

The following two sections present the findings on the importance of transport, first, focusing on the role of transport as one self-contained sector of the economy, and second as a facilitator of competitiveness.

8.1 The economic importance of transport

Though transport constitutes a derived demand it has a role to play on its own for the European economy. This can be shown by looking at the two main sectors of transport, which is the production of **transport equipment** (i.e. cars, trucks, buses, planes, ships, trains, two-wheelers) and the provision of **transport services** (i.e. rail, road, water, air and auxiliary transport services).

Looking at the share of transport equipment and transport services for the two major macroeconomic indicators employment and production for the two points of time 1995 and 2002 we observe: first, significant shares of transport and, second, differences of levels and development trends for the EU15 and the US (see Figure 27)[69].

Transport equipment is of similar importance for **employment** in both regions laying in the range of 1.43% (US) and 1.89% (EU15) in 1995, respectively, and reducing slightly in importance for direct employment to 1.25% (US) and 1.55% (EU15). **Transport services** contribute a more than twofold higher share to **direct employment.** Again the US shows the lower share with 3.13% while it reaches 3.73% for the EU15 in 1995. Here the trends until 2002 differ as in the US employment remains stable while in the EU15 it is increasing slightly to 3.96%.

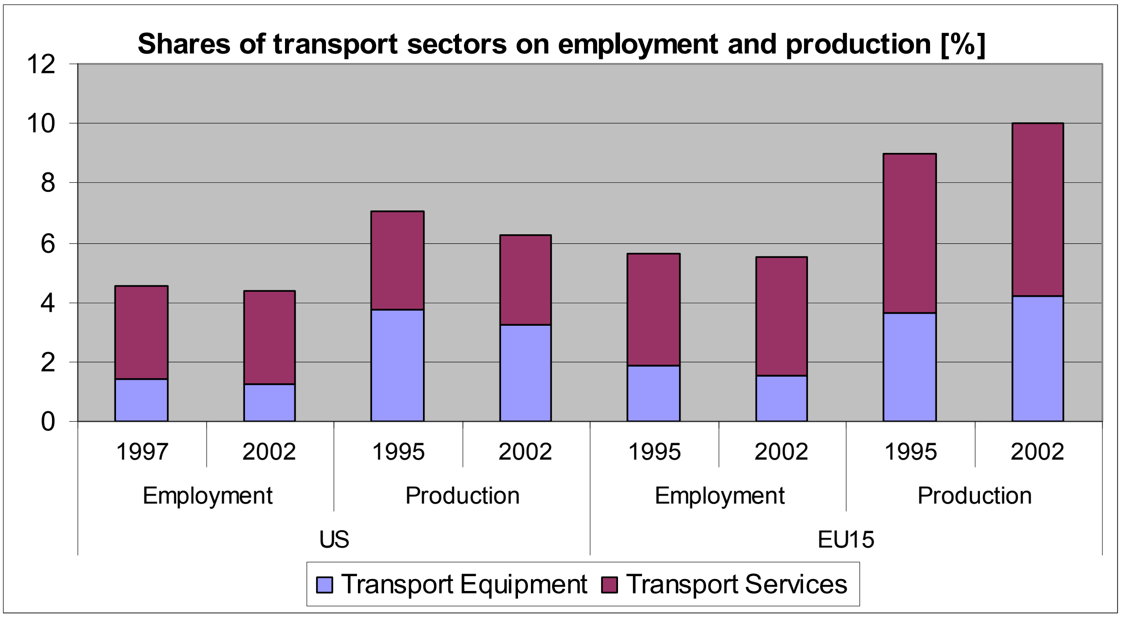
---

[69] For the EU10 no comprehensive past data is available. Looking at selected EU10 countries that dispose of data, different tendencies than for EU15 can be observed. E.g. production value and employment of transport services are declining due to strongly growing car-ownership and private road transport. On the other hand for transport equipment in some countries both employment and production value are growing due to location of new road vehicle manufacturing plants in these countries.

Looking at the contribution of transport to **production** the trends are quite different. In 1995 **transport equipment** in the US contributed 3.75% of total production. In the EU15 the share was slightly lower with 3.62%. In both regions it is at least double the employment share of the total. Until 2002 the trends of production of transport equipment in the US and EU15 differ. For the US a decline to 3.22% is observed (-14%) and for the EU15 a growth reaching a share of 4.2% (+16%).

For the production of **transport services** the levels and developments also differ between the US and the EU15. In the US the share is reduced from 3.32% to 3.04% of total production (-8%). For EU15 it is the opposite: the share grows from 5.38% to 5.82% (+8%), which to large extent comes from the auxiliary transport services (e.g. logistics, travel agencies) and much less from the modal transport services.

The trends of total transport importance (equipment plus services) in the US and the EU15 accordingly differ significantly. For the US we observe a slight decline of the importance of transport between 1995 and 2002 consistently for both employment (from 4.55% to 4.38%) and production (from 7.07% to 6.26%). However, for the EU15 only the share on total employment is reduced (from 5.62% to 5.51%), while the share of **total transport** on production is growing by more than 11% starting at 9% in 1995 and reaching 10.02% in 2002. This confirms that transport on its own constitutes already one of the most relevant sectors in the EU15 in terms of economic importance and that its importance is growing.[70]



Source: own calculations based on EUROSTAT Structural Business Statistics (Online), OECD STAN (Online).

Figure 27: Contributions of transport to employment and production

---

[70] The numbers for production in Figure 27 come from the OECD STAN Online statistics and include some assumptions on missing values to fill data gaps for a few countries. Taking the numbers from the EUROSTAT Structural Business Statistics on sectoral production value following the NACE classification the share of total transport production value (equipment plus services) on total production value would even be higher reaching 13% for the EU25 in 2002. This number would even be larger when sales and maintenance of motor vehicles and sales of fuel would also be considered.

Looking at the results in Figure 27 three things should be kept in mind: first, different data sources provide a bandwidth of results e.g. looking at input-output tables, which are not available for all countries for both points of time, the share of transport on total production value of EU15 in 2002 amounts to 10-11% which is similar than values derived from the OECD STAN but smaller than can be calculated on the base production value taken from the EUROSTAT Structural Business Statistics.[71] In all three cases, it should be kept in mind that the reference total is not GDP, but the total of all production or production value taken from the respective statistics. Second, this result refers to monetary values and hence is not valid in the analysis of decoupling of transport, which focuses on decoupling of physical units (volume or performance) from monetary units (GDP, output, production value). E.g. the increase in logistic services would not show up in the physical units but would be included in the monetary units, which is of course affecting these results since logistics are strongly growing in the last decade.

The result of growing importance of transport in the European economies is also confirmed by the analysis of **labour productivity** of transport services (section 7.2), which concluded that LP grew stronger in the EU than in the US. A deeper analysis focussing on total factor productivity development revealed that this is partially due to higher capital investments in the EU than in the US (i.e. transport infrastructure, vehicles) as in terms of TFP growth the US always ranks amongst the top 3 of the analysed countries. Nevertheless, this confirms that the European infrastructure policy e.g. fostering the implementation of European transport networks and the construction of inter-modal transport terminals provides positive stimuli for the economy.

In terms of **operating cost** (section 2.2), which can be seen as expenditures of an economy for their transport activity, the US spends a higher share of their GDP for transport. This differs from the picture drawn by the share of transport on production (Figure 27). However, the operating cost present partially a narrower picture as they cover merely the transport activity, while e.g. logistics activities are excluded and by these activities the EU generates a larger share of their transport production, and partially a broader picture as the operating cost include expenditures made in non-transport sectors like financial services (e.g. vehicle insurance), energy (e.g. fuel) or trade and repair (e.g. vehicle maintenance).

However, the operating cost analysis seems to indicate another success of the European transport sector and policy as the average cost per tkm of road freight in the US is much higher than in the EU, which could result from the higher input of auxiliary services (i.e. logistics) in the EU leading to better organised freight transport (e.g. higher load factors, better choice of most efficient alternative mode).

We have started this discussion of the economic importance of transport by looking at the direct shares of the various transport sectors on the economy. Now, we turn towards the contribution of transport to the production of other sectors, i.e. the **intermediate input of the transport service sectors** in relation to the production of other sectors documented by

---

[71] Some countries report in their Input-Output-Tables much higher growth of transport importance than derived for the EU15 from the OECD STAN database with +11%. For instance, transport importance measured as share of transport output to total output, i.e. total use in the IO-Tables, grew between 1995 and 2000 for Denmark by +25.1%, for Germany by +23.6% and for Austria by +15.6%.

input-output-tables. This share reflects the dependence of other sectors on transport services in monetary terms. However, with 1.9% for the US and 2.2% for the EU15 it is much smaller than what we have identified as the overall contribution to production above. The differences emerge because of two main reasons: first, own account transport is not included in the intermediates of the transport service sectors of the IO-tables, which should increase this share by roughly one third (derived from Klaus/Kille 2006). Second, private passenger transport also accounts for a significant share of production of the transport sectors (measured in terms of operating cost about one third of European expenditures).

It should be pointed out that all the previous analyses focus on the monetary footprint of transport. Changes of the usage of time, in particular time savings through transport improvements, are only considered as far as they reduce the capital cost (e.g. if fewer vehicles are needed) or wage expenditures (e.g. if fewer personnel is required). But in microeconomic-founded Cost-Benefit-Analysis (CBA), which for instance is used to assess the viability of transport infrastructure projects, the time savings on average contribute the largest share of benefits (e.g. in the previous German cross-modal federal infrastructure plan about 70% of benefits were time savings). To capture a similar indicator as GDP for the national level of analysis it would be required to establish a reporting of (travel) time usage indicators documenting for which purposes time is used.[72] However, there is some evidence that transport improvements that possibly would reduce travel times often are not used to save time but to increase transport distances and to dedicate a constant time budget for transport.

One aspect of this report considers explicitly the time component of transport, which is the congestion analysis. Congestion increases travel time that can be monetised similar as in a CBA and can be put into relation to GDP. With delay cost that amount to about 0.7% of GDP for the EU15 congestion reaches a noticeable level. Three points affecting the importance of congestion should be mentioned: first, from the efficiency point of view a certain level of congestion is reasonable as otherwise the infrastructure would be over-dimensioned and hence inefficient. Second, a large share of this delay cost affects private passenger transport. Third, the interviews conducted with key persons of different economic sectors revealed that besides for two sectors (one of which is the transport services sector itself and the other one is banking and insurance, which is expecting problems for high-level managers due to rising congestion of air transport) congestion is not seen as a problem, but reliability. More precise, the delays caused by congestion are not seen as a significant negative influence on economic activity, as long as they are reliable (i.e. occur regularly and thus can be considered in transport scheduling like the early morning peak-periods), while the uncertainty about arrival times is seen as an obstacle for economic success.

8.2 The influence of transport on competitiveness

We can treat competitiveness from three different angles: first, the cost of intermediate inputs into products and services is a determining influence on competitiveness of products or sectors, and, second, the relative labour productivity or total factor productivity of sectors

---

[72] Such an attempt is made for Germany to analyse comprehensively the time use of different person groups and the time flows between the groups i.e. the time spent of adults for child care e.g. driving of children to school or kindergarden (Stahmer/Herrchen/Schaffer 2004).

compared with the competitors in other countries provides an indicator for competitiveness of a sector. Third, high export shares or dynamic growth of exports also constitute an indication of significant competitiveness of sectors or economies.

We have shown by analysis of input-output tables that the share of transport intermediate input to output is rather small with on average 2.2% for the EU15. However, some sectors reach levels of above 10% in some countries e.g. trade and the transport service sectors themselves. For such sectors transport policies may play a significant role for their competitiveness.

The input-output results are confirmed by the ECOTRA study (TRT 2006). This study identified the shares of transport input in comparison with the value of the final product. The highest share is observed for processed food with 5-10% (e.g. tuna 5.7%, tomatoes 9.5%). For automobiles the share is slightly below 4% and for textiles in the range of 1-3% (e.g. Jeans 0.9%, suit 2.8%). Especially the automobile sector belongs to the crucial sectors of many European economies as it is contributing significant shares of exports. On the other hand with 4% transport input it reaches a non-negligible level of automobile production value. Looking at the transport activities of the automobile sector it can be observed that it is one of the sectors which is increasingly using rail transport, in particular block trains. To large extent this seems to be enabled by the European transport policy of the past 15 years, which focussed on the revitalising of railways in particular by liberalisation e.g. enabling new entries on the freight railway market that specialised for specific goods or sectors like automobiles or chemicals; by harmonisation simplifying or even enabling for the first time significant cross-border rail freight traffic, which is especially important for rail transport that disposes of competitive advantages in particular for longer transport distances; and by promoting the concept of dedicated freight railways, which increases the speed and reliability of rail freight transport. All three measures are still in the process of continued implementation such that it can be expected that in the future they will deliver further contributions to increase the competitiveness of rail freight and hence of important sectors like automobiles or chemicals.

The analysis of the development of labour productivity and total factor productivity (sections 7.2 and 7.3) shows that especially labour productivity of the EU15 revealed a catch-up in comparison with the US in the 1990ies, which would mean that the EU increased its competitiveness compared to the US. However, looking at TFP the US always is amongst the three top countries of the EU15 plus US group of countries. This indicates that capital investment was a driver of the labour productivity growth increasing capital intensity in the transport sectors. This seems plausible also in the light of the EU policies to invest into TEN-T and into inter-modal terminals as well as other goods handling facilities and equipment.

The econometric analysis of TFP growth suggests that investment into public transport and communication infrastructure affects the growth of the transport sector and hence on the whole economy (though with small elasticities of about 0.05 to 0.06). Our growth model produced a similar prediction for the effect of transport infrastructure expenditure on economic growth (in the range 0.05-0.1). These results are of interest particularly because they are compatible with the results of previous empirical studies (discussed in our literature review), but at (or even slightly below) the lower end of the range found previously.

For the influence of liberalisation the econometric analysis found no robust evidence of a significant general direct impact. However, together with the construction of new infrastructure, liberalisation exhibited a significant positive impact on TFP growth — i.e. as a consequence of liberalisation new infrastructure could be used more productively. In addition, in the rail sector, liberalisation had a mild positive direct effect on productivity — this may tend to support our arguments above that in this sector the European transport policy had a significant impact on productivity of the sector and hence also on competitiveness of sectors using rail transport in a growing manner like automobiles and chemicals.

Another issue relevant for competitiveness concerns potential future bottlenecks in the transport system, which would affect reliability as this was mentioned as the most crucial issue by most of the interviewed sectors. The most crucial issue seems to be the bottleneck of the ports in the North Atlantic and Baltic regions and the Hinterland connections of some of these ports. Though the ports infrastructure mostly is of good quality two of the most dynamic economic developments affect these ports: first, the continuous strong growth of world trade (globalisation and extraordinary economic growth of China and India) which to large extent passes through these ports as far as European exports to other world regions are concerned, and second the growing containerisation of freight transport (which even leads in some cases to bulk transport stored in containers) with its specific needs for loading/unloading, storage and Hinterland distribution. If such bottlenecks affect reliability over a longer period, like in the 2004 crisis at the Los Angeles/Long Beach ports in the US, the competitiveness of European economies could be affected.

9 Conclusions

The COMPETE project tackled a number of complex issues circling around transport, congestion, structural change and competitiveness of the European Union as such and in comparison with the US. As far as possible COMPETE aspired to provide hard facts for these issues, which was not always possible.

The Panorama of Congestion broadly revealed that road congestion is mainly a problem for selected cities in Europe, in particular the capitals, for the trunk road network in some Central European countries and for the suburban arterials in a number of other European cities. In contrast, in the US road congestion is not seen as a major issue, neither for interurban transport nor for urban transport.

Despite this perception of congestion not being important the US and Canada set-up congestion monitoring systems that can provide a blueprint for Europe to establish an own congestion monitoring system that enables to observe congestion and to track the impacts of policies on congestion. Such a monitoring system would be started on selected sections of the TEN-T networks and in selected large cities including the European capitals and would measure the delays caused by congestion.

Both in the EU and the US congestion is or could become relevant for those ports and their Hinterland connections that serve a large share of international trade in particular those flows using containers.

A sectoral analysis concerning the vulnerability to congestion concluded that only a few sectors like transport services themselves, agriculture, food and retail sector reveal a high vulnerability to congestion. This result is confirmed both by setoral interviews and by the construction of a quantitative Index on Vulnerability of the Economy to Congestion (IVEC) based on input-output tables for 11 countries. The interviewees pointed out that delays themselves are not a significant problem but (un-)reliability would pose a thread to their businesses.

The econometric analysis of transport suggests that the elasticity of output to infrastructure investments is in the range of 0.05 – 0.1, which is slightly lower than in the literature. Furthermore a catch-up process of labour productivity of the EU15 compared with the US is observed for the mid 1990ies such that at the beginning of this century the EU15 reached a significantly higher level of labour productivity of their transport service sectors than the US.

The importance of transport for the economy seems to be higher for the EU than for the US, which is a difference that largely developed over the past 10 years, which was a period with strong transport policy-making by the EU, such that this should, at least partially, be a consequence of European transport policy.

In particular, the EU policy of liberalisation, harmonisation and implementation of new (cross-border) infrastructure for railways was successful as it raised productivity and hence competitiveness of the railway sector, which was then more attractive for important economic sectors of several EU countries like automobiles and chemicals. Both sectors significantly increased the demand for rail freight service e.g. for transport of automobiles on block trains.

10 Further research questions

Though in theory the COMPETE project was a consultancy service, we had to treat it to a large extent as a research project generating new knowledge but also ending with some new research questions that could not be answered directly. This section briefly outlines a number of these research questions dividing them into research and consultancy questions.

Research questions:

- How reliable and comparable are international input-output-tables for transport economic analysis i.e. how is own-account transport treated and to which extent is transport only a correction factor to balance IO-tables (could be consultancy if only practice of preparing IO-tables is collected by survey).
- What is the value of reliability for passenger and freight transport i.e. willingness-to-pay and meta analysis, proposal for standard valuation (differentiating recurring and non-recurring congestion).
- What is the option value of offering alternative modes to transport users and of being more resilient to external shocks. Is it more efficient to be resilient but more costly as a transport sector or more vulnerable, less costly and the government pays the sector in case of external shocks.
- Cohesion vs competitiveness of the EU: how to design transport policies to make them both fit together.
- Is there an advantage e.g. in terms of employment of a self-sufficient regional economy in comparison with a trade and transport growth driven globalised economy.
- Do innovations of transport generate spillovers to the rest of economy and what is the size of these spillovers (differentiate two kind of innovations new technology and new organization).
- How does increased competitiveness of the transport sector affect and drive the competitiveness of the whole economy i.e. probably requires full economic models like CGE, econometric or system dynamics economic models. In particular, the usability of an explicit time component in such model makes it useful.

Consultancy questions:

- Surveying of trends of out-/insourcing logistics in sectors in the EU and the US.
- Implementation of congestion monitoring system developed with the work of COMPETE on the Panorama of Congestion.
- In-depth analysis of congestion costs in the aviation and in the road freight sector including development of delay costs and mechanisms of cost shifting in competitive markets based on standardised surveys. For aviation the comparison between EU and US would be useful.

11 Glossary of terms

Term	Explanation
Convoy kilometres	Convoy kilometres, in the context of this report, refers to output in the public transport sector defined in terms of the capacity provided for public transport, rather than the actual utilisation of the service.
Cost function	It is a function which relates costs of production to a set of input prices and output level. It results from the cost-minimising behaviour of firms.
Diminishing returns	A fall in the marginal product of an input that occurs as additional units of the input are added to production, holding all other inputs constant
Divisia index	The Divisia index is a weighted sum of growth rates, where the weights are the components' shares in total value.
Economies of scale	When an expansion in output leads to less than proportionate increase in costs, so that average costs per unit decrease
Economies of density	In a network industry, returns to density tells the increase in costs brought about by changes in output, keeping network characteristics (e.g. customers or network length) fixed.
Elasticity	Elasticity measures the percentage change that will occur in one variable in response to a one percentage change in another variable, holding all other things constant. Elasticity of substitution measures the elasticity of the ratio of two inputs to a production function with respect to the ratio of their marginal products. With competitive demands, this is also the elasticity with respect to their price ratio.
Homogeneity of degree N	A function y is said to be homogenous of degree N when, if you scale all arguments in the function by a factor x, the value of the function is multiplied by x^N.
Marginal cost	The marginal cost is the change in cost that arises to produce an additional unit of output.
Marginal product	The change in output as one more unit of an input is added, holding all other inputs constant.
Optimisation problem	The optimisation problem for a firm usually involves profit maximisation: which is either to maximise production for a given level of costs, or minimise costs for a given level of output. An optimal level of inputs is chosen, given assumptions regarding the parameters of the production and cost function. For a consumer the optimisation problem involves maximising utility by choosing levels of consumption of goods, subject to a budget constraint.
Perpetual inventory method	It is one of the most widely used methods to build capital stock series from data on gross fixed capital formation and assumptions on the initial capital stock, scrap rates and (if the final objective is net, rather than gross, capital stock) depreciation rates.
Present value	The present value of a stream of monetary values adjusts the funds for time preferences by discounting appropriately (usually with the rate of interest)
Production function	A function that specifies the relationship between output and the inputs of production.
Public good	A good that has the property that one individual's consumption of it does not reduce others' ability to consume (non-rivalrous). It is also not possible to exclude some consumers from consuming the good once the good has been provided (non-excludable).
Returns to scale	In a production function framework, returns to scale tell, for a given increase in all inputs, the increase in output: there are increasing returns to scale when the increase in output is more than proportional than the increase in inputs.
Shadow price of public infrastructure	The shadow price of public infrastructure is measured as minus the derivative of the cost function with respect to the stock of public infrastructure, so that a positive value means that an extra unit of public infrastructure reduces private costs. The shadow price of public infrastructure might also be defined as the gross return of public infrastructure
Socially optimum	A socially optimum equilibrium is one where the net social benefits are maximised (this includes both private costs and benefits and externalities imposed on others)

Social user cost of public infrastructure	It might be defined as the sum of the depreciation rate, the opportunity cost of public capital and the shadow price of public funds.
Total factor productivity	Total factor productivity is a measure of the output of an industry or economy relative to the size of its factor inputs. A growth in TFP is the growth of real output beyond what can be attributed to increases in the quantities of labour and capital employed.
Tornqvist approximation	Tornqvist approximation is a discrete-time approximation to a Divisia index, in which averages over time fill in the quantities of capital and labour.
Utility function	A function that defines how the utility (well-being) of an individual changes with consumption of the goods, which can also be defined broadly to include leisure.

12 References

ACI - Airports Council International (2005): “Air capacity, efficiency and safety in Europe”. General Comments on Commission Staff Working Document. http://ec.europa.eu/ transport/air/consultation/2005_11_30_en.htm.

AEA - Association of European Airlines (2005): "AEA Comments on the Commission Staff Working Document Airport capacity, efficiency and safety in Europe". November 14, 2005.

AECOM (2001): "Freight Benefit/Cost Study: Compilation of the Literature". FHWA, US Department of Transportation. http://ops.fhwa.dot.gov/freight.

Airlines Gate (2001): “Airports and Airspaces Congestion Issues”. The World of Commercial Aviation. http://airlinesgate.free.fr/articles/.

Appert, M (2004): “Dynamiques territoriales méditerranéenne : dynamiques urbaines méditerra-néenne – Evaluation de la congestion des réseaux routiers urbains : les cas de Montpellier, Nice et Lille”. Report, University of Montpellier.

Aschauer DA (1989): “Is public expenditure productive?”. In: *Journal of Monetary Economics*, vol. 23, pp. 177-200.

Aschauer DA (2000): “Do states optimize? Public capital and economic growth”. In *Annals of Regional Science*, vol. 43, 3, pp. 343-363.

AVV (2005): "Filemonitor 2005". Adviesdienst Verkeer en Vervoer, Rotterdam, February 2005.

BAG - Bundesamt für Güterverkehr (2004): "Marktbeobachtung Güterverkehr, Jahresbericht 2003". Köln.

Bajo Rubio O, Sosvilla Rivero S (1993): “Does public capital affect private sector performance?”. In: *Economic Modelling*, pp. 179-185.

Barkeley M (2004): “Airport Capacity Benchmark Report”. US Department of Transportation, Federal Aviation Association (FAA). http://www.faa.gov/events/benchmarks/.

Barnes G, Langworthy P (2003): "The Per-mile Costs of Operating Automobiles and Trucks". University of Minnesota, Minneapolis.

Barro R, Sala I Martin K, (1992): "Public finance in models of economic growth". In: *Review of Economic Studies*, 59, p. 645 – 661.

Barro R, Sala I Martin K, (2004): "Economic Growth". MIT Press.

Baum H (2001): "Kapazitätssituation der Verkehrsinfrastruktur in Deutschland". Institut für Verkehrswissenschaft an der Universität zu Köln, 2001. Studie für das FOCUS Magazin, in Auszügen veröffentlicht in Focus Nr. 50 vom 10.12.2001, p. 244 - 250.

Bell MGH, Quddus MA, Schmöcker JD, Fonzone A (2004): "The impact of the congestion charge on the retail sector". Centre for Transport Studies, Imperial College London. www.johnlewispartnership.co.uk/assets/pdf/BellReport.pdf.

Bennett, S (2005): "World Cities Research - Report on Comparable Medium Sized Cities". Report prepared for the UK Commission on Integrated Transport. MVA, March 2005.

BGL (2002): "Verkehrswirtschaftliche Zahlen (VWZ) 2002". Bundesverband Güterkraftverkehr, Logistik und Entsorgung (BGL) e. V., Frankfurt am Main.

BGL (2006): "Kosteninformationssystem für leistungsorientierte Kalkulation von Strassengütertransporten". Bundesverband Güterkraftverkehr, Logistik und Entsorgung (BGL) e. V., Frankfurt am Main.

Bisignani G (2006): "State of the Industry Annual General Meeting and World Air Transport Summit 2006". International Air Transport Association (IATA). http://www.iata.org /pressroom/speeches/2006-06-05-01.htm.

Boarnet M (1996): "Spillovers. The direct and indirect economic effect of transportation infrastructure". In: *Department of Urban and Regional Planning and Institute for Transportation Studies, University of California, Irvine. UCTC*, 340.

Bozuwa J, Van der Flier M, Tollenaar R, Vocks L (1999): "Transport costs in relation to Europe's competitiveness on a global level". Institute for Perspective Technological Studies. NEI, Rotterdam.

Bremmer D, Cotton K, Cotey D, Prestrud Ch, Wetstby G (2004): "Measuring Congestion: Learning From Operational Data". Washington State Department of Transportation. http://plan4operations.dot.gov/Docs/WSDOT.pdf.

Brooks MR, Hodgson JR, Frost JD (2006): "Short Sea Shipping on the East Coast of North America: An analysis of opportunities and issues". Canada–Dalhousie University.

BTS (2005): "National Transportation Statistics 2005". Bureau of Transportation Statistics (BTS), U.S. Department of Transportation. Washington DC.

BTS (2006): National Transportation Statistics. Online Document accessed June 2006. URL: http://www.bts.gov/publications/national_transportation_statistics/ .

Cadot O, Roller LH, Stephan A (1999): "A political economy model of infrastructure allocation: an empirical assessment". In: *CEPR Discussion paper*, 2336.

Cadot O, Roller LH, Stephan A (2004): "Contribution to productivity or pork barrel? The two faces of infrastructure investment". In: *DIW Discussions Papers*, 458.

Cambridge Systematics (2004): "Cross Border Short-sea Shipping Study". Final Report prepared for Transport Canada.

Cambridge Systematics (2005a): "Traffic Congestion and Reliability: Trends and Advanced Strategies for Congestion Mitigation". Final Report, Texas Transportation Institute. http://ops.fhwa.dot.gov/congestion_report_04/index.htm.

Cambridge Systematics (2005b): "An Initial Assessment of Freight Bottlenecks on Highways." White paper, prepared for Federal Highway Administration Office of Transportation Policy Studies.

Canaleta CG, Arzoz PP, Garate MR (1998): "Public capital, regional productivity and spatial spillovers". In: *University of Navarra*, mimeo.

CEDR (2004): "European Road Users Survey 2004". Conference of European Directors of Roads, I&O Research Enschede.

CETE Méditerranée (2004) : "Analyse de la saturation routière en PACA" (Provence – Alpes – Côte d'Azur). Report.

Cohen J, Morrison C (2003a): “Airport infrastructure spillovers in a network system”. In: *Journal of Urban Economics*, vol. 54, pp. 459-473.

Cohen J, Morrison C (2003b): “Public infrastructure investment, inter-state spillovers, and manufacturing costs”. Mimeo.

Crowhurst E (2003): "Traffic Speeds in English Urban Areas" 2002. Department for Transport. London, March 2003.

CSCMP (2006) : "2State of Logistics Report 2006". Council of Supply Chain Management Professionals.

De Ceuster G et al. (2005): "ASSESS - Assessment of the contribution of the TEN and other transport policy measures to the mid-term implementation of the White Paper on the European Transport Policy for 2010", Final Report.

DEFRA (2005): "The Validity of Food Miles as an Indicator of Sustainable Development". Final Report. AEA Technology on behalf of DEFRA (Department for Environment, Food and Rural Affairs, UK). Didcot UK.

Delgado Rodriguez MJ, Alvarez Ayuso I. (2000): “Public productive infrastructure and economic growth”. In: *ERSA 39th Congress*.

Denis, McMorrow, Röger (2004): "An analysis of EU and US productivity developments (a total economy and industry level perspective)". Economic Papers, European Commission DG ECFIN, Brussels.

DETR (1998): "National Road Traffic Forecasts" (Great Britain) 1997. Working Paper No. 4, Constraining Forecast Traffic Growth to the Road Network: The Fitting-On Process. Department for the Environment, Transport and the Regions, 1998.

DETR (2006): "National strategy to reduce congestion on America’s transportation network", Department for the Environment, Transport and the Regions, May 2006.

DfT (2000) Transport, Statistics, Roads (2000): "A measure of road traffic congestion in England", Method and 2000 Baseline figures. London, 2000.

DfT (2001): "Vehicle Speeds in Great Britain" 2000, Department for Transport, Local Government and the Regions. Statistical Bulletin (01)18. London, July 2001.

DfT (2003): "Vehicle Speeds in Great Britain" 2002. Department for Transport, Local Government and the Regions, Statistical Bulletin (03)24. London, June 2003.

DfT (2005): "Vehicle Speeds in Great Britain" 2004, Department for Transport, Local Government and the Regions. Statistical Bulletin (05)23. London, May 2005.

DfT (2006). "Transport Trends 2005 edition". Transportation Statistics, Department for Transport (DfT) London, UK. http://www.dft.gov.uk/stellent/groups/dft_transstats/documents/downloadable/dft_transstats_035650.pdf.

Direction Régionale de l’Équipement d’Ile-de-France (2004): "Les Déplacements sur le réseau de vois rapides urbaines d’Ile-de-France". www.sytadin.equipement.gouv.fr.

Dodgson J, Lane B (1997): "The Cost of Road Congestion in Great Britain". NERA Briefing Paper. www.nera.com/image/3897.pdf.

Doll C (2002): "Transport User Cost and Benefit Case Studies". UNITE (UNIfication of accounts and marginal costs for Transport Efficiency) Deliverable 7. Funded by 5th Framework RTD Programme. ITS, University of Leeds, Karlsruhe, November 2002.

DOT (2006): "Air Travel Consumer Report". Issue February 2006. Edited by the Office of Enforcement and Proceedings, Department of Transportation, Washington DC.

DOT (2006b): "National Strategy to Reduce Congestion on America's Transportation Network". Department of Transport, Washington DC, May 2006.

Duggal V, Saltzman C, Klein L (1999): "Infrastructure and productivity: a nonlinear approach". *Journal of Econometrics*, vol. 92, pp. 47-74.

Dunning J (2005): "World Cities Research", Final Report on Comparable World Cities. Report prepared for the UK Commission on Integrated Transport. MVA, March 2005.

EC - European Commission (1992): "The future development of the common transport policy - A global approach to the construction of a Community framework for sustainable mobility". COM (1992) 494, Brussels.

EC - European Commission (1998): "Fair Payment for Infrastructure Use: A phased approach to a common transport infrastructure charging framework in the EU". COM (1998) 466, Brussels.

EC - European Commission (2000): "The Auto-Oil II Programme". A report from the services of the European Commission: Directorates General for Economic and Financial Affairs, Enterprise, Transport and Energy, Environment, Research and Taxation and Customs Union.

EC - European Commission (2001): "White Paper: European Transport Policy for 2010: time to decide". http://europa.eu.int/comm/energy_transport/library/lb_texte_complet_ en.pdf. Accessed July 25th 2005.

EC – European Commission (2002): "European Union: Energy & Transport in Figures 2002". Published by EC DG-TREN and EUROSTAT, Brussels.

EC - European Commission (2003): " European Union: Energy & Transport in Figures 2003". Published by EC DG-TREN and EUROSTAT, Brussels.

EC – European Commission (2005a): "European Union: Energy & Transport in Figures 2005". Published by EC DG-TREN and EUROSTAT, Brussels. http://ec.europa.eu/dgs/ energy_transport/figures/pocketbook/2005_en.htm.

EC - European Commission (2005b): "Air capacity, efficiency and safety in Europe". Commission Staff Working Document, . http://ec.europa.eu/transport/air/consultation/ 2005_11_30_en.htm

EC – European Commission (2005c): "Transport and Energy in Figures 2005". Directorate General for Energy and Transport in co-operation with Eurostat.

EC - European Commission (2006): "Keep Europe moving - Sustainable mobility for our continent. Mid-term review of the European Commission's 2001 Transport White Paper". http://ec.europa.eu/transport/transport_policy_review/index_en.htm. Accessed June 29th 2006.

ECMT – European Conference of Ministers of Transport (1998): "Round Table 110: Road Congestion in Europe". Paris.

Economic Development Research Group (2005): "The Cost of Congestion to the Economy of the Portland Regions". http://www.portlandalliance.com/pdf/Congestion_Report.pdf.

ECORYS (2006): "Analysis of the impact of oil prices on the socio-economic situation in the transport sector". Draft Final Report. ECORYS Transport and Consultrans on behalf of the European Commission, DG TREN. Rotterdam.

Edinburgh City Centre Management Company (2004): "Proposed Congestion Charge Scheme for Edinburgh: An Assessment of its Potential Impact on the Retail Sector". Edinburgh.

ERF – European Union Road Federation (2004): "European Road Statistics: 2004". Brussels.

Ernst & Young (2006): "Review of Transport for London's Assessment of the Business and Economic Impacts of the Congestion Charge in Chapter 6 of *Impacts Monitoring – Third Annual Report 2005*". Final Report, Ernst & Young.

ESRC Transport Studies Unit (2004): "The Economic Costs of Road Traffic Congestion". Discussion Paper from Rail Freight Group. University College London, UK.

EUROCONTROL (2004): "Challenges to Growth Study 2004 (CTG04)". European Organisation for the Safety of Air Navigation, Eurocontrol.

EUROSTAT (2004). "Extra EU trade of Member States by mode of transport". Statistics in Focus, Eurostat. http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-NZ-04-003/EN/KS-NZ-04-003-EN.PDF

EUROSTAT (2006a): "Online Statistics". http://epp.eurostat.ec.europa.eu/portal/page?_pageid=0,1136173,0_45570701&_dad=portal&_schema=PORTAL.

EUROSTAT (2006b): "Relative price levels for new passenger cars in Europe for 2004". Statistics in focus, Economy and Finance 3/2006. Eurostat, Luxembourg.

Evans P, Karras G (1994): "Is government capital productive? Evidence form a panel of seven countries". In: *Journal of Macroeconomics*, vol. 16, pp. 271-279.

FGSV (1997): "EWS - Empfehlungen für Wirtschaftlichkeitsstudien an Straßen" (Recommendations for the economic assessments of roads), Forschungsgesellschaft für Straßen- und Verkehrswesen, Köln.

FGSV (2005): "HBS – Handbuch für die Bemessung von Straßenverkehrsanlagen" (Handbook for the dimensioning of road facilities). Forschungsgesellschaft für Straßen- und Verkehrswesen (FGSV), Köln, edition 2001, revised 2005.

FHWA – Federal Highway Administration (2004): "Highway Statistics 2004". https://www.fhwa.dot.gov/policy/ohim/hs04/mv.htm.

Frost (2006): "Innovation Spurs North American Air Traffic Management Markets". HIS Aerospace. http://aero.ihs.com/news-06Q2/frost-air-traffic-management.jsp.

Giuliano G, Brien Th, Dell'aquila P, Hayden S (2005): "The Terminal Gate Appointment System at the Ports of Los Angeles and Long Beach: An Assessment". TRB 2006 Annual Meeting CD-Rom. http://www.metrans.org/nuf/documents/Giuliano_OBrien.pdf.

GLA (2005): "The congestion charge's impact on retail – The London experience", Working Paper 12, Greater London Authority (GLA) Economics, Authors: M. Quddus, A. Carmel and M. g. H. Bell. London.

Golob TF, Regan AC (2000): "Freight Industry Attitudes Towards Policies to Reduce Congestion". Transportation Research-E, Vol. 36, pp. 55 - 57.

Gramlich EM (1994): "Infrastructure Investment: a review essay". In: *Journal of Economic Literature*, vol. 32, pp. 1176-1196.

Griffith R, Redding S, Van Reenen J (2004): "Mapping the two faces of R&D: productivity growth in a panel of OECD industries". In: *The Review of Economics and Statistics*, vol. 86, pp. 883-895.

Günthner W (2001): "Technische und logistische Maßnahmen zur weiteren Entwicklung der Verkehre über die deutschen und österreichischen Donauhäfen". Studie Donau-Logistik, Garching bei München.

Hamer, R., Jong, G. De, Kroes, E.P. (2005): "The value of reliability in Transport – Provisional values for the Netherlands based on expert opinion". RAND Technical Report Series, TR-240-AVV, Netherlands.

Hansen M, Gosling G, Margulici JD, Wei WB (2001): "Influence of Capacity Constraints on Airline Fleet Mix". Institute of Transportation Studies. Research Reports. http://repositoiries.cdlib.org/its/reports/UCB-ITS-RR-2001-6.

Hartwig KH (2005): "Volkswirtschaftliche Effekte unterlassener Infrastrukturinvestitionen". Institut für Verkehrswissenschaft, Westfälische Wilhelms-Universität Münster, Münster.

Head K, Ries J, Swenson D (1995): "Agglomeration Benefits and Location Choice: Evidence from Japanese Manufacturing Investment in the United States". Journal of International Economics, Vol. 38(3/4, May), pp. 223 - 247.

Holtz-Eakin D (1994): "Public-sector capital and the productivity puzzle". In: *The Review of Economics and Statistics*, vol. 76, pp. 12-21.

House of Commons (2002): "Overcrowding on Public Transport". Seventh Report of Session 2002-03, Volume 1. House of Commons Transport Committee, London.

Hvid EL (2004a): "Traffic Congestion Costs (in the wider Copenhagen Region)". English summary report, COWI A/S, Copenhagen, August 2004.

Hvid EL (2004b): "Trængselskortlægning i Hovedstadsområdet". Full report to the Traffic con-gestion costs study (Danish only).

HypoVereinsbank (2005): "Europas Beste – Vorbilder für deutsche Metropolen im Standortwettbewerb?!" Hamburg – München – Köln. http://www.hypovereinsbank.de /media/pdf/HVB_Metropolenstudie_Berlin_Nov_05.pdf.

IATA - International Air Traffic Association (2006): "Airline network benefits". IATA Economic Briefing No3.

INFAS/DIW (2004): "Mobilität in Deutschland 2002 - Kontinuierliche Erhebung zum Verkehrsverhalten". KONTIV Ergebnisbericht. Institut für angewandte Sozialwissenschaft (Infas) und Deutsches Institut für Wirtschaftsforschung (DIW) im Auftrag des Bundesministeriums für Verkehr, Bau- und Wohnungswesen, Bonn und Berlin.

Infras (1998): "Astra - Staukosten im Strassenverkehr". Schlussbericht. Infras, Bern, 31.12.1998.

Infras (2003): "Stau und Langsamfahrkosten im Kanton Zug". Amt für Raumplanung Kanton Zug. Bern, 22.05.2003.

IRU (1998a): "Economic Cost of Barriers to Road Transport". Executive Summary. The Hague Consulting Group on behalf of the International Road Transport Union (IRU). Geneva.

IRU (1998b): "Economic Cost of Barriers to Road Transport". Full Report. The Hague Consulting Group on behalf of the International Road Transport Union (IRU). Cambridge.

IVV/Brilon (2004): "Engpassuntersuchung für das BAB-Netz - Stufe 2". Report to the Federal Ministry for Transport, Building and Housing (BMVBS), Referat S10. Aachen, Bochum, October 2004.

Kamps C (2004): “New estimates of Government net capital stocks for 22 OECD countries 1960-2001”. In: *IMF working papers*, 67.

Kamps C (2005): “Is there a lack of public capital in the European Union?”. In: *Kiel Institute of World Economics*.

Karp A (2005): “Maxing Out East. Congestion and capacity constraints are threatening the East Coast’s top cargo airports.” Air Cargo World. http://www.aircargoworld.com/ archives/.

Kelejian H, Robinson D (1997): “Infrastructure productivity estimation and its underlying econometric specifications: a sensitivity analysis”. In: *Regional Science*, vol. 76, pp. 115-131.

Kemmerling A, Stephan A (2002): “The contribution of local public infrastructure to private productivity and its political economy: evidence from a panel of large German cities”. In: *Public Choice*, vol. 113, pp.403-422.

Klaus P, Kille C (2006): "Die TOP 100 der Logistik – Marktgrößen, Marktsegmente und Marktführer in der Logistikdienstleistungswirtschaft". 4th edition, Deutscher Verkehrs Verlag, Hamburg.

Koopmans C, Kroes E (2004): "Estimation of Congestion Costs in the Netherlands". Discussion Paper No. 28, Universiteit van Amsterdam. SEO.

Kouwenhoven M., Jong GC de, Rietveld P (2005a): "Reliability Ratio’s voor het Goerderenveroer". Final report to AVV. RAND Technical Report Series, WR-274-AVV, Netherlands.

La Ferrara EL, Marcellino M (2000): “Is public expenditure productive?”. In: *mimeo, Universita’ Bocconi*.

Lakshmanan TR, Anderson WP, Li D (2005): "Growth of U.S. Trade and Industrial Competitiveness: The Role of Transportation". Report prepared for the US-DOT, Boston.

Lakshmanan TR, Anderson WP (2002): "Transportation Infrastructure, Freight Services Sector and Economic Growth". Centre for Transportation Studies, Boston University. http://www.ncgia.ucsb.edu/stella/meetings/20020115/Lakshmanan.pdf.

Link H, Stewart L, Maibach M, Sansom T, Nellthorp J (2000): "The Accounts Approach". UNITE (UNIfication of accounts and marginal costs for Transport Efficiency) Deliverable 2. Funded by 5th Framework RTD Programme. ITS, University of Leeds, Leeds, October 2000.

Maibach M, Rothengatter W, Banfi S, Doll C, Sieber N, Zuber J (2000): "External Costs of Transport 1995". Final Report to the International Union of Railways (UIC), Paris. Zurich, Karlsruhe, April 2000.

Maibach M, Rothengatter W, Doll C, Schneider C, Schmedding, D and Schreyer, C (2004): "External Costs of Transport – Update Study". Final Report to the International Union of Railways (UIC), Paris. Zurich, Karlsruhe, October 2004.

Mamatzakis EC (1999): “Public infrastructure, private input demand, and economic performance of the Greek industry”. In: *Queen Mary & Westfield College Working Paper*, 406.

McKinnon A (2003): "The Effects of Transportation Investments on Logistical Efficiency". Heriot-Watt University, Edinburgh UK.

McKinnon A (2004a): "The Impact of Increasing Traffic Congestion on Logistical Efficiency". Logistics Research Centre, Heriot-Watt University, Edinburgh UK.

McKinnon A (2004b): "Logistics in an Era of Congested Infrastructure". Logistics Research Centre, Heriot-Watt University, Edinburgh UK. www.tnn.co.uk/research/plonearticle.2004-10-27.7615857255.

METRANS (2002): "Transportation, International Trade and Economic Competitiveness". American Association of State Highway and Transportation Officials (AASHTO), Long Beach, California, US.

Ministerio de Fomento (2006): "Observatorio de costes del transporte de mercancías por carretera". Ministerio de Fomento España, Secretaría General de Transportes, Dirección General de Transportes por Carretera.

Moore B, O’Neill D (1996): "The Impact of redundancies on local labour markets and the post redundancy experience". Research Studies RS23, Department for Education and Employment.

Moreno R, Lopez Bazo E, Artis M (2003): “On the effectiveness of private and public capital”. In: *Applied Economics*, vol. 35, pp. 727-740.

Morrison C, Schwartz AE (1996): “State infrastructure and productive performance”. In: *The American Economic Review*, vol. 86, pp. 1095-1111

Munnel AH (1990): “How does public infrastructure affect regional economic performance?”. In: *New England Economic Review*, pp. 11-32.

Muñoz de Escalona, Francisco (2004): La congestión del tráfico urbano. Causas, medidas, costes. Contribuciones a la Economía, September 2004.

Nadiri MI, Mamuneas T (1998): “The effects of public infrastructure and R&D capital on the cost structure and performance of the U.S. manufacturing industries”. In: *The Review of Economic and Statistics*, vol. 76, pp. 22-37.

Nash Ch, Sansom T (1999): "Calculating Transport Congestion and Scarcity Costs". Final Report of the Expert Advisors to the high Level Group on Infrastructure Charging (Working Group 2, ITS).

Nash et al. (2003): "UNITE" (UNIfication of accounts and marginal costs for Transport Efficiency) Final Report for Publication, Funded by 5th Framework RTD Programme.

NCHRP Report 463 (2001): "Economic Implications of Congestion”. Transportation Research Board, National Academy Press, Washington D.C.

NEA (2004): "Cost comparison and cost developments in the European road haulage sector". NEA Transport research and planning. Rijswijk (NL).

NEI (2001): "Competition in East-West Road Transport Markets". An executive summary of a study, commissioned by the IRU. http://www.iru.org/Publications/PDF/Competition.pdf.

Network Rail (2005): Annual Report 2004.

Nicoletti G, Scarpetta S (2003): "Regulation, productivity and growth: OECD evidence". In: *Economic Policy*, April, pp.9-72.

North American Transportation Statistics (2006): "North American Merchandise Trade statistics". U.S. Department of Transportation, Bureau of Transportation Statistics; U.S. Department of Commerce, Census Bureau; Statistics Canada, Transport Canada; Instituto Mexicano del Transporte, Instituto Nacional de Estadística, Geografía e Informática, Secretaría de Comunicaciones y Transportes.

O'Mahoney, Ark (2003): "EU Productivity and Competitiveness: an industry perspective – can Europe resume the catching-up process".

OECD - Organisation for Economic Co-operation and Development (1995): "Urban Travel and Sustainable Development". Paris.

OECD – Organisation for Economic Co-operation and Development (1999): "TRILOG-Europe project". End Report.

OECD – Organisation for Economic Co-operation and Development (2006): "STAN Bilateral Trade Database". http://cs4-hq.oecd.org/oecd/.

Pereira A, Roca Sagales O (1999): "Public capital formation and regional development in Spain". In: *Review of Development Economics*, vol. 3, pp. 281-294.

Picci L (1999): "Productivity and Infrastructure in the Italian Regions". In: *Giornale degli Economisti a Annali di Economia*.

Quddus M, Carmel A, Bell M (2005): "The congestion charge's impact on retail - The London experience". Working Paper No. 12, Greater London Authority. City Hall.

RECORDIT (2001): "REal COst Reduction of Door-to-door Intermodal Transport (RECORDIT) - Deliverable D5: Identification and calculation of taxes charges and subsidies". NO-INRO/ ISIS /Gruppo CLAS/ ZEW /ENPC/ Cranfield University/IER/ TETRAPLAN.

Regan A, Golob T (1999): "Freight Operators' Perception of Congestion Problems and the Application of Advanced Technologies: Results from a 1998 Survey of 1200 Companies Operating in California". Transportation Journal 38 (3): pp. 57.

REVENUE (2005): "Revenue Use form Transport Pricing (REVENUE)". Case Studies Specification. REVENUE Project Deliverable D3. S. Suter, U. Springer, A. de Palma, R. Lindsey, S. van der Loo, A. Ricci, P. Fagiani, P. Moilanen, M. van der Hoofd, M. Carmona and J. Baker. Funded by 5th Framework RTD Programme. ISIS, Rome.

RHA (2006): "Goods Vehicle – Operating Costs 2006". Road Haulage Association (RHA).

Robusté F, Monzón A (1995): "Una metodología simple para estimar los costes derivados de la congestión del tráfico en ciudades. Aplicación a Madrid y Barcelona". Congreso Nacional de Economía. Las Palmas de Gran canaria. Diciembre, 1995. CIES, vol. 3 "Economía del Transporte", pp. 117-123.

Rovolis A, Spence N (2002): “Duality theory and cost function analysis in a regional context: the impact of public infrastructure capital in the Greek regions”. In: *Annals of Regional Science*, vol. 36, pp. 55-78.

Sauvant A. (2002) “Des réserves importantes de capacité à long terme dans les principales lignes ferroviaires à grande vitesse et les grands aéroports parisiens”. Notes de Synthèse du SES.

Schade W, Schaffer A, Czyzewski A, Orlowski W (2004): "Qualitative Assessment of Transport Policy Impacts in Accession Countries, Transportation Infrastructure and Policy: A macroeconomic Analysis for the EU". Cambridge Econometrics. http://www.camecon.co.uk/services/projects/Tipmac/pdfs/TIPMAC_D6_040524.pdf.

Schrank D, Lomax T (2005): "The 2005 Urban Mobility Report". Texas Transportation Institute (TTI). http://mobility.tamu.edu/.

Scottish Executive (2003): Congestion on Scottish Trunk Roads 2003.

Seitz H, Licht G (1995): “The impact of public infrastructure capital on regional manufacturing production cost”. In: *Regional Studies*, vol. 29, pp. 231-240.

Shioji E (2001): “Public capital and economic growth: A convergence approach”. In: *Journal of Economic Growth*, vol. 6, pp 205-227.

Smith ASJ (2006): "Are Britain's Railways Costing Too Much?" Journal of Transport Economics and Policy, Volume 40 Part 1, January 2006, pp. 1 - 44.

Sposavic Lazar N (2001): "Mobility and the Cost of Congestion in New Jersey". New Jersey Institute of Technology. Newark. New Jersey. http://transportation.njit.edu/NCTIP/final_report/Mobility_and_the_Costs_of_Congestion.pdf.

Stahmer C, Herrchen I, Schaffer A (2004): "Sozio-ökonomische Input-Output-Rechnung 1998". German Statistical Office DeStatis, Wiesbaden.

Stephan A (2001): “Regional infrastructure policy and its impact on productivity: a comparison of Germany and France”. In: *DIW Discussions Papers*.

Stephan A (2003): “Assessing the contribution of public capital to private production: evidence from the German manufacturing sector”. In: *International Review of Applied Economics*, vol. 17, pp. 399-418.

Stiftung Warentest (2001): "(Un)puenktlichkeit der Bahn". Stiftung Warentest, 20.11.2003.

Sturm JE, de Haan J (1995): “Is public expenditure really productive? New evidence for the US and the Netherlands”. In: *Economic Modelling*, vol. 12, pp. 60-72.

Sturm JE, de Haan J (1998): “Modelling government investment and economic growth on a macro level: a review”. In: Brackman S, van Eas, H Kuipers SK (eds), *Market Behaviour and Macroeconomic Modelling.* MacMillan Press, London.

Tatom JA (1991): “Public capital and private sector performance”. In: *Federal Reserve Bank of st. Luis*.

TEN-STAC (2003): "Scenarios, Traffic Forecasts, and Analysis of Corridors on the Trans-European Networks - Deliverable D6: Traffic, Bottlenecks, and Environmental Analysis on 25 Corridors".

Transport Canada (2006): "The Cost of urban congestion in Canada". Transport Canada Environmental Affairs March 22, 2006.

TRB (2000): "Highway Capacity Manual (HCM)". Edition 2000. Transportation Research Board, Washington D. C., 2000.

TRT (2006): "ECOTRA: Energy use and cost in freight transport chains". Final Report on behalf of the Institute for Prospective Technological Studies (IPTS), EC DG-JRC. TRT Trasporti e Territorio srl, Milano.

TTI/CS (2004): "Monitoring Urban Freeways in 2003: Current Conditions and Trends from Archived Data". US Department of Transportation, Federal Highway Administration, Washington D.C. Texas Transportation Institute and Cambridge Systematics, December 2004.

Ufficio Italiano dei Cambi (2004): "I costi del trasporto internazionale di merci". Ufficio Italiano dei Cambi (UIC), Roma.

UIC (2006): "International Railway Statistics 2004". Union Internationale des Chemins de fer (UIC). Paris.

UNECE (2000): Census of motor traffic on main international traffic arteries. United Nations Economic Commission for Europe, Paris.

US-DOT – US Department of Transportation (1998): "Transportation Equity Act for the 21st Century (TEA-21)". http://www.fhwa.dot.gov/tea21/index.htm. Accessed June 26th 2006.

US-DOT – US Department of Transportation (2000): "The Changing Face of Transportation". Washington.

US-DOT – US Department of Transportation (2003): "Strategic Plan 2003 – 2008: safer, simpler, smarter transportation solutions". http://www.dot.gov/stratplan2008/ strategic_plan.htm. l Accessed June 26th 2006.

US-DOT – US Department of Transportation (2005a): "Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU)". http://www.fhwa.dot.gov/safetealu/ index.htm. Accessed June 26th 2006.

US-DOT – US Department of Transportation (2005b): "The Electronic Freight Management Initiative". Federal Highway Administration, Washington, D.C. http://ops.fhwa.dot.gov /freight/intermodal/efmi/index.htm.

US-DOT - US Department of Transportation (2006a): "Freight in America -A New national picture". Washington D.C.

US-DOT – US Department of Transportation (2006b): "Air travel Consumer Report: Aviation Consumer Protection Division". http://airconsumer.ost.dot.gov/reports/2006/feburary/ 0602atcr.pdf.

US-EIA – US Energy Information Administration (2006): "International Energy Outlook 2006".

Vanhove F, De Ceuster G (2003): "Traffic Indices for the use of the Belgian motorway network". Working Paper No. 2003-01, Transport & Mobility, Leuven.

Vickermann R (2005): "Evaluating the wider economic impacts of congestion charging schemes: the limitations of conventional modelling approaches". Centre for European, Regional and Transport Economics, University of Kent. Paper for 45th ERSA Congress Amsterdam 2005, http://www.kent.ac.uk/economics/staff/rwv/WorkingPapers/ERSA2005-congestioncharging.pdf.

Viegas, J. M. (2005): "Inter-Urban Road Pricing for Trucks in Europe". Research in Transportation Economics, vol. 11. Elsevier.

VTPI (2006): "The Cost of Driving". Victoria Transport Policy Institute (VTPI). www.vtpi.org/tdm/tdm82.htm.

Washington Research Council (2001): "Congestion Inflates Local Cost of Living". http://www.researchcouncil.org/Briefs/2001/PB01-27/CongestionCPI.htm.

Weisbrod G, Vary D, Treyz G (2003): "Measuring the Economic Costs of Urban Traffic Congestion to Business". Transportation Research Record, Issue No. 1839, pp. 98 - 106.

Wharton D (2005): "Congestion charging schemes for Australian cities". Posted Monday, 25 July 2005 in Australia's e-journal of social and political debate. http://www.onlineopinion.com.au/view.asp?article=3662.

Winsor-Cundell E (2003): "The retail survey: The impact of the congestion charge on the retail sector". The London Chamber of Commerce and Industry, London. www.londonchamber.co.uk/DocImages/395.pdf.

Zugasti A, Garcia RG, Maldonado JS (2001): "The effects of public infrastructure on the cost structure of Spanish industries". In: *Spanish Economic Review*, vol. 3, pp. 131-150.