Main outcomes of a new pan-European meta-model for freight and passenger transport (EXPEDITE)

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Abstract

This paper presents the main results of the EXPEDITE project. The EXPEDITE project was carried out for the European Commission, Directorate-General for Energy and Transport (DGTREN) by a consortium of consultants and institutes (Stratec, ARPA, TØI, Transek, HBVC, ICSTM, ETHZ), coordinated by RAND Europe, as part of the 5th Framework.

The objectives of EXPEDITE were to generate forecasts for both passenger and freight transport for Europe up to 2020, to identify which policies can be effective to achieve substitution from environmental extensive modes to less extensive modes and to identify market segments that are sensitive (and those that are insensitive) to policy measures. The EXPEDITE models cover the geographic area of the 15 EU members, eight Central and Eastern European Countries, Norway and Switzerland.

The paper describes the EXPEDITE approach both for the freight and passenger model. The description includes the role of national freight and passenger sector and the European SCENES and NEAC models. The main focus of the paper will be on the results of the policy runs and the conclusions about the effectiveness of policy measures to shift the transport modes from road and air to other modes.

1. Introduction

The EXPEDITE project was carried out for the European Commission, Directorate-General for Energy and Transport (DGTREN) by a consortium of consultants and institutes (Stratec, ARPA, TØI, Transek, HBVC, ICSTM, ETHZ), coordinated by RAND *Europe*, as part of the 5th Framework. The EXPEDITE project started in May 2000 and was completed in October 2002.

EXPEDITE had the following aims:

- producing multi-modal demand forecasts up to 2020 for passengers and freight transport for Europe (using the NUTS2 zoning system for Europe, with about 250 zones in the study area),
- identifying market segments which react most to control measures, and
- formulating efficient policy bundles to achieve mode switching in line with Common Transport Policy (CTP) objectives (this means substitution away from car and air transport for passengers and away from road transport in freight).

The geographical coverage of EXPEDITE comprises the current EU member states, eight accession countries (Estonia, Latvia, Lithuania, Poland, Hungary, Czech Republic, Slovakia, Slovenia) Norway and Switzerland.

Section two of this paper describes the EXPEDITE approach both for the freight and passenger model. Section three describes the reference scenario and presents a overview of the policy measures. Section four, the main focus of this paper, is on the results of policy runs. In this section an extensive list of conclusions is presented regarding the effectiveness of policy measures mainly intended to shift the transport modes from road to other modes.

This paper does not address the following parts of the EXPEDITE work:

- discussion of international and national passenger and freight models (see EXPEDITE deliverable D2);
- discussion of existing reference scenarios (see EXPEDITE deliverable D3);
- results of Scenes and national model runs (see EXPEDITE deliverable D5, D6 and D7);
- technical specification of the EXPEDITE passenger and freight model (see EXPEDITE deliverable D8).

2. EXPEDITE Approach

The EXPEDITE meta-model has been developed because there is a need to explore a large number of policy options and the impacts on many segments on the transport markets in the EU. The requirements of the EXPEDITE model were that it would run quickly (to test many policy options), includes many segments and that the model covers the whole of the EU and future accession states.

For predictions focusing on long-distance, inter-zonal transport EXPEDITE uses outcomes of runs with one or more European transport models, in particular new runs with the SCENES European model (see SCENES consortium, 2001). The EXPEDITE goals cannot solely be realized by running the SCENES model because existing pan-European models such as the SCENES model are time consuming to run and do not have as many segmentations and sensitivities as needed to analyse the impacts of the policies. Furthermore the pan-European models are inadequate for short distance transport (more than 90% of all passenger trips are below 30 km).

The disaggregate national models used in the EXPEDITE framework do have an extensive segmentation and an adequate modellng of short distance transport. However using the national models themselves as analysis instrument to explore the policy options is also time consuming. Other disadvantages are that international transport is often not included in these models and that there are no national models for all of the countries in the EU25.

2.1 Passenger modelling approach

For forecasts focusing on passenger transport with trip distances up to 160 km, EXPEDITE has developed the EXPEDITE meta-model for passenger transport, based on the outcomes of runs with five national passenger transport models, taken to represent behaviour of travellers. The five national models for passenger transport in EXPEDITE are:

- the Dutch National Model System (NMS or LMS)
- the Norwegian National Model (NTM-4)
- the Italian National Model (SISD)
- the Danish National Model
- the Swedish National Model (SAMPERS).

All five passenger transport models, use disaggregate, behavioural (based on the micro-economic concept of utility maximisation) model structures. These five models are all the existing national models based on this methodology, as far as we are aware.

In EXPEDITE the results of these runs of the underlying models are transferred to other zones in Europe, corrected for specific factors such as may arise from specific geographical differences. Results of the meta-model for a specific zone are obtained by scaling results for a prototypical area to match known totals (e.g. from transport statistics, sector statistics, etc). For a large number of segments within a zone, the meta-model produces a levels matrix (distribution of tours and passenger-kilometres by mode and distance class) and switching matrices for different policy measures. For each zone, expansion factors were calculated depending on the importance of the segments in the zone (many of these weights could be zero for a specific zone).

Within any of the five existing national passenger transport models, simulations were carried out concerning the impact on transport demand of differences in the distribution of the population, employment, incomes, densities, both by looking at the existing inputs for the country and by making the inputs represent other areas. The outcomes of these simulations are used in the meta-model.

Characteristics of the EXPEDITE passenger meta-model
Modes

- Car driver
- Car passenger
- Train
- BTM
- Non-motorized

Travel purpose

- Commuting
- Business travel
- Education
- Shopping
- Other purposes

Distance classes (km)

- 0 – 1.5
- 1.5 – 3.1
- 3.1 – 8
- 8 – 16
- 16 – 40
- 40 – 80
- 80 – 160
- > 160

Segmentation

- Age; under 18, 18 –65, 65 and older
- Gender; male and female
- Occupation; employed and not employed
- Household size; one, two, three, four and more persons
- Household income class (net annual incomein Euro's); < 11300, 11300 –18200, 18200 – 29500, 29500 – 38600 and above 38600
- Car ownership; person in a household without a car, person without driving license in a household with a car, person in a household with car competition, person in a household with car freely available

2.2 *Freight modelling approach*

The EXPEDITE freight meta-model has the same 'look and feel' as the passenger model meta-mode, but is conceptually simpler. The EXPEDITE meta-model for freight is based on runs with four national freight transport models available within EXPEDITE, runs with the SCENES model, and runs with the NEAC model (see Chen and Tardieu, 2000). In the freight meta-model impacts in terms of tonnes and tonne-kilometers of changes in policy variables can only be calculated on top of the levels given for a reference case by SCENES and NEAC. It should be noted that within EXPEDITE only marginal changes are generated in the freight traffic forecast.

The four national models for freight transport in EXPEDITE are:

- the Swedish model (SAMGODS);
- the Norwegian model (NEMO);
- the Belgian model (WFTM);
- the Italian model (SISD).

The first three freight transport models are all built up around a so-called network model (this is a model that searches for the modes and routes that minimize transport cost on the network) while the latter is based on discrete choice theory (explaining choices between alternatives such as modes on the basis of utility maximization).

Characteristics of the EXPEDITE freight meta-model
Modes

- Lorry
- Conventional train
- Combined road-rail transport
- Inland waterway transport
- Maritime transport

Zones

- NUTS 2 level, around 250 zones in larger EU (can be aggregated, e.g. to country)

Distance classes (km)

- 0 – 10
- 10 – 25
- 25 – 100
- 100 – 200
- 200 – 500
- 500 – 1000
- > 1000

Commodity class

- Bulk
- Petroleum and petroleum products
- General cargo

2.3 Applying EXPEDITE

The meta-models for freight and passengers have been used, together with the SCENES and NEAC model,

- to simulate the Reference Scenario;
- to simulate the impact of a large number of policy measures;
- to identify policy-sensitive and non-sensitive market segments;
- to reach statements about feasible and efficient bundles of policy measures.

Running the EXPEDITE model for 1995 or for a future year (2000, 2005, 2010, 2015, 2020) can be called fairly simply and fast running (seconds or minutes). The user can analyze the policy impacts for a large number of dimensions (many combinations are possible) in the passenger meta-model by mode, purpose, geographical unit, distance band and characteristics of the person (age, gender, occupation, household size, household income and car ownership status). In the freight meta-model the user can analyze the results of policies by modes, geographical unit (EU, country, nuts 2 zone), distance class and commodity type. For the user applying the freight meta-model is identical to applying the passenger model.

The policy evaluation modules run sequential to the passenger and freight meta-models. Policy evaluation modules, which use the policy impacts on travel demand from the meta-models as inputs, have been developed to give other impacts of the policy measures on society such as emissions, noise and accidents. For a description of the policy evaluation modules we refer to EXPEDITE publishable final report (MR-1673-DGTREN).

3. Reference scenario for 2020 and policies

3.1 Reference scenario

Several scenarios have been developed for the European Union, in EXPEDITE these scenarios have been reviewed. For the EXPEDITE project a single reference scenario has been selected/developed. The SCENES reference scenario for 2020 functions as the basis of the EXPEDITE scenario. However the EXPEDITE scenario needs to produce forecasts for the intermediate years, the SCENES scenario doesn't, and EXPEDITE needs more disaggregated information (about population segments). For these intermediate years EXPEDITE has developed its own reference scenario, using information from SCENES and other European projects. Car ownership rates in the EXPEDITE scenario differ strongly from the SCENES scenario and are adopted form the ASTRA project.

To show the sensitivity of the predictions to external factors, notably car ownership and income, EXPEDITE also carried out a run with SCENES for 2020 for a scenario that is identical to the SCENES external scenario with the constant cost policy scenario, but that differs in two ways:

- The number of cars per 1,000 persons in 2020 will be 85% of the levels that are in the SCENES constant cost scenario. This implies that car ownership will still grow between 1995 and 2020, but the average growth in motorisation in the EU15 + CEEC8 will not be 61%, but 36%.
- The gross domestic product (GDP) and gross value added (GVA) per head in 2020 will be 85% of what is in the SCENES constant cost scenario. This is consistent with an average economic growth of just above 2% per year.

For both car ownership and income, the distribution by country will remain the same as in the SCENES constant cost scenario: only the average growth is different, not its distribution. This additional scenario is called : 'the 85% scenario'. The scenarios simulated for 2020 with the SCENES model can be summarised as follows (please note that the % changes refer to the entire study area, including the CEEC):

Scenario	*income growth 1995-2020*	*growth in motorisation 1995-2020*
EXPEDITE Reference	*+2.7% p.a.*	*+34%*
SCENES constant cost	*+2.7% p.a.*	*+61%*
EXPEDITE 85%	*+2.0% p.a.*	*+36%*

Figure 1. Percentage growth of car kilometres in trips up to 160 km in Europe 1995-2020 under the Reference Scenario

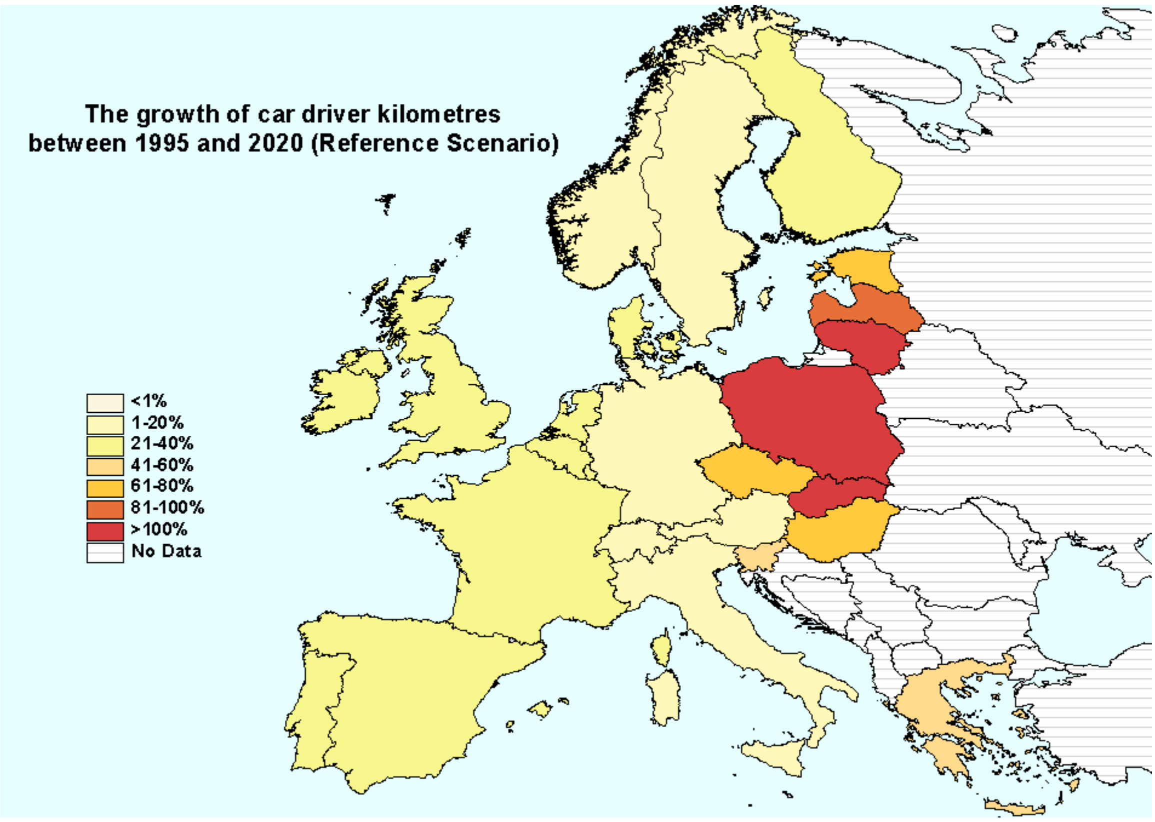
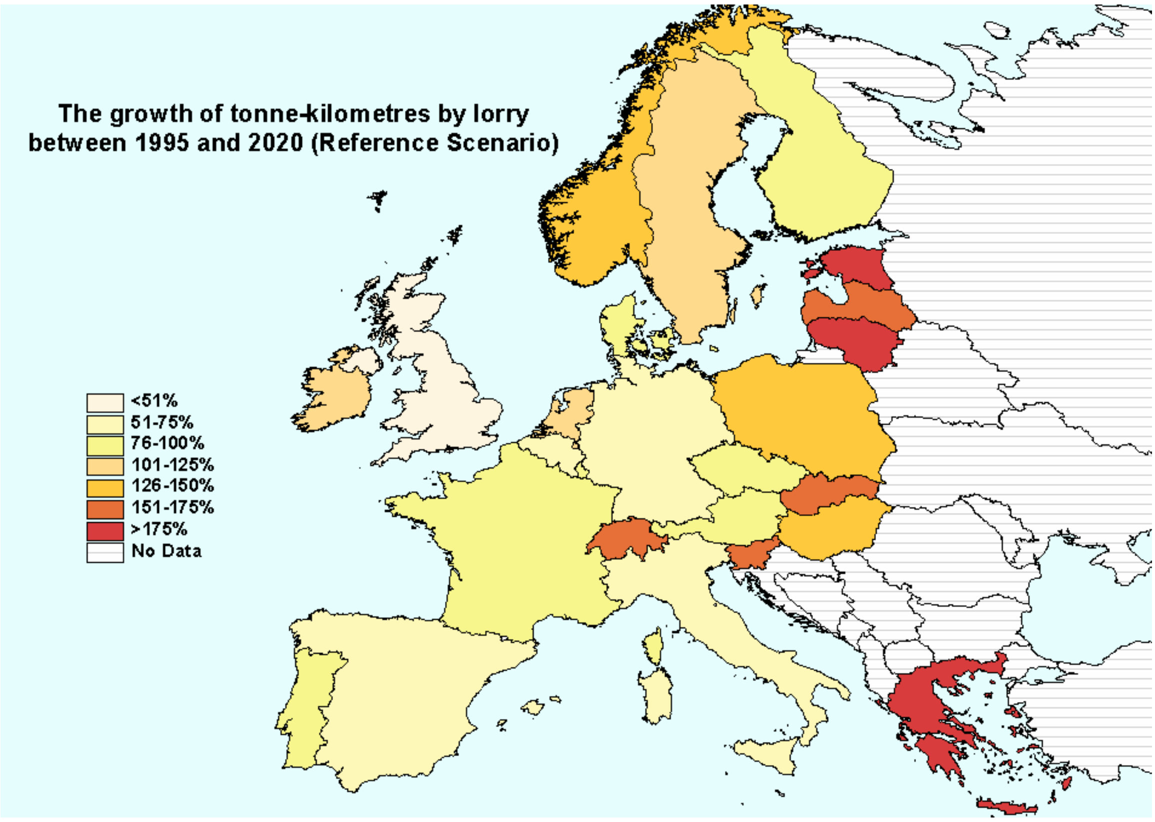


Figure 2. Percentage growth of lorry tonne-kilometres in Europe 1995-2020 under the Reference Scenario (domestic and international transport, by country of generation; Norway: only international transport)



3.2 Policy measures simulated in EXPEDITE

Policy measures considered in EXPEDITE were derived form documents on the Common Transport Policy of the European Commission and from the recent 'Time to Decide' white paper. The selection of policy measures to be simulated in EXPEDITE was discussed with experts at a number of THINK-UP workshops and seminars. The policies listed were classified in Table 1, taking into account the comments made by the experts, using a two-way classification of policy measures:

- whether strong assumptions are needed to simulate the policy in EXPEDITE ;
- the potential for a mode shift away from passenger car, lorry and airplane, towards public transport, freight by train, inland waterways and sea transport.

The policy background of the EXPEDITE project is to determine for which market segments policy measures influence the modal split and which measures are most effective in doing this.

EXPEDITE was tasked with the following policy simulations:

- policy measures in D were simulated first ;
- policy measures from C were simulated in a second round ;
- selected policy measures from B were to be simulated in a third round, if time and budget allows ;
- policy measures in A were not to be simulated.

Table 1. Classification of policy measures for passenger transport (p) and freight (f) (policy measures in italics were added in accordance with the 'Time to Decide' White Paper)

Strong assumptions needed to get model input Potential for mode shift*	Yes	No
Low	***A*** Advanced ICT (unless in relation with intermodality or rail interoperability) *(p-f)* Cost and tax harmonisation *(p-f)* Border effect within EU *(f)* Border effect with non-EU countries *(f)* Harmonisation of social regulations *(f)* Eco-points *(f)* Public transport fare integration *(p)* New trends in logistics *(f)* *Single sky (p-f)* *Revision of slot allocation (p-f)* *Tighter maritime safety rules (f)* *Road interoperability (p-f)* *Reflagging of ships to Union (f)*	***B*** TEN-roads *(p-f)* Rail network electrification *(p-f)* Promotion of teleworking & teleservice *(p)* Promotion of carpooling *(p)*
High	***C*** New urban public transport *(p)* Rail and fluvial interoperability *(p-f)* Market liberalization *(p-f)* Cost internalisation *(p-f)* Maximum speed limits *(p)* Vignette *(f)* Promoting housing densification *(p)* Promoting employment location in corridors along public transport routes or around stations *(p)* *Sea motorways (f)* *Harmonisation of inspections and controls (f)* *Harmonise rules/penalties on speeding (f)* *Deregulation for sea and inland waterways transport (f)*	***D*** TEN-public transport (e.g. HST) *(p)* Intermodality *(p-f)* Interconnectivity *(p-f)* Rail freeways *(f)* Fuel price increase *(p-f)* Congestion pricing *(p-f)* Urban/suburban road pricing *(p-f)* Parking policies *(p)* Public transport pricing *(p)* Infrastructure tariff *(f)*

* Shift away from car, lorry and airplane, towards public transport, freight by train, inland waterways and sea transport.

The outcomes, presented in the next section, are from the first and second round (categories D and C) of policy simulations. Time and budget did not permit to simulate selected measures from category B in the current project (but doing this is possible with the combination of SCENES and the meta-models). The policy measures from D and C were translated into changes in the input variables of the passenger and freight meta-model and the SCENES model. For most policy measures, several changes in the model input variables have been simulated, because there is a great deal of uncertainty about the impacts on travel time and cost by mode of the policy measures. Carrying out simulations for several changes in the inputs can be regarded as a kind of sensitivity testing for different assumptions on how the policies might affect the cost and time by mode.

4. Results of policy runs for freight and passenger transport

The EXPEDITE meta-model for freight and passenger transport has been used to test a large number of policy measures. Furthermore the Scenes passenger model was used for a subset of these policies. Results, both for passenger and freight, were produced in many dimensions including distance bands, purpose/commodity type, geographical units (zone, country, group of countries). The passenger meta-model results can also be split out by population segment.

Policy simulation with the EXPEDITE meta-models gives the impact of various policies on traffic volumes. This is however only a part of the policy assessment, a cost and benefit assessment should include other aspects as well. In EXPEDITE a policy evaluation module has been developed for freight and passenger transport. The approach included the following costs:

- The direct costs of transport (i.e. running vehicles);
- The cost of time spent travelling;
- External costs:
  - Emissions (pollutants and greenhouse gases);
  - Noise;
  - Accidents, safety;
  - Road damage costs (freight transport only);
- Investment, maintenance and operating costs (qualitative judgment)

4.1 Main results of freight transport policies; sensitive and insensitive segments

- If lorry costs increase, there will only be significant shifts at trip distances above 100 kilometres. Below 100 kilometres, road transport is the dominant mode (except for some small niche segments, e.g. shipments between firms with rail sidings or inland waterways or sea terminals at both origin and destination). Policy measures are unable to change this situation below 100 kilometres; it is an insensitive market segment. This is not generally true for shipments with trip distances above 100 kilometres. Here, an increase in lorry cost can lead to substitution, mainly to inland waterways transport (where available) and train.

- If the lorry transport time goes up, there will also be only significant mode shifts for consignments above 100 kilometres. For this change in transport conditions, most of the substitution is towards combined road-rail transport, but also to conventional rail transport.
- If the rail/combined transport cost or time decreases, then for fuels and ores, metal products, basic and other chemicals, large machinery (but only above 100 kilometres) there will be a significant decline in lorry tonne-kilometrage, but a shift will also take place from inland waterways transport (where this mode exists).
- If the cost or time of inland waterways transport decrease, then there will only be a significant reduction of lorry transport for specific countries (where inland waterways transport is a viable option, such as The Netherlands, Belgium, Germany and France).
- If the sea shipping cost or time goes down, there will only be small shifts towards sea transport and no significant reduction for lorry.
- In passenger transport an increase in transport time by x% has a bigger impact than an increase in transport cost by x%. This is not generally true in freight transport; in many situations an x% change in cost has a bigger impact than an x% change in time.
- Elasticities keep increasing with distance after 100 kilometres (especially time elasticities).
- Changes in tonne-kilometres are bigger than changes in tonnes for lorry, while the changes are close to being equal in tonnes and tonne-kilometres for rail and inland waterways. This shows that goods would mostly be transferred between modes in consignments where trip lengths are longer than average lorry trips.
- The most effective policy measures to achieve substitution from road to other modes are (without implying that these are the best policies for society; that depends on the outcomes of the overall evaluation; see the last three bullet points for freight):
  - Increases in lorry cost for all or the higher distances (congestion and road pricing, infrastructure tariff, cost internalisation, kilometre charging, fuel price increase);
  - Increase in lorry time (maximum speed limits, harmonisation of rules on speeding);
  - Decrease in non-road handling and storage cost (intermodality and interconnectivity).
- Policies that make the non-road modes cheaper or reduce the travel times on the non-road networks are less effective for reducing lorry tonne-kilometrage; often they also lead to substitution between the non-road modes.
- Effective policy bundles should contain elements of the three most effective policies (increased cost and time for road, lower non-road handling and storage cost). Decreasing the non-road travel times and cost can only have a substantial effect on substitution away from the road mode if the bundle includes measures that make all non-road modes more attractive. Otherwise, there will be a large amount of substitution between the non-road modes.
- To make polices effective the target segment should be shipments above 100 kilometres. Also policies targetted at bulky products are more effective for substitution from road to the other modes than policies focusing on other commodities.

- Increasing the lorry cost (one of the three effective types of policy mentioned above) leads to increases in the cost for the users of transport, which according to the evaluation carried out, are not compensated by the reduction in external cost for society as a whole (emissions, noise, accidents). On the other hand this type of policy increases government revenues.
- Policies that increase the lorry transport time (another of the three effective types of policies) increase the time cost of transport users, but decrease the driving cost of the user and the external cost (because of substitution from road to modes that are cheaper and have lower external cost). The total internal and external costs remain more or less the same, according to our evaluation.
- Intermodality and interconnectivity, simulated as a decrease in handling and storage cost (the third of the above effective policies) reduce both internal user cost and external cost of transport. These policies however require substantial investments in infrastructure and do not generate government revenues.

The above conclusions on the policy measures for freight transport are summarised in the table below.

Summary table for the assessment of policies for freight transport

	Effectiveness (modal shift from road to other modes)	**Change in internal and external transport cost**	**Required investment and operation and maintenance cost**
Intermodality	High	Small user cost reduction	Medium
Interconnectivity	High	Small user cost reduction	Medium
Congestion and road pricing	High	Big user cost increase	Low and government revenues
Parking policies	Low	Big user cost increase	Low and government revenues
Infrastructure tariff	High	Big user cost increase	Low and government revenues
Rail and fluvial interoperability	Medium	Small user cost reduction	Medium
Market liberalization (rail)	Medium	Small user cost reduction	Low
Cost internalisation	High	Big user cost increase	Low and government revenues
Maximum speed limits	High	No change in user cost	Low
Vignette, Eco-points, km charge	High	Small user cost increase	Low
Sea motorways	Low	Small user cost reduction	Low
Harmonisation of inspections and controls	High	Small user cost increase	Low
Harmonisation of rules on speeding	High	No change in user cost	Low
Deregulation for sea and IWW	Low	Small user cost reduction	Low
Fuel price increase	High	Big user cost increase	Low and government revenues

4.2 Main results of passenger transport policies; sensitive and insensitive segments

- Policies that increase car cost (fuel price increase, congestion and road pricing, parking policies, infrastructure tariff, cost internalisation), will only have limited mode shift effects, especially for business travel. There will be non-marginal reductions of car use, but most of the impact on car kilometrage is due to destination switching. The biggest reduction in car kilometrage is found for 'other' purposes (social and recreational traffic).
- Policies that lead to an increase in car time (speed limits, speed controls) are a relatively effective means of reducing car use (again mainly through destination switching, not mode shift). This does not automatically imply that these are the most desirable policies for passenger transport; this also depends on the other impacts (see the evaluation outcomes below) of the measures than just the impacts on the transport volumes.
- Air transport (especially the leisure segment) is very sensitive to the level of the airfares.
- Increasing travel time by x% has a larger impact than increasing travel cost by x%. This goes for changes in cost and time for all modes.
- Policies that decrease the public transport cost or time (intermodality, interconnectivity, public transport pricing, rail and fluvial interoperability, rail market liberalisation), will have a large impact on kilometrage for the mode itself (or these modes themselves), but a very limited impact on car use.
- Elasticities (in absolute values) increase with distance.
- None of the policies simulated was really effective in shifting passengers from car driver to the non-car modes. Policies that increase the car cost or time are most effective in reducing car kilometres (mainly through destination switching, not much modal shift), but considerable increases in car cost or time are needed for this. To be effective in reducing car use, a policy bundle should include elements of a car cost and/or car time increase. At the same time, such a policy could be complemented by policies that make public transport more attractive (also for equity purposes and to provide accessibility to lower income groups).
- Segments of the passenger transport market that might be targeted because of their higher than average sensitivity to policy measures are long distance travel and social/recreational travel (and by definition for policies that make car less attractive: travellers from car owning-households). We did not find clear differences between the responsiveness of different income groups, area types and countries.
- Policies that make public transport cheaper or faster, such as public transport pricing, intermodality, interconnectivity, new urban public transport, interoperability and rail market liberalisation lead to a reduction in the total internal and external cost of transport. Such policies increase the user benefits from transport, because the public transport users have lower fares or lower time costs, and at the same time (slightly) decrease the external effects. Not taken into account here is that the revenues of the public transport operator might decrease when the fares are reduced. Most policies that make public transport more attractive require substantial investment and/or operation costs.

- Promoting housing densification or employment densification leads to a decrease in the external costs, but the increase in internal cost for the travellers dominates the picture.
- Cost internalisation, congestion pricing, road pricing, parking policies, harmonisation of rules on speeding, maximum speed limits and fuel price increases all make car more expensive or slower. This leads to a substantial increase in the user cost (the travellers have to pay more or incur higher time costs), which is not outweighted by the reduction in the external cost for society as a whole. Therefore all these policies lead to an increase in the total internal and external cost of transport. Not taken into account here is that the policy measures that increase the cost for transport users also increase government revenues (there is a shift of taxes or charges from the transport users to the government). Moreover, policies that make car less attractive usually have lower investment cost than policies that make public transport more attractive.

The above conclusions on the policy measures for passenger transport are summarised in the table below.

Summary table for the assessment of policies for passenger transport

	Effectiveness (modal shift from road to other modes)	**Change in internal and external transport cost**	**Required investment and operation and maintenance cost**
Intermodality	Low	Big reduction	Medium
Interconnectivity	Low	Big reduction	Medium
Congestion and road pricing	High	Medium increase	Low and government revenues
Parking policies	High	Medium increase	Low and government revenues
Rail and fluvial interoperability	Low	Small reduction	Medium
Market liberalization (rail)	Low	Small reduction	Medium
Cost internalisation	High	Big increase	Low and government revenues
Maximum speed limits	High	Big increase	Low
Harmonisation of rules on speeding	High	Big increase	Low
Public transport pricing	Low	Big reduction	Medium
New urban public transport	Low	Medium reduction	Medium
Fuel price increase	High	Big increase	Low and government revenues
Housing and employment densification	Low	Big increase	Medium

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