The EXPEDITE project: applying meta-models for passenger and freight transport in Europe

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Abstract

In the EXPEDITE project, carried out for the European Commission, a model was developed and applied in forecasting and policy simulation for passenger and freight transport, with the following characteristics:

- It is fast and easy to use, so that it can be run for many policies and packages;
- It distinguishes between many different population segments, so that differences in behaviour can be incorporated, as well as differences in how policy measures affect the segments;
- It focuses on representing transport over everyday distances.

The EXPEDITE meta-model for passenger transport integrates results from the five discrete choice national model systems and the SCENES European model. For freight, outcomes from runs with two European transport models and four national models are used. It has been applied for a Reference Forecast for 2020 and many policy measures focussing on the impact on the modal split in passenger and freight transport.

Keywords: European transport model, passenger transport, freight transport, transport forecasts, transport policy simulation, meta-model.
Topic area: transport modelling.

1. Introduction

In its White Paper on **European Transport Policy in 2010 'Time to Decide'**, the European Commission (2001) accepts that at the European level, as at local and national levels, the answer to traffic emissions, accidents and chronic delays cannot just be to build new infrastructure and open up markets. A large number of pricing and regulatory policy measures is proposed to shift the balance between modes of transport, notably to reduce the growth of road and air traffic. Little is known about the effectiveness of these measures at the European scale and about the groups of society that will be affected most.

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In Europe, many transport models are available at the national and regional level. Furthermore, there are models at the European scale. However, these are usually network-based models with considerable run times. Moreover, these large European models can only provide a limited number of segmentations of the population and policy sensitivities, especially for short distance transport (more than 90% of all passenger travel in European countries is on trips below 30 km).

Therefore, there is a need for a model with the following characteristics:

- ❖ The model is fast and easy to use, so that it can be run for many policies and bundles of policies;
- ❖ The model distinguishes between many different segments of the population, so that differences in behaviour can be incorporated, as well as differences in how policy measures affect the population segments;
- ❖ The model focuses on representing transport over everyday distances, to complement the long-distance models developed for trans-European travel.

In the EXPEDITE project, carried out for the European Commission, such a model was developed and applied in forecasting and policy simulation. Actually there are two models: the meta-model for passenger transport and the meta-model of freight transport, each with different building blocks, but with the same 'look and feel' for the user.

2. General methodology

Meta-analysis can be described as the statistical analysis of analyses. It is a research method for systematically describing and analysing existing findings on some quantitative relationship (see Button et al., 1999). These definitions also apply to the EXPEDITE meta-models, but these meta-models differs from the usual approach in meta-analysis. Most meta-models are based on results from the literature, whereas the EXPEDITE meta-models integrate results from runs with 'underlying' models, that have been carried out within the EXPEDITE project itself.

The EXPEDITE meta-models are not intended to replace detailed network-based models, but to offer the possibility of a quick scan for the effects of a large number of policy measures. More detailed studies for promising measures and for the assessment of specific infrastructure projects should then be done using the network models.

2.1 The meta-model for passenger transport

The EXPEDITE meta-model for passenger transport integrates results from the following models (see EXPEDITE Consortium, 2000):

- ❖ Five national models:
  - ➢ 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).
- ❖ The SCENES European model.

These five national models are all based on disaggregate, behavioural methods (see Ben-Akiva and Lerman, 1985).

A large number of runs have been carried out (up to 80 runs per model) with each of the above national models and with the SCENES model for passenger. To the maximum possible extent, the same runs were done with each of the models. For the base-year (1995), outcomes were generated in the form of 'levels matrices'. The levels matrices for tours give the number of tours per person per year by mode and distance band. A 'tour' is defined as a round trip, starting and ending at home. The levels matrices for passenger kilometres give the number of kilometres travelled per person per year, by mode and distance band. The modes are:

- car-driver;
- car-passenger;
- train;
- bus/tram/metro;
- non-motorised.

There are different levels matrices (tours and kilometres) for five travel purposes and for many population segments. The travel purposes in the meta-model for passenger transport are:

- commuting;
- business;
- education;
- shopping;
- social, recreational and other.

The socio-economic and demographic population segmentation used in the meta-model is as follows:

- age distribution (<18, 18-<65, >=65);
- gender (male, female);
- occupation of persons (employed; not employed);
- household size (1, 2, 3, 4+);
- household net income class (0-11300, 11300-18200, 18200-29500, 29500-38600, 38600 Euro per year);
- car ownership (person in a household without a car, person without a driving licence in a car-owning household, person with a licence in a household that has more driving licences than cars, person with a licence in a household that has at least as many cars as licences).

Besides levels matrices for 1995, the outcomes of the national model runs also consist of switching matrices: changes in tours or in passenger kilometres (same units as the levels matrices), as a result of a change in a policy-related model input variable. There are switching matrices for changes in the running cost of the car, travel times by car, and for cost, in-vehicle time, wait and transfer time and access/egress time of train and bus/tram/metro. Runs for different percentage changes (e.g. +10%, + 25%, +40%, -10%, -30%) were carried out, because the travel demand response to cost and time changes may very well not be linear.

For each segment, the levels and switching matrices in tours and kilometres from all five national models were averaged (unweighted) to get the "prototypical" matrices that are used in the meta-model to forecast for Europe.

The zoning system in the meta-model, as in the SCENES model, is the NUTS2 level. At this levels there are around 250 zones in the following study area:

- the EU15;
- Norway;
- Switzerland;
- Estonia;
- Latvia;
- Lithuania;
- Poland;
- Hungary;
- The Czech Republic;
- Slovakia;
- Slovenia.

For each zone, expansion factors were calculated depending on the importance of the population segments in the zone (many of these weights could be zero for a specific zone). By multiplying the tours and passenger kilometres from the prototypical matrices with the expansion factors, initial predictions for each of the zones are derived. These are forecasts for all travel demand generated in the zone, with one-way distances up to 160 km, by mode, distance class, travel purpose and population segment.

These initial forecasts are first corrected for differences in travel behaviour by area type and by road and rail network type, based on runs with the Dutch national model, the ANTONIN model for the Paris region and the SCENES model. These factors were not taken into account in the population segmentation, and therefore they are included in a subsequent step. The area types used in EXPEDITE are:

- metropolitan;
- other big cities;
- areas around the metropolitan areas;
- areas around the other big cities;
- medium density areas;
- low density areas;
- very low density areas.

For road and rail network type, there are five categories, depending on the density of the network. In this correction the use of public transport and non-motorised modes in metropolitan areas is increased, as is car use in the areas with lower density, at the expense of the other modes.

The model forecasts for 1995 that result after applying the area and network type correction factors have been validated against observed data on the use of each mode (if available by distance class), by country. This has resulted in a set of mode-specific, distance-class-specific and country-specific correction factors, which are also kept in forecasting.In this way, the meta-model accounts for 'residual' factors affecting travel demand, such as climate, hilliness and historical developments.

This meta-model for passenger transport also includes area-wide speed-flow curves (as in Department of the Environment, Transport and Regions, 2000) to take account of the feedback effect of changes in congestion due to policies that change the amount of car use.

The meta-model for passenger transport based on the five national models, is for travel up 160 km. To obtain forecasts for all distance bands, results from the SCENES model for travel above 160 km can be added to those of the meta-model (this can also be done within the EXPEDITE meta-model, 'reproducing' SCENES based on the outcomes of a number of runs with the SCENES model carried out within the EXPEDITE project).

Calculating the impact of policy bundles

For a change in travel time or cost for which the national models have not been run (e.g. +20%), we could have derived the switching matrices by linear interpolation between the matrices of a 10% change and a 25% change. This would amount to assuming a piece-wise linear response to cost changes. However, in the meta-model we try to account for the non-linearities in the response to policy changes by going back to the original logit formulation, as used in the national models. This method is also used to calculate the impact of a policy bundle

A policy bundle is a combination of individual policy measures (e.g. increase in car cost and decrease in public transport cost). A limited number of policy bundles have been tested in the national models, and change matrices for these bundles are directly available for use in the meta-model. For all other policy bundles, the meta-model calculates the effects of the combination of policy measures from the results of individual policy measures, taking account of non-linear effects:

- sub-additivity: the combined effect is less than the sum of the separate effects
- super-additivity: the combined effect is more than the sum of the separate effects.

The method used can lead to both types of effects, depending on the location on the logit curve.

Measure of welfare change

These underlying utility functions are also used to calculate the change in the logsum, that is caused by a policy measure or bundle. This gives the change in consumer surplus (see Small and Rosen, 1981), and can be segmented by population segment to analyse how different population segments are affected by a policy.

2.2 The meta-model for freight transport

Within the EXPEDITE Consortium, a large number of freight transport policy runs have been carried out with the SCENES European transport model and with four national models for freight transport (see EXPEDITE Consortium, 2000):

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

The first three freight models use assignment to multi-modal transport networks, whereas the Italian model uses discrete choice theory, as in the national models for passenger transport.

The amount of freight transport by mode, distance band and commodity class for 1995 and the 2020 reference is taken from the SCENES (for the current fifteen member states of the EU) and NEAC (for the accession countries) models/databases. The EXPEDITE meta-model can only give the impact in terms of tonnes and tonne-kilometres of changes in policy variables such as the transport time ands cost by mode, on top of the levels provided by SCENES and NEAC. For this, the EXPEDITE meta-model for freight contains almost 3,000 elasticities, which are unweighted averages of elasticities from the four national models and the SCENES model.

The modes considered are:

- road transport;
- conventional train;
- combined road-rail transport;
- inland waterways transport;
- maritime transport.

3. Use of the meta-models for forecasting

3.1 The Reference Scenario

EXPEDITE has chosen the SCENES Reference Scenario for 2020 as the basis for its own Reference Scenario. For the intermediate years for which EXPEDITE needs to produce forecasts (2005, 2010, 2015), the SCENES project could only provide some aggregate information. For these years, EXPEDITE developed its own Reference Scenario, using information from SCENES and other European projects.

In SCENES the scenarios for 2020 consist of two elements. The first is called the 'External' scenario, to emphasise that it includes autonomous changes, not policy changes. The second component is a transport scenario.

The EXPEDITE Reference Scenario includes for 2020:

- Population will grow in most EU15 countries, but will decline in some (e.g. Italy); Net migration is included in these forecasts. In the Central and Eastern European countries (CEEC), population will decline somewhat, except in Poland and the Slovak Republic; By the year 2020 the total EU15 population will have grown by almost 4% compared to 1995.
- The share of persons of 65 year and older will increase.
- Employment will increase in most EU15 countries, but will declines in some (e.g. Greece); the same applies to the CEEC.
- Car ownership rates per 1000 persons will increase in all countries, especially in Eastern Europe; for the EU15 by about 25% in total, for some CEEC countries the motorisation rate will almost double. For the EU15, EXPEDITE adopted the ASTRA forecasts on the future number of passenger cars per 1000 persons. The SCENES consortium adopted growth rates from the PRIMES project, which give a total growth in motorisation in the EU15 of 50% in the period 1995-2020. It has been argued that these growth rates are too high (notably for the EU15), and we agree with this. Therefore we have chosen the

–lower- ASTRA forecasts for the EU15. For the CEEC, the predictions on motorisation from the SCENES Internet Database are used.

- For most EU15 countries the gross domestic product (GDP) will in the period 1995-2020 grow by between 2 and 3 % per year; in the CEEC the growth rates are 4-5.5%. We also tested a scenario with a lower income growth.
- The transport networks will be expanded according to planned national and international infrastructure developments (especially the European Commission's 'TEN Implementation Report'); the networks are the same in all scenarios tested using the SCENES model, unless otherwise specified. In the runs with the EXPEDITE meta-models (which are not network models), we use the assumption that in the Reference Scenario in the EU15 the travel times will stay the same. Where travel demands grow over time, at some links the new demand may exceed the old capacity. Here our assumption implies that capacity will be expanded to keep the network performance at the 1995 level. For the CEEC we assume that the network performance of the road and rail networks will become better between 1995 and 2020, moving towards West-European standards.

In SCENES there are four different transport scenarios, both for passenger and freight transport. The only differences are in the future levels of transport cost by mode, the networks and travel times are the same in all scenarios tested. For both passenger and freight transport we used one of the four, the constant cost transport scenario: all modes have constant cost in real terms.

For the CEE countries (both for passenger and for freight transport) there is only one scenario in SCENES with decreasing car cost (following past Western European developments) and increasing public transport cost (less subsidies, privatisation).

In EXPEDITE we use the combination of the SCENES external scenario (but modified for motorisation in the EU15) with the SCENES constant cost scenarios for passengers and freight as the Reference Scenario for 2020. In the following, this scenario is called the 'EXPEDITE Reference Scenario'.

3.2 Forecasts for passenger transport with one-way distances up to 160 km

The meta-model yields a limited overall growth in the number of tours for the distances up to 160 km in the period 1995-2020 in the Reference Scenario: +5%. Please note that travel for longer distances is predicted to grow much faster than this (see below). The mode that grows fastest is car driver (+22%).

As can be seen in Figure 1, for car passenger and train as main mode, there is also a growth in the number of short distance tours per year (+4% and +10% respectively). Bus/tram/metro tours and non-motorised (walking, cycling) tours will between 1995 and 2020 decrease by 12% and 5% respectively, according to the meta-model.

The total number of passenger kilometres (in trip distances up to 160 km) grows faster than the total number of tours: +10% versus +5% for the period 1995-2020. There is thus not only an increase in the number of tours, but also in the average tour distance. As for tours, car driver is the mode with the highest growth (24% more passenger kilometres in the study area). Car passenger grows by 4% and train traveller kilometrage by 5%. The kilometrage travelled by bus/tram/metro and by the non-motorised modes will between 1995 and 2020 decline by 6% and 9% respectively.

- See here Figure 1 -

The variation between countries is considerable, as can be seen from Figure 2.

- See here Figure 2 –

The increase in the number of kilometres as car driver is lowest in countries which already have the highest car ownership levels, such as Italy and Germany. It is highest in the CEEC, where the number of car-driver kilometres sometimes goes up by more than 100%. These high growth rates of car use are mainly caused by the predicted increases in car ownership and income in the CEEC (to a lesser extent also by the increased performance of the road networks).

3.3 Forecasts for passenger transport at all distance bands

To get forecasts for passenger transport for all distance bands, the meta-model results for trip distances up to 160 km need to be combined with results for the longer distances from the SCENES model. In Figure 3 forecasts from both models are combined.

- See here Figure 3 –

In the SCENES model, there is no distinction between car driver and car passenger; the ‘car’ mode includes both. For this mode we see for the longer distances (both for work-related travel, such as commuting, business trips, and for leisure trips) a large increase, much larger than for the short to medium distances, in passenger kilometrage between 1995 and 2020. Also for long distance train transport, a big growth is predicted. For bus transport, there is no significant work-related long-distance travel, but there is for leisure travel. The latter is also predicted to grow considerably. But the largest growth by far (+5.6% per year) is for long distance air travel, both for leisure and work-related travel.

3.4 Forecasts for freight transport (all distance bands)

The growth in tonnage lifted for all the countries together over the 25-year period is 41%. Tonnes by lorry (used here to indicate all goods transport by road) increase by almost the same percentage: 39%.

The total growth in tonne-kilometrage (79%) between 1995 and 2020 is almost twice as high as for tonnes: the average transport distance is increasing quite a lot. The increase in GDP in the study area is of the same magnitude as the increase in tonne-kilometres. In terms of tonne-kilometres, lorry transport (+89%) grows more than average (+79%), whereas in terms of tonnage growth, lorry was just below the average growth percentage. The reason for this is that lorry grows fastest in the distance classes 500-1000 km and >1000 km.

If we look at the non-road modes, then we see that in the EXPEDITE Reference Scenario, in terms on tonnes, inland waterways transport, and rail transport grow slightly more than average, and sea transport considerably more. But for tonne-kilometres the picture is quite different: rail grows as fast as the total does, inland waterways and sea transport grow less fast and lorry grows fastest. For train the distance class pattern is the same as for lorry, but less pronounced. Inland waterways and sea transport do not witness extra growth in tonne-kilometrage at the large distance end. Therefore their increase in overall tonne-kilometrage is not much bigger than the growth in tonnes.

4. Outcomes of policy simulations

4.1 The policy measures simulated in passenger transport

The policy measures simulated with the meta-model were mainly taken from documents of the European Commission on the Common Transport Policy (CTP), including the 'Time to Decide' White Paper (European Commission, 2001). The selection of policy measures was also discussed with experts at a number of THINK-UP workshops and seminars. The focus in the simulations is on policies that might lead to a substitution in passenger transport from car to public transport and non-motorised modes and in freight transport from lorry to rail and sea and inland waterways-based modes. The policy measures and the way these were translated into input variables for the meta-model are given in Table 1.

4.2 Outcomes of policy runs for passenger transport

The meta-model for passenger transport was used to simulate the amount of tours and passenger kilometres in 2020 for each of the policy measures in Table 1 (see EXPEDITE Consortium, 2002). The outcomes (in passenger-kilometres by mode and country) were used in an evaluation module. In Table 2 the outcomes for the policies are given in terms of the change in the sum of the internal and external (emissions, noise, accidents) cost of transport (in billions of Euros of 1995, or rather ECU's the predecessor of the Euro). The change in internal costs is measured here as the change in the logsum variable (compared to the 2020 Reference Scenario). A reduction means that the cost to society are reduced. The cost of investment, operation and maintenance of the infrastructure (except road damage) are not included in this table.

Table 1. Policy measures and translation of policy measures for simulation (BTM=bus, tram, metro)

Policy	F=freight P=passengers	Simulation (for 2020)
Intermodality	F	Rail/combined/sea handling and storage cost –5%, -10%, or travel time rail/combined/iww/sea –3%, -5%
	P	Rail and BTM access/egress time –5%, -10% and Rail and BTM wait and transfer time –5%, -10%
Interconnectivity	F	Rail/combined/sea handling and storage cost –5%, -10%, or travel time rail/combined/iww/sea –3%, -5%
	P	Rail and BTM access/egress time –5%, -10% and Rail and BTM wait and transfer time –5%, -10%
Fuel price increase	P	Variable car cost +10%, +25%, +40%
	F	Lorry cost +10%, +25%
Congestion and road pricing	P	Variable car cost +25%, +40% in high density area types
	F	Variable lorry cost +25%, +40% in high density area types
Parking policies	F	Lorry cost +25% for trips <100 km in/from high density area types
	P	Car cost +25% in/from high density area types
Public transport pricing	P	Rail and BTM cost –10%, -30%
Infrastructure tariff	F	Lorry cost +10%, +25% and rail cost +10%, +25%
New urban public transport	P	BTM travel times in high density area types –10%, -25%
Rail and fluvial interoperability	F	Rail/combined times -5% and cost -5%, and IWW times -5% and cost –5%
Market liberalization (rail)	P	Rail times -5% and cost -5%
	F	Rail cost –5%, -10%
Cost internalisation	P	Car cost +25%, +40%, and Bus cost +10%, +25%
	F	Lorry cost +25%, +40%
Maximum speed limits	P	Car time +10%, +20%
	F	Lorry time +10%, +20%
Vignette, Eco-points, km charge	F	Lorry cost +3%, +5%, +10% for trips above 200 km
Promoting housing densification	P	Shift of population from low-medium area types to high density area types
Promoting employment densification	P	Shift of employed population from low-medium area types to high density area types
Sea motorways	F	Sea time –10%, -20%
Harmonisation of inspections and controls	F	Lorry cost +3%, +5% and lorry time +3%, +5%
Harmonisation of rules on speeding	F	Lorry time +5%, +10%
	P	Car time +5%, +10%
Deregulation for sea and IWW	F	Sea and IWW cost –5%, -10%

Table 2. Main outcomes of the evaluation results of the policy measures for passenger transport (change w.r.t. the 2020 Reference Scenario in internal and external cost of transport in billions of Euros)

Policy	Total change	Internal cost change	External cost change			
			total	emissions	noise	accidents
Intermodality/ Interconnectivity, low	-42.47	-41.23	-1.24	-0.31	0.06	-1.00
Intermodality/ Interconnectivity, high	-101.45	-97.50	-3.94	-0.89	-0.17	-2.89
Rail and fluvial interoperability	-13.55	-13.14	-0.40	-0.12	0.10	-0.39
Cost internalisation, low	109.74	113.97	-4.24	-0.77	-0.95	-2.51
Fuel price increase 10%	38.28	41.27	-3.00	-0.55	-0.64	-1.81
Fuel price increase 25%	76.45	83.40	-6.94	-1.28	-1.48	-4.18
Fuel price increase 40%	111.35	121.60	-10.25	-1.89	-2.18	-6.18
Public transport pricing, low	-18.68	-17.37	-1.31	-0.30	-0.03	-0.98
Public transport pricing, high	-130.98	-126.42	-4.56	-1.05	-0.09	-3.42
Cost internalisation, high	173.86	179.84	-5.98	-1.07	-1.43	-3.49
Market liberalization (rail), low	-2.18	-2.12	-0.06	-0.03	0.07	-0.09
Market liberalization (rail), high	-4.60	-4.48	-0.12	-0.06	0.13	-0.20
New urban public transport, low	-12.67	-12.54	-0.13	-0.04	0.04	-0.13
New urban public transport, high	-38.79	-38.37	-0.42	-0.13	0.10	-0.39
Harmonisation of rules on speeding, low	65.36	72.62	-7.27	-1.34	-1.54	-4.38
Harmonisation of rules on speeding, high; Maximum speed limits, low	128.16	142.60	-14.44	-2.67	-3.06	-8.71
Maximum speed limits, high	217.21	243.25	-26.04	-4.82	-5.50	-15.71
Congestion and road pricing, or parking, low	28.78	30.52	-1.74	-0.34	-0.35	-1.04
Congestion and road pricing, high	42.19	44.75	-2.56	-0.50	-0.51	-1.54
Promoting housing densification	71.47	73.51	-2.05	-0.23	-0.44	-1.38
Promoting employment densification	39.53	40.72	-1.19	-0.13	-0.26	-0.80

For these effects of the policies, only a qualitative categorisation of policies could be given.

The best policies (on this aggregates cost measure) are the ones that make public transport cheaper or faster, such as public transport pricing, intermodality, interconnectivity, new urban public transport, interoperability and rail market liberalisation. According to the meta-model, these policies are not effective (the cross elasticities are very close to zero) in reducing car use. But such policies increase the user benefits (measured through the logsum variable) from transport, because the public transport users have lower fares or lower time costs, and at the same time these policies (slightly) decrease the external effects. All these policies lead to a reduction in the total internal and external cost of transport. Not taken into account here is that the revenues of the public transport operator might decrease when the fares are reduced.

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 (measured by the change in the logsum, and converted into money units), which is not outweighted by the reduction in the external cost. Therefore all these policies lead to an increase in the total internal and external cost of transport. These policies have a significant, though not very large impact on car kilometrage (as in De Jong and Gunn, 2001). The implied overall long run price elasticities of car kilometrage are between –0.05 and –0.35 (taking into account the congestion feedback effect that reduces the sensitivity), depending on the travel purpose. The transport time elasticities are bigger: around –0.5. However, this is not so much due to modal shift but to destination switching: if car use becomes more expensive or slower, than in the long run there will be a shift to the shorter distance classes, especially for shopping and 'social, recreational and other' travel. These car costs and time measures have the highest impact on car use of all policies simulated. Not taken into account here is that the policy measures that increase the cost for transport users also increases the government revenues (there is a shift of taxes or charges from the transport users to the government).

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. The reduction in car use is small (about –1%).

Most policies that make public transport policy more attractive require substantial investment, operation and maintenance cost. Most policies that make car less attractive have lower costs for these items. In Table 3 is an overall assessment of the policies.

A simple categorization has been introduced for readability. Given that effectiveness is the main objective, and that in money terms internal+external costs over a project lifetime usually dominate investment costs (except maybe for new infrastructure), a simple ranking can be implied by ordering policies first on the effectiveness criterion, then on internal+external costs, then on investment costs. The result is clear; policies penalizing motorists through parking or road charging are best. Cost internalisation, fuel price increases and lower maximum speeds are next; in the same league for effectiveness, but hitting the users harder. Policies to affect land use by densification, or making public transport more attractive, come bottom of the league; they are simply ineffective. All of the policies investigated have been characterised by levels of change to the system which have been judged to be

Table 3. Overall assessment of the 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	Relatively high	Medium increase	Low and government revenues
Parking policies	Relatively high	Medium increase	Low and government revenues
Rail and fluvial interoperability	Low	Small reduction	Medium
Market liberalisation (rail)	Low	Small reduction	Medium
Cost internalisation	Relatively high	Big increase	Low and government revenues
Maximum speed limits	Relatively high	Big increase	Low
Harmonisation of rules on speeding	Relatively high	Big increase	Low
Public transport pricing	Low	Big reduction	Medium
New urban public transport	Low	Medium reduction	Medium
Fuel price increase	Relatively high	Big increase	Low and government revenues
Housing and employment densification	Low	Big increase	Medium

realistic, and if other levels were posited (e.g. free public transport or zero interchange costs for intermodal transport) other results would emerge.

4.3 Outcomes of policy runs for freight transport

The meta-model for freight transport was used to simulate the amount of tonnes and tonne-kilometres in 2020 for each of the policy measures in Table 1. The outcomes (in tonne-kilometres by mode and country) were used in an evaluation module. Table 4 contains the main results of the evaluation. For each policy run, done with the meta-model for freight, four changes are given:

- ❖ The sum of the change in driving cost, time cost and external cost;
- ❖ The change in driving cost (the monetary cost of the mode used);
- ❖ The change in time cost (the transport time change multiplied by appropriate values of time);
- ❖ The change in external cost (emissions, noise, accidents, road damage).

All costs are measured in millions of ECU (now EURO) of 1995. A negative number means that the costs to society are reduced; in this respect the lowest value (most negative) is the best.

Table 4. Main evaluation results for the policies for freight transport (change w.r.t. the 2020 Reference Scenario)

		Total	**Driving**	**Time**	**External**
Policy	**Scenario**	**MECU95**	**MECU95**	**MECU95**	**MECU95**
		%diff	%diff	%diff	%diff
1. Intermodality	1 Handling and storage costs -5% (rail, combined and sea)	-1.8%	-2.0%	-1.1%	-1.7%
	2 Handling and storage costs -10% (rail, combined and sea)	-3.5%	-4.1%	-2.3%	-3.4%
	3 Travel time -3% (rail, combined, IWW and sea)	-0.5%	-0.5%	-0.7%	-0.5%
	4 Travel time -5% (rail, combined, IWW and sea)	-0.9%	-0.8%	-1.1%	-0.8%
2. Interconnectivity	1 Handling and storage costs -5% (rail, combined and sea)	-1.8%	-2.0%	-1.1%	-1.7%
	2 Handling and storage costs -10% (rail, combined and sea)	-3.5%	-4.1%	-2.3%	-3.4%
	3 Travel time -3% (rail, combined, IWW and sea)	-0.5%	-0.5%	-0.7%	-0.5%
	4 Travel time -5% (rail, combined, IWW and sea)	-0.9%	-0.8%	-1.1%	-0.8%
3. Congestion and road pricing	1 Variable lorry costs +25%; area types 1,2,3,4	11.6%	17.7%	-0.8%	-0.9%
	2 Variable lorry costs +40%; area types 1,2,3,4	18.4%	28.0%	-1.3%	-1.4%
4. Parking policies	1 VLC +25%; area types 1,2,3,4; trips <100km	12.3%	18.5%	-0.5%	-0.3%
5. Infrastructure tariff	1 Lorry and rail transport costs +25%	9.1%	15.8%	-4.5%	-4.9%
	2 Lorry and rail transport costs +10%	4.3%	7.2%	-1.5%	-1.6%
6. Rail and fluvial interoperability	1 Rail combined IWW travel time and transport costs -5%	-1.8%	-2.1%	-1.1%	-1.3%
7. Market liberalisation	1 Rail transport costs -10%	-1.7%	-2.2%	-0.5%	-1.1%
	2 Rail transport costs -5%	-0.8%	-1.1%	-0.3%	-0.5%
8. Cost internalisation	1 Lorry transport costs +25%	6.1%	11.4%	-4.5%	-6.2%
	2 Lorry transport costs +40%	8.2%	16.0%	-7.3%	-10.0%
9. Maximum speed limits	1 Lorry time +10%	0.0%	-2.3%	6.6%	-2.6%
	2 Lorry time +20%	-0.1%	-4.7%	12.7%	-5.3%
10. Vignette Eco-points	1 Lorry transport costs +3%	1.0%	1.6%	-0.4%	-0.6%
	2 Lorry transport costs + 5%	1.6%	2.7%	-0.6%	-1.0%
	3 Lorry transport costs +10%	3.0%	103.0%	203.0%	303.0%
11. Sea motorways	1 Sea travel time -10%	-0.6%	-0.5%	-0.8%	-0.4%
	2 Sea travel time -20%	-1.2%	-1.0%	-1.7%	-0.8%
12. Harmonisation of inspections and controls	1 Lorry transport costs and travel time +3%	0.9%	0.9%	1.5%	-1.5%
	2 Lorry transport costs and travel time +5%	1.5%	1.5%	2.5%	-2.5%
13. Harmonisation of rules on speeding	1 Lorry travel time + 10%	0.0%	-2.3%	6.6%	-2.6%
	2 Lorry travel time + 5%	0.0%	-1.2%	3.4%	-1.3%
14. Deregulation for sea and IWW	1 Sea and IWW transport costs -5%	-0.9%	-1.2%	-0.3%	-0.4%
	2 Sea and IWW transport costs -10%	-1.8%	-2.4%	-0.6%	-0.7%
15. Fuel price increase	1 Lorry fuel cost +10%	2.8%	5.1%	-1.8%	-2.5%
	2 Lorry fuel cost +25%	6.1%	11.4%	-4.5%	-6.2%

The policies that involve an increase in the lorry cost were found to be effective in terms of substitution from road to other modes (this is not destination switching as happened in passenger transport, but pure modal shift). The implied overall cost elasticities on lorry tonne-kilometrage are in a range from –0.4 to –0.7. But in Table 4 we can see that these policies (congestion and road pricing, parking policies (but this one was not particularly effective), infrastructure tariff, cost internalisation, vignette/ecopoints/kilometre charging and a fuel price increase) all lead to an increase in the internal plus external cost of transport, of sometimes more than 10%. This is caused by an increase in the driving cost: all lorry transports that do not shift to unaffected modes have to pay a higher cost. For these policies this is not compensated by the decrease in the time cost and the external cost. The time cost decrease here because the value of time is mode-specific: substitution from road to rail, combined, sea or inland waterways transport means that the shipment will use a slower mode, but also a mode with a lower value of time. If we would have used a fixed value of time for the substitution (not mode-specific), then the time cost would have increased as well for these policies. The external costs are reduced if tonne-kilometres are shifted from road to the other modes, but this is not sufficient here to reduce the total cost. On the other hand, in these policies there will also be a benefit for the government (higher revenues from fuel tax, or other form of charging), which is not accounted for in the above total cost change. This is a shift from the transport users to government. In a first-best world (without externalities), such a shift is a distortion of the free markets, that reduces overall welfare. In a second-best situation, where externalities already distort the picture, such shifts might be justifiable.

Intermodality and interconnectivity were also quite effective in influencing the modal split (lorry tonne-kilometrage is reduced by between 1% and 6%) and these policies lead to a reduction of the total internal and external cost of transport. So, unlike the policies that increase the lorry cost, mentioned above, these policies combine effectiveness with low cost for the transport users. But intermodality and interconnectivity require a medium amount of investment in infrastructure and do not generate government revenue, whereas the polices on lorry cost require lower investment costs and produce revenue for the government.

The policies that try to make the non-road modes cheaper and/or faster (rail and fluvial interoperability, rail market liberalisation, sea motorways and deregulation for sea and inland waterways) had a limited effect on the transport volumes by mode and also have a limited effect on the total internal and external cost of transport. The cross elasticities of lorry tonne-kilometrage are generally between 0 and 0.2

The policies that make road transport slower also had a sizeable impact on the mode split (implied overall time elasticities of lorry tonne-kilometrage between –0.4 and –0.7), but the cost impacts are rather small. There is an increase in the time cost (since all road transport is affected, also the lorry transports that stay on the road), but this is completely or largely compensated by gains in driving cost (because of substitution to cheaper modes) and in external cost.

The above results are summarised in Table 5.

Table 5. Overall assessment of the 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 liberalisation (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

For freight transport policy, the best options do seem to be to improve intermodality and interconnectivity. Tightening regulations on speed and on working practices for road freight are next most effective. Parking policy is irrelevant here. Improving water-based freight is ineffective as means to reduce road freight.

5. Conclusions

The EXPEDITE meta-model for passenger and freight transport was developed in a project for the European Commission, Directorate-General for Energy and Transport (DGTREN). This is a fast and relatively simple model, without explicit transport networks, that integrates results from a number of national and international models.

This meta-model was used to generate forecasts for both passenger and freight transport for Europe for a number of future years up to 2020. Furthermore we reported on the policy runs carried out with those models and the evaluation of these policies.

For the period 1995-2020, the meta-model predicts for the Reference Scenario that for distances up to 160 km the number of tours will grow by 5% (car driver +22%) and passenger kilometrage will increase by 10% (car driver +24%). There will be a much higher growth in Central and Eastern Europe .

Long distance travel (above 160 kilometres) increases much faster (car, train and especially air) than short to medium distance transport.

A number of the policies (e.g. from the 'Time to Decide' White Paper) put forward to reduce car kilometres and road freight transport (some were packages of measures) have been evaluated in EXPEDITE in terms of effectiveness (modal shift from road to other modes), impact on internal and external costs and required investment, operation and maintenance costs.

Policies penalizing motorists through parking or road charging are best in passenger transport. Cost internalisation, fuel price increases and lower maximum speeds are next; in the same league for effectiveness, but hitting the users harder. Policies to affect land use by densification, or making public transport more attractive, come bottom of the league; they are simply ineffective.

For freight transport policy, the best options seem to be to improve intermodality and interconnectivity. Tightening regulations on speed and on working practices for road freight are next most effective. Parking policy is irrelevant here. Improving water-based freight is ineffective as means to reduce road freight.

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Figure 1. Changes (in %) between 1995 and the 2020 Reference Scenario in the number of tours and the number of passenger-kilometres, by mode, in the study area (BTM = bus, tram, metro)

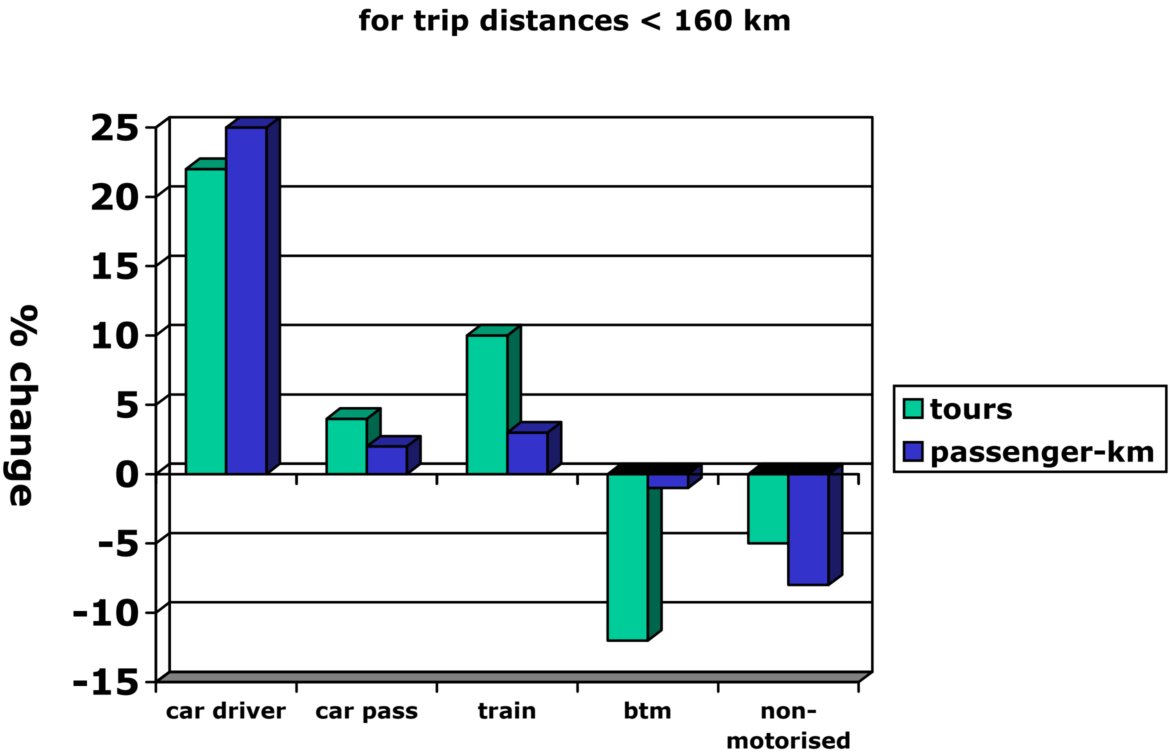

Figure 2. Percentage growth of car kilometres in trips up to 160 km in Europe 1995-2020 under the Reference Scenario

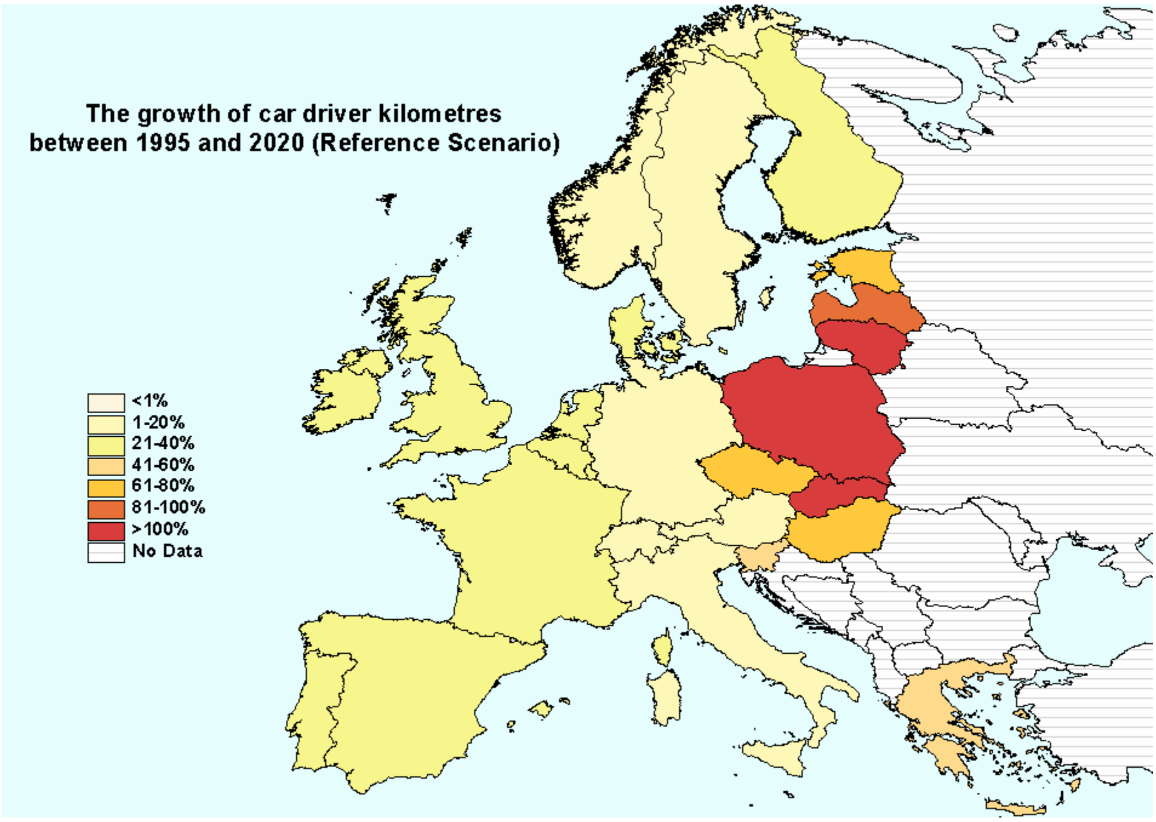

Figure 3. Passenger kilometrage in 1995 and the 2020 Reference Scenario, from SCENES for trips above 160 km and from the meta-model for distances up to 160 km (BTM = bus, tram, metro).