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A meta-model for passenger and freight transport in Europe

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Abstract
On the basis of the outcomes of five disaggregate national models for passenger transport, four national models for freight transport and two European transport models, a fast and approximate meta-model for passenger and freight transport in Europe has been developed. The meta-model for passenger transport includes a detailed segmentation of the population, which makes it possible to investigate the impact of policies on many different groups of the population. The meta-model for passenger and freight transport has been applied for a reference scenario for 2020 and to simulate many elements of the European Commission's Common Transport Policy. These policy measures were also assessed in terms of the consequences on the internal and external cost of transport.

1. Introduction

In Europe, many transport models are available for forecasting and policy simulation at the national and regional level. Furthermore, there are models at the European scale (either for the current 15 member states of the European Union or also covering countries that will join the Union in 2004). Examples of models at the scale of the extended EU are:

- the SCENES model for passenger and freight transport and its predecessor the STREAMS model (see SCENES consortium, 2001);
- the NEAC model for freight transport (see Chen and Tardieu, 2000);
- the VACLAV-VIA model for passenger transport (see Shoch, 2000).

These are all network-based models with considerable run times. The focus of the European models is usually on long-distance transport, but for instance the SCENES

[1] This paper is based on the outcomes of the EXPEDITE project, that was carried out by the EXPEDITE consortium for the European Commission DGTREN. The consortium consisted of: RAND Europe (coordinator), Stratec (Belgium), ARPA (Italy), Transek (Sweden), Institute of Transport Economics (Norway), Heusch/Boesefeldt Verkehrsconsult (Germany), Imperial College of Science, Technology and Medicine (UK) and the Swiss Federal Institute of Technology. The EXPEDITE project greatly benefitted from interaction with the THINK-UP thematic network, which brought together experts on transport modelling and transport policy.

model does include transport within the zones by using a sub-model of distance band choice. Running the SCENES model with its 250 zones in Europe and multi-modal networks is cumbersome and time-consuming. Moreover, the SCENES model 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;
- The model includes 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 short distance transport.

In the EXPEDITE project, carried out for the European Commission, such a model was developed and applied in forecasting and policy simulation. This model, called the EXPEDITE meta-model, integrates outcomes of five national passenger transport models and four national freight models and results of the SCENES and NEAC models. A model that also has some of the above characteristics, but uses a very different methodology, is the ASTRA system dynamics model (see Martino and Schade, 2000). ASTRA has a broader coverage than EXPEDITE (e.g. it also includes land use and economic development), but has less detail on transport demand by population group. The advantages of the EXPEDITE meta-model over a network-based transport model for Europe, such as SCENES, are that it runs much faster, is easy to use, and contains information on transport behaviour of many (close to 1,000) different socio-economic groups. But unlike SCENES, the EXPEDITE meta-model cannot produce assignments to the networks. The meta-model is 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.

In section 2 of this paper, the methodology of the EXPEDITE meta-model is explained. Forecasting results for 2020 are given in section 3 and outcomes of runs for many different policies are presented in section 4. Finally, in section 5 a summary and conclusions are provided.

2. The methodology of the EXPEDITE meta-model.

2.1 Meta-models

Meta-analysis (see for example Button el al., 1999; Nijkamp and Pepping, 1998) 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. These definitions also apply to the EXPEDITE meta-model, but this meta-model differs in two ways from the usual approach in meta-analysis. This is described below.

First, most meta-models are based on results from the literature, whereas the EXPEDITE meta-model integrates results from runs with 'underlying' models that have been carried out within the EXPEDITE project itself.

Second, most meta-analyses estimate a regression equation with parameter values or elasticities as dependent variable and attributes of the underlying studies (e.g. type of data used, sample size, year of observation, country, functional specification, estimation technique) and background variables (e.g. income) as explanatory variables. This meta-regression can later on be used to produce values or elasticities for other study areas, for which there is no information on the quantitative relationship ('value-transfer'). In our meta-model we derive levels matrices from the runs with the underlying models for the number of tours and kilometres in many segments, and switching matrices for various changes in policy variables (e.g. running cost of the car +10%, +25%). This gives a highly flexible relationship between travel demand and policy variables: simple interpolation would lead to piecewise linear functions and the specific method used (see below) leads to a piecewise non-linear (logistic) functions. In the EXPEDITE meta-model a large number of background variables (segmentation variables) is used, much larger than would be possible in a (dummy) regression model. The models used in EXPEDITE are very similar, which reduces the need for including attributes of the national study methodologies. The value-transfer method is also used in EXPEDITE, but with correction to zonal data.

The EXPEDITE meta-model

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 of the transport markets in the European context. The requirements for the EXPEDITE meta-model therefore are that it will run fast and extend the available national models to cover the whole (future) EU. In this extension, it is not of vital importance that models for all countries in the EU are included, but that the most relevant segments of the travelling population in the EU are included in the models used and expanded properly, and that the outcomes are calibrated to observed base-year distributions for transport in the respective zones. This methods builds on a similar methodology developed for giving the demand impacts of car cost and car time changes in Europe (TRACE consortium, 1999, de Jong and Gunn, 2001)

2.2 The national models

Since the mid-1980's, a number of model systems have been developed in Europe, predicting future passenger transport at the national scale, using disaggregate, behavioural (based on the concept of random utility) model structures. Within the EXPEDITE consortium, five of these models are available. These are all the existing national models based on this methodology, as far as we are aware. National models based on different methodologies exist in for instance France, Germany, Hungary and Switzerland. Disaggregate, behavioural models have been developed for large regions within a country (e.g. Paris, Portland, Sydney) and have also been used for international corridors (e.g. Great Belt, Fehmarn Belt). The five models are (in the order in which they were originally developed):

- 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).

Within the EXPEDITE Consortium, there are four national models for freight transport:

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

The first three 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), as the national models for passenger transport. The Italian model contains components for both passenger and freight transport.

The starting point for the EXPEDITE project was the question how one can benefit from the detailed knowledge on transport behaviour and reactions to policy measures embodied in the above national models in forecasting and policy simulation at the European scale. The methods used to extend this knowledge to a study area comprising the current fifteen member states of the EU, eight accession countries, Switzerland and Norway are discussed below.

2.3 Integrating the outcomes of the underlying models for passenger transport

In the first part of the EXPEDITE project, 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 and freight transport. In the explanation below, we describe the meta-model for passenger transport first, and then we explain where the freight model differs. 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.

Distance band is the other dimension of the levels matrices. As in the SCENES project, the following classification is used:
- 0-1.5 km;
- 1.6-3.1 km;
- 3.2-7.9 km;
- 8.0-15.9 km;
- 16-39.9 km;
- 40-79.9 km;
- 80-160 km.

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.

The modelling approach used in EXPEDITE for passenger transport is also outlined in Figure 1 (on the left-hand side).

- See here Figure 1 -

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. The trip distances over 160 km are missing here, because several national models used have only a limited coverage of long distance travel.

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 to take account of the feedback effect of changes in congestion due to policies that change the amount of car use.

To obtain forecasts for all distance bands (the meta-model for passenger transport, based on the national models is for travel up 160 km), results from the SCENES model for travel above 160 km can be added to those of the meta-model. In an ongoing project, these outcomes of runs with SCENES for transport above 160 km are being built into the meta-model itself, in the same way as the national model results were included.

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 in the following way.

- 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. As an example we study the combined effect of an increase in the car running cost of 25% and a decrease in the train and bus/tram/metro cost by 25%.

The switching matrices for both of these measures in isolation are available from the national model runs.

We now calculate probability matrices P_{mdp} (m indicates mode, d distance class and p population segment) by dividing all numbers in the levels matrix of a segment by the total in the bottom-right cell for:

- the levels matrices T_{mdp};
- the levels matrices with policy 1: $T_{mdp} + D^1_{mdp}$;
- the levels matrices with policy 2: $T_{mdp} + D^2_{mdp}$.

We further assume that:

- the non-linearities in the responses of the meta-model to policy measures are due to the logit nature of the underlying utility-based models;
- the average utility of the shortest distance band for the non-motorised modes will remain unchanged in any forecast scenario (this is just a standardisation).

Now the average utilities (standardised by the utility of the shortest distance band for the non-motorised modes) can be calculated from the probability matrices as follows.

The general formula for the multinomial logit model is:

$$P_{mdp} = \frac{e^{U_{mdp}}}{\sum e^{U_{mdp}}}$$

Therefore:

$$\ln(P_{mdp}) = U_{mdp} - \ln(\sum e^{U_{mdp}})$$

and:

$$U_{mdp} = \ln(P_{mdp}) + \ln(\sum e^{U_{mdp}})$$

The same can be done for the average utility of the shortest distance band for the non-motorised mode. The standardised utility for mode m, distance class d and primitive p then becomes:

Standardised $U_{mdp} = \ln(P_{mdp}) - \ln(P_{m=non\text{-}motorised,d=shortest,p})$

Given we start from the 'p's, i.e $e^U/\Sigma e^U$, we need a scale standardisation to recover comparable logsums $\ln(\Sigma e^U)$ as between base and forecast/scenario. Since the forecasts/scenarios did not have pedestrian schemes or bike lanes, short distance non-motorised was chosen as base. Note that if there had been such schemes, we would only have had to run more of the base models, with and without them – the method can handle improved short/non-motorised options.

We now calculate these average utility matrices for each of the three situations (base, base with policy 1, base with policy 2). Then to obtain the utility matrix of the policy bundle 1&2, we add the utility of the base, the utility change of policy 1 and the utility change of policy 2. After that we standardise the outcome by using the utility of the shortest distance band for non-motorised as the base. The results is transformed to probabilities (by exponentiation). The resulting probability matrices for the base with the policy bundle 1&2 are below.

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.

Logsum = $\ln(\sum e^{U_{mdp}})$

This gives the change in consumer surplus, and can be segmented by population segment to analyse how different population segments are affected by a policy.

2.4 The meta-model for freight transport

The EXPEDITE freight meta-model is conceptually simpler than the passenger meta-model (also see Figure 1, right-hand side). It takes elasticities from runs done within EXPEDITE with national models for Norway, Sweden, Belgium and Italy and the SCENES European model. The amount of freight transport by mode, distance band and commodity class for 1995 and the 2020 reference however is taken from the SCENES (EU15) and NEAC (other 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. These impacts are represented inside the meta-model in the form of elasticities. In total 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 distance bands for freight transport are:

- 0-10 km
- 10-25 km;
- 25-100 km;
- 100-200 km;
- 200-500 km;
- 500-1000 km;
-]more than 1000 km.

The commodity classes are:

- bulk products;
- petroleum and petroleum products;
- general cargo

The modes considered are:

- lorry (we use this word to indicate all road freight vehicles);
- conventional train;
- combined road-rail transport;
- inland waterways transport;
- maritime transport.

3. Meta-model outcomes for the Reference Scenario 2020

3.1 The reference scenario for 2020

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'.

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

The overall growth in the number of tours for the distances up to 160 km in the period 1995-2020 in the Reference Scenario is limited: +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%).

- See here Figure 2 -

As can be seen in Figure 2, 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). The growth rates for vehicle kilometres (=car driver kilometres) in the EU15 countries are between 10 and 40%, but can go as high up as 150% in the CEEC. 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). 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.

The variation between countries is considerable, as can be seen from Figure 3.

- see here Figure 3-

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%.

In Figure 4 are the mode shares (in percentages) in the 1995 passenger kilometrage in all 25 countries studied, by income class. Income is measured here as net annual household income in Euros of 1995. This graph and the next one are included to give some insights in how the meta-model works in forecasting, and particularly to show why the meta-model predicts big increases in car use in the CEEC.

- see here Figure 4 -

If in Figure 4 one moves from the left to the right within some mode, income goes up. So one can see here that if household income increases, the share of car driver in total kilometrage clearly increases as well. For car passenger, there is no clear pattern with income. For train, the highest mode share is in the lowest income group, but the one but highest mode share is in the highest income group. This is also true for bus/tram/metro, but here the lowest income group is relatively more important. The share of non-motorised transport declines with income.

- see here Figure 5 -

Figure 5 also gives the mode shares in the total 1995 passenger kilometrage, but now by type of car ownership. There are four car ownership categories in the meta-model:

- persons in households without a car;
- persons who do not have a driving licence, in households with a car;
- persons with a driving licence in households where there are more driving licences than cars, so they have to share (the) car(s);
- persons with a driving licence in households with as least as many cars as driving licences, so they do not have to compete for a car, it is freely available.

If there is no car in the household, there is only little car use (rented car, somebody else's car). If the person does not have a driving licence and the household has a car, there is no car use, but there is a considerable share for the car passenger mode. In the shared car segment and especially in the car freely available segments, the car modes are very important in total kilometrage (89% of all kilometres travelled in the car freely available segment are done as car driver or car passenger). The shares of train, bus/tram/metro and the non-motorised modes decrease as car availability goes up.

Figure 4 and 5 tell the story of the main mechanism in forecasting with the meta-model, especially for predicting for the CEEC. Between 1995 and 2020 persons in the CEEC are (in the Reference Scenario) moving from lower to higher income classes and from car ownership types with limited car availability to types with greater car availability. In the model this is represented by using higher fractions in the expansion for 2020 for the higher income and car ownership categories (the behaviour of the segments will not change, but the importance of the behavioural segments will change). Also in the CEEC the road network performance will increase, whereas the real car cost will decrease in the CEEC. Because of these shifts, the use of the car mode (especially as car driver) will increase considerably in Central and Eastern Europe.

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 6 forecasts from both models are combined.

- see here Figure 6 -

In the SCENES model, there is no distinction between car driver and car passenger; the 'car' mode includes both. For this mode we see both for work-related travel (commuting, business trips) and leisure trips a large increase (much larger than for the shorter distances) in passenger kilometrage between 1995 and 2020 for the longer distances. 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 at all distance bands

Both the predictions for 1995 and for the EXPEDITE Reference Scenario for 2020 come from the SCENES model (transports originating in the EU15) and the NEAC model (transports originating in Norway, Switzerland and the CEEC8), which are combined in the EXPEDITE freight meta-model. Figure 7 gives the growth in tonnes and tonne-kilometres generated in each country. These are both domestic and international transports (but for Norway only the latter).

- see here Figure 7 -

The growth in tonnage lifted for all these 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 of 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.

- see here Figure 8 -

The variation between countries (Figure 8) is considerable. There are seven countries with more than 150% growth (for lorry only), five in CEE, Greece and Switzerland (recent or planned measures such as the Eurovignette and kilometre-based charging have not been included in the Reference Scenario; however, these are included in the policy runs reported below).

4. Policy simulation with the meta-model

4.1 The policy measures simulated

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 recent ‘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. Some policies were also simulated with the SCENES model.

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

- see here Table 2 -

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. An additional effect, that is not included in this table with the changes in internal (user) cost and external cost, is that the revenues of the public transport operator might decrease when the fares are reduced. This effect should be included in an overall evaluation of the effects for society, in which one might also include that the shadow price of public funds is greater than unity.

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 the highest impact on car use of all policies simulated, with implied overall long run price elasticities of car kilometrage 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, than in the long run there will be a shift to the shorter distance classes, especially for shopping and 'social, recreational and other' travel. 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.

- see here Table 3 -

A simple categorization has been introduced for readability. In EXPEDITE the main objective, following the White Paper on transport policy (European Commission, 2001), is a change in modal split and modal usage away from car transport. Of course, this is more an operational, intermediate goal, than a final objective for policy (such as sustainability). Given that effectiveness in terms of a reduction in car use is the main objective here, 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; according to the model 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 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.

- see here Table 4 -

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 policies 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. Deregulation of rail markets could have important impacts on productive efficiency. This was not taken into account here, other than by reducing the transport costs for the users.

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 reductions in driving cost (because of substitution to cheaper modes) and in external cost.

The above results are summarised in Table 5.

- see here Table 5 -

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. Summary and 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 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. On the basis of these policy runs we can also reach conclusions on the effectiveness of policy measures and on (in)sensitive market segments.

Conclusions on passenger transport:

- In 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 distance transport.
- Policies that increase the car cost (fuel price increase, congestion and road pricing, parking policies, infrastructure tariff, cost internalisation), will only have limited mode shift effects. There will be non-marginal reductions of car use, but most of the impact on car kilometrage is due to destination shift. 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 relatively effective means of reducing car use (again mainly through destination shift, 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.

- If the travel time goes up by x% then this will have a bigger impact than an increase in the travel cost up 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.
- 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 shifts, not much modal shift). 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 for policy measures are long distance travel and social/recreational travel (and by definition for policies that make car less attractive: 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 having to pay more or incurring higher time cost), 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. But one should also take into account 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). Moreover, policies that make car less attractive usually have lower investment cost than policies that make public transport more attractive.

Conclusions on freight transport:

- In the period 1995-2020, in the Reference Scenario, the number of tonnes lifted in the study area will increase by 44% (lorry +39%) and tonne-kilometrage will grow by 79% (lorry +89%). A higher growth is predicted for the Central and Eastern European Countries.
- The most effective policy measures to reach substitution from road to other modes are (it does not follow 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 transports above 100 km. Also policies targetted at bulky products are more effective for substitution from road to the other modes than policies focussing 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. On the other hand this type of policy increases the 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. 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.

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Figure 1. Outline of the modelling approach in EXPEDITE

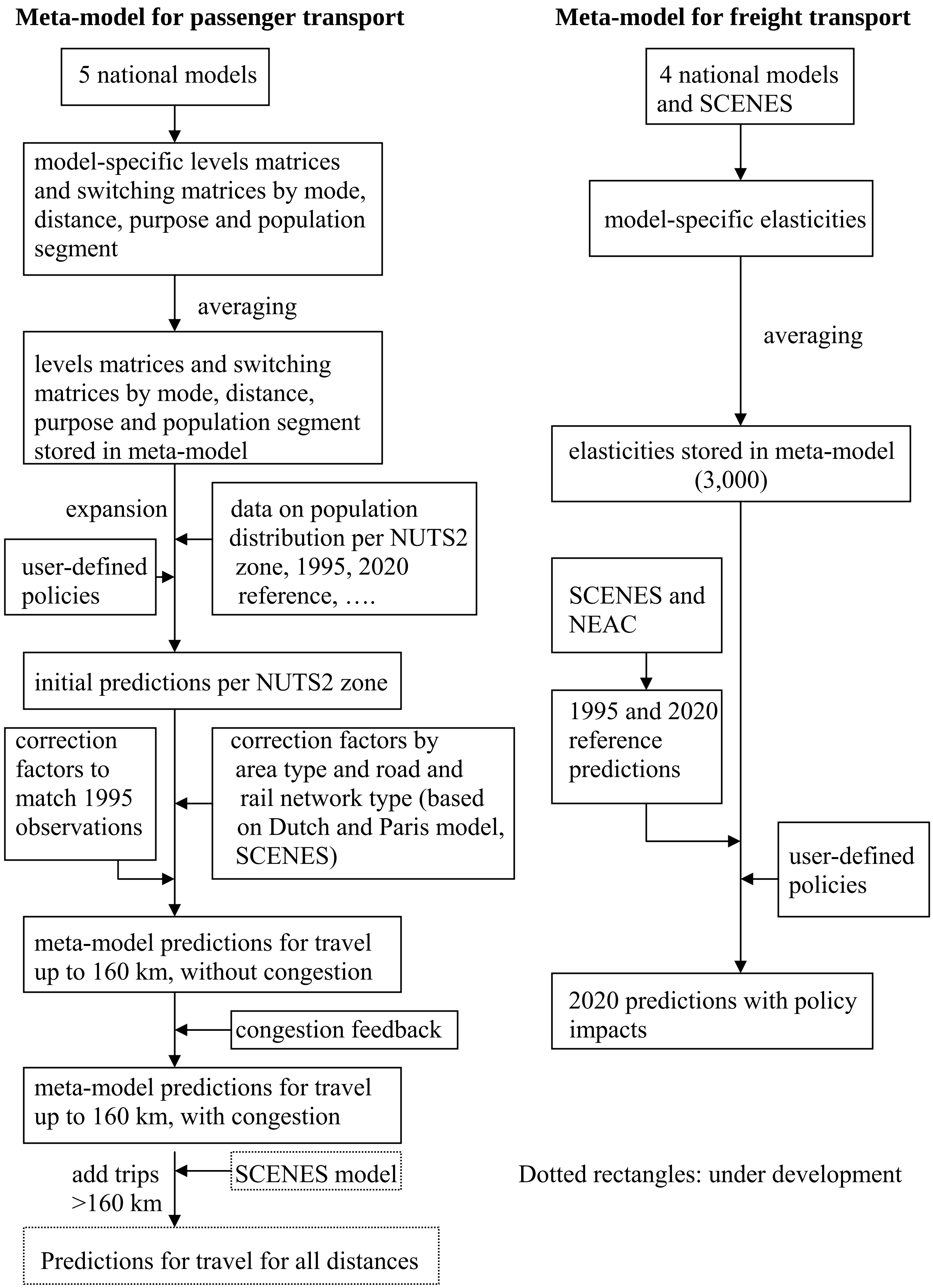

Figure 2. Changes (in %) between 1995 and the 2020 Reference Scenario in the number of tours and the number of passenger-kilometres, by mode, in the study area (btm = bus, tram and metro)

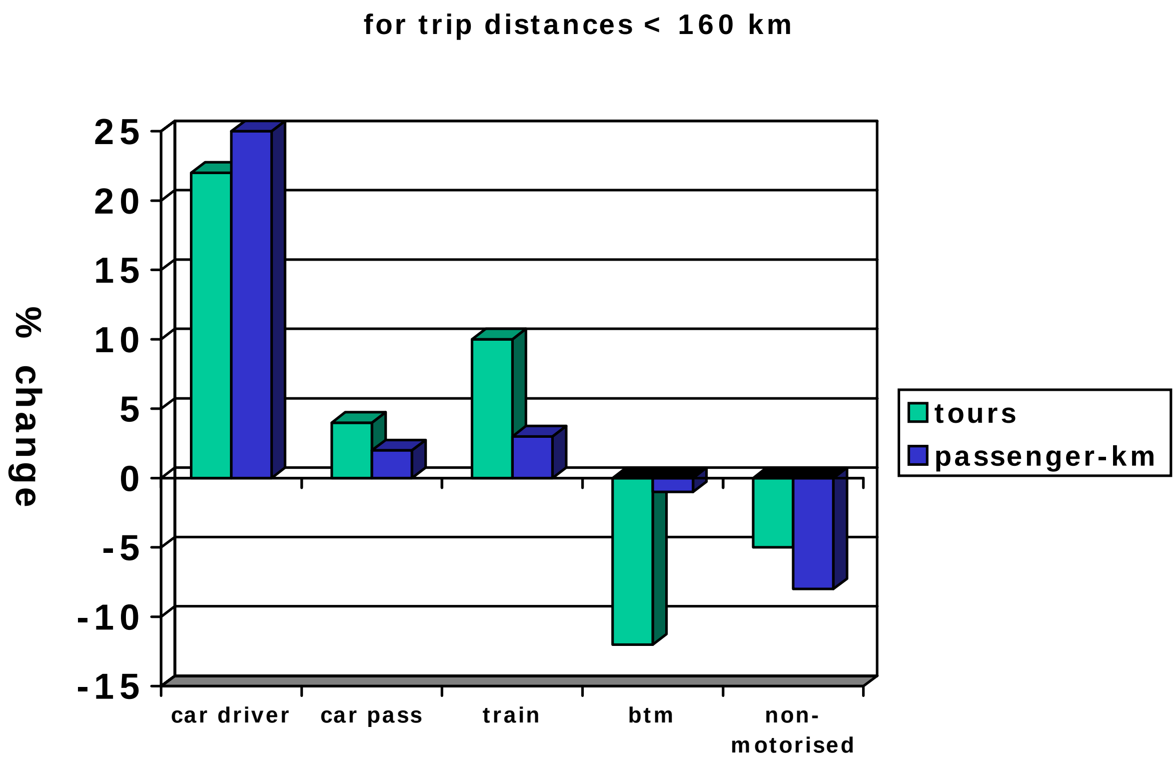

Figure 3. Percentage growth of car kilometres in trips up to 160 km in Europe 1995-2020 under the Reference Scenario

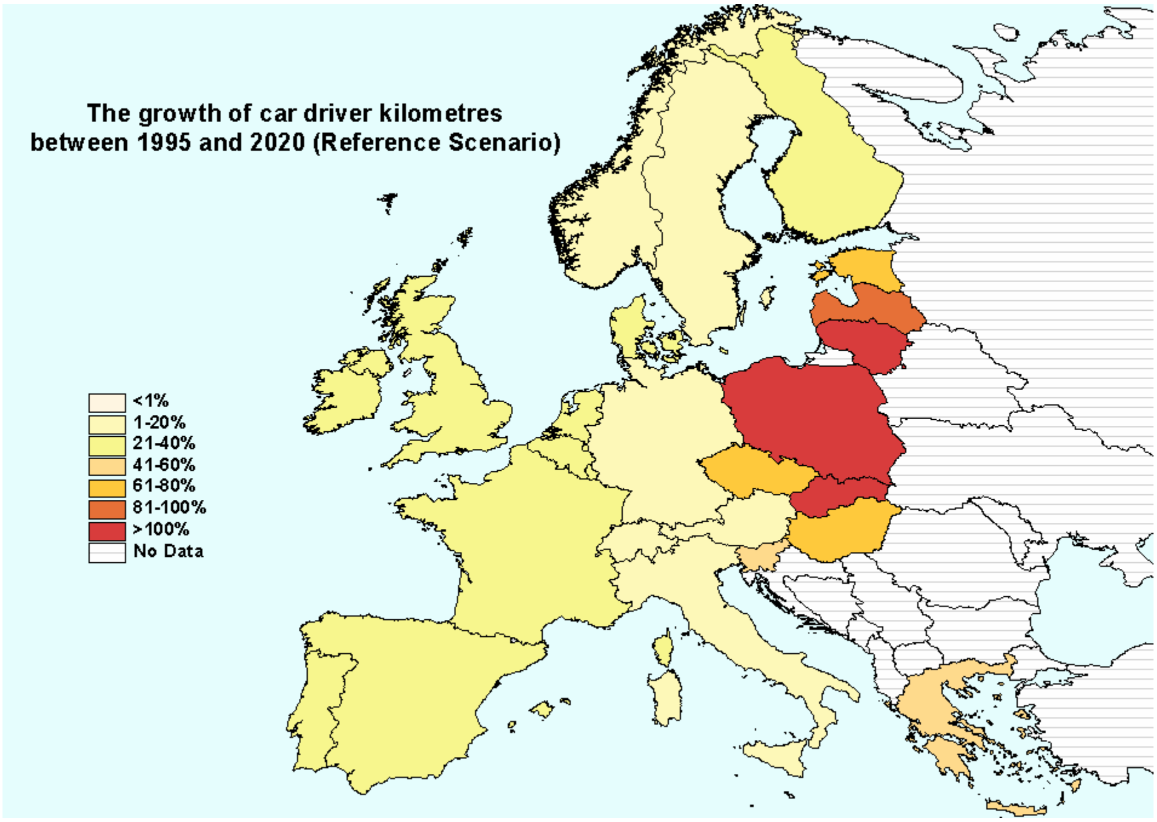

Figure 4. Mode shares (in percentages of total passenger kilometrage in study area in 1995) by net annual household income

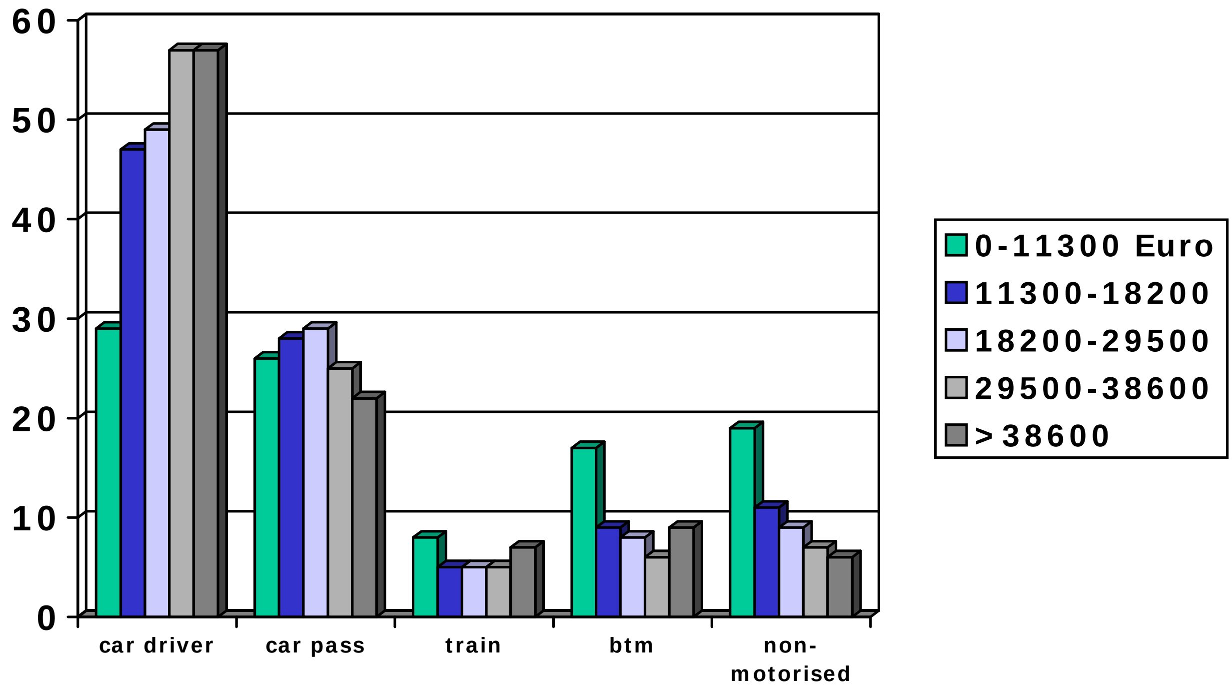

Figure 5. Mode shares (in percentages of total passenger kilometrage in study area in 1995) by type of car ownership

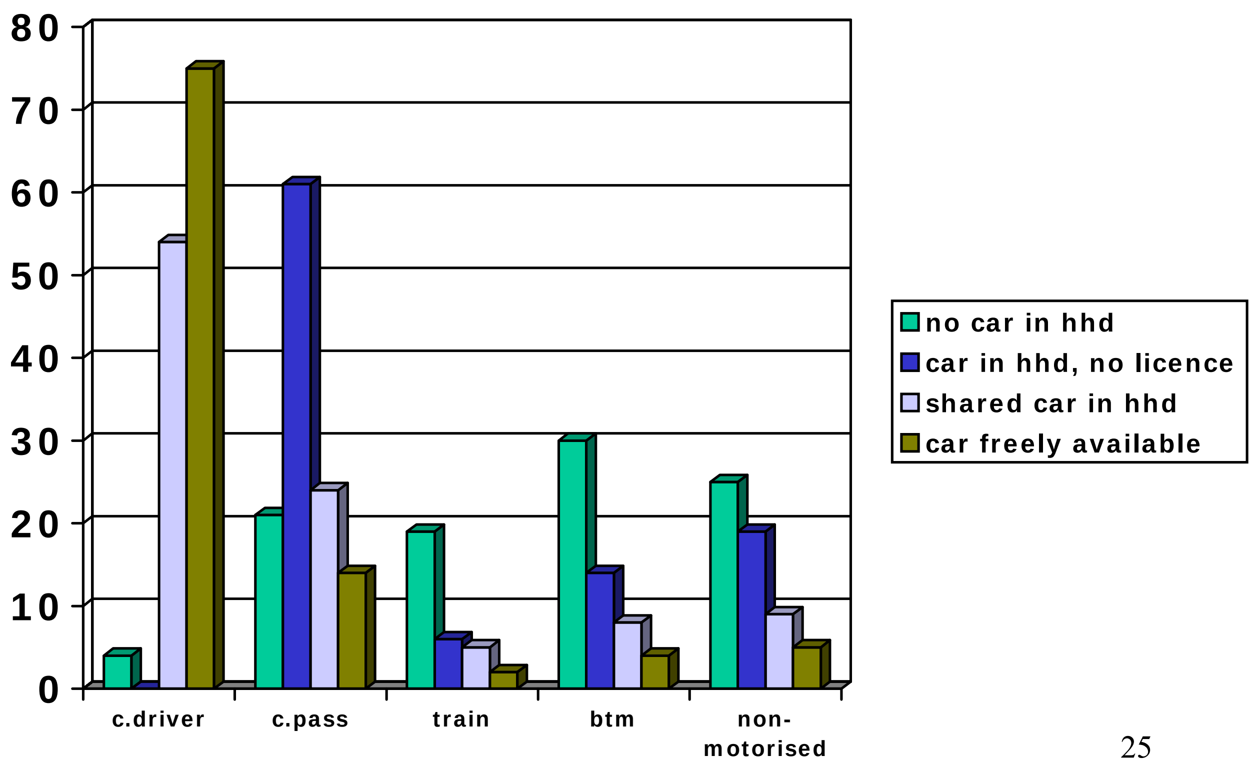

Figure 6. Passenger kilometrage in 1995 and the 2020 Reference Scenario, from SCENES for trips >160 km passenger kilometrage and the meta-model for distances up to 160 km.

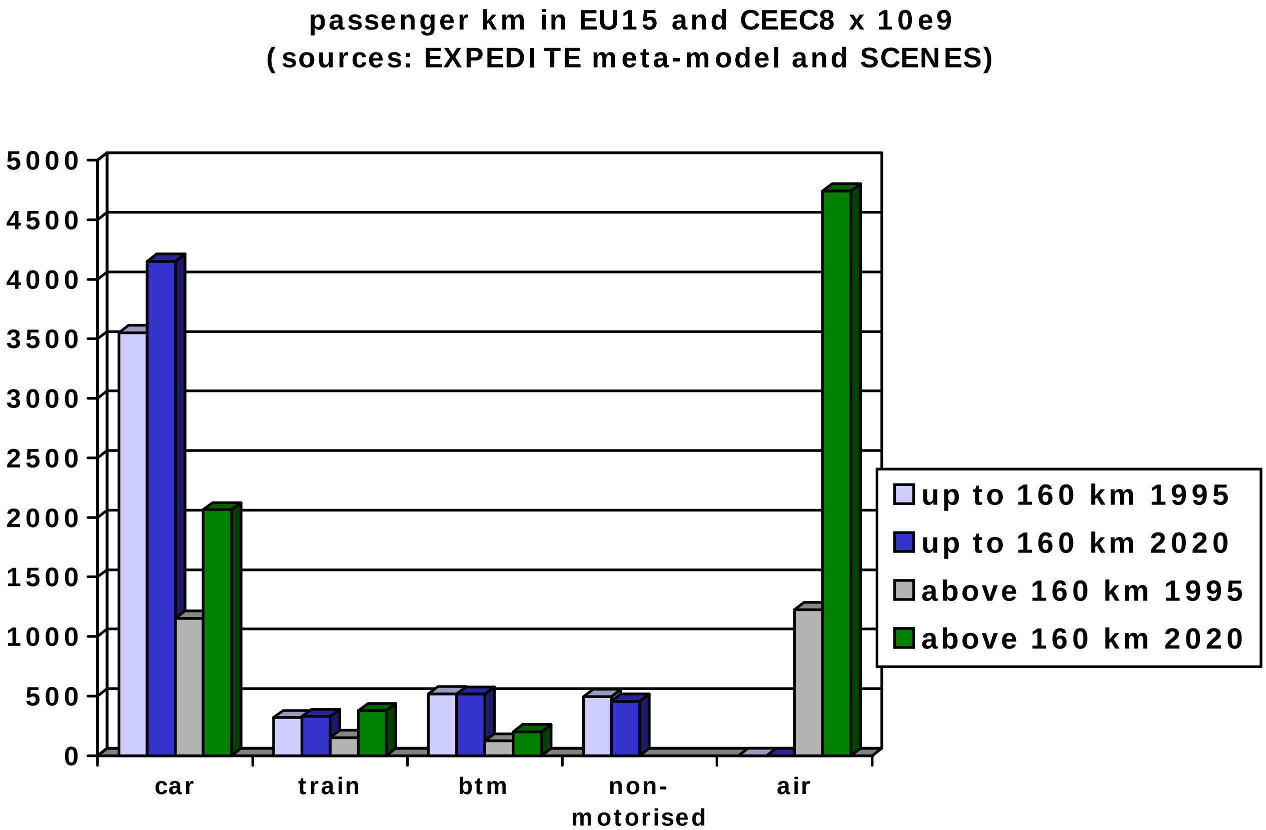

Figure 7. 2020 Reference Scenario freight forecasts by mode (1995=100; IWW=inland waterways transport)

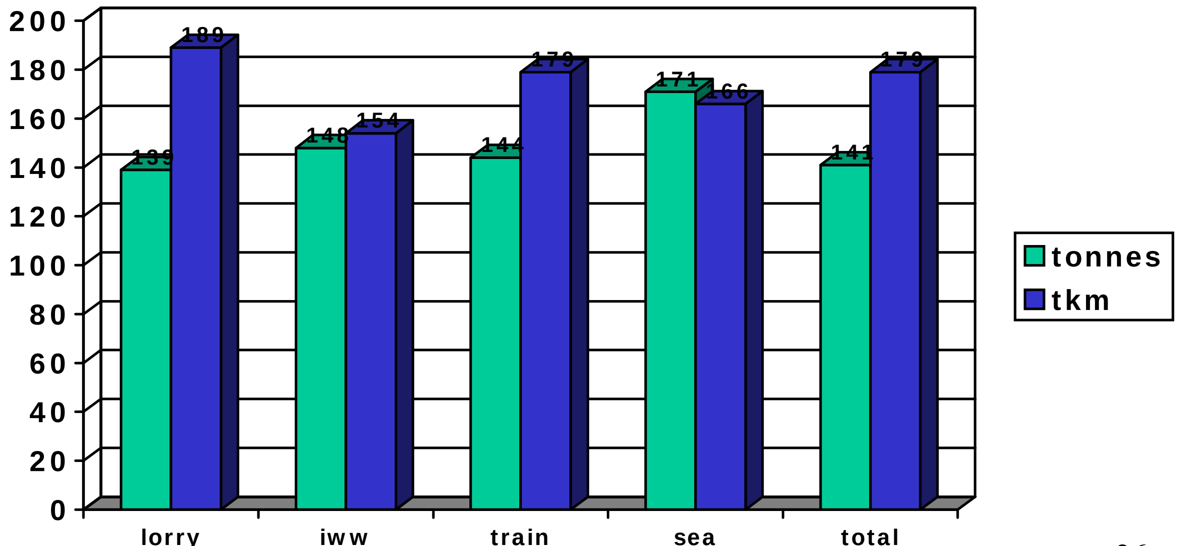

Figure 8. Percentage growth of lorry tonne-kilometres in Europe 1995-2020 under the Reference Scenario (domestic and international transport, by country of generation; Norway: only international transport)

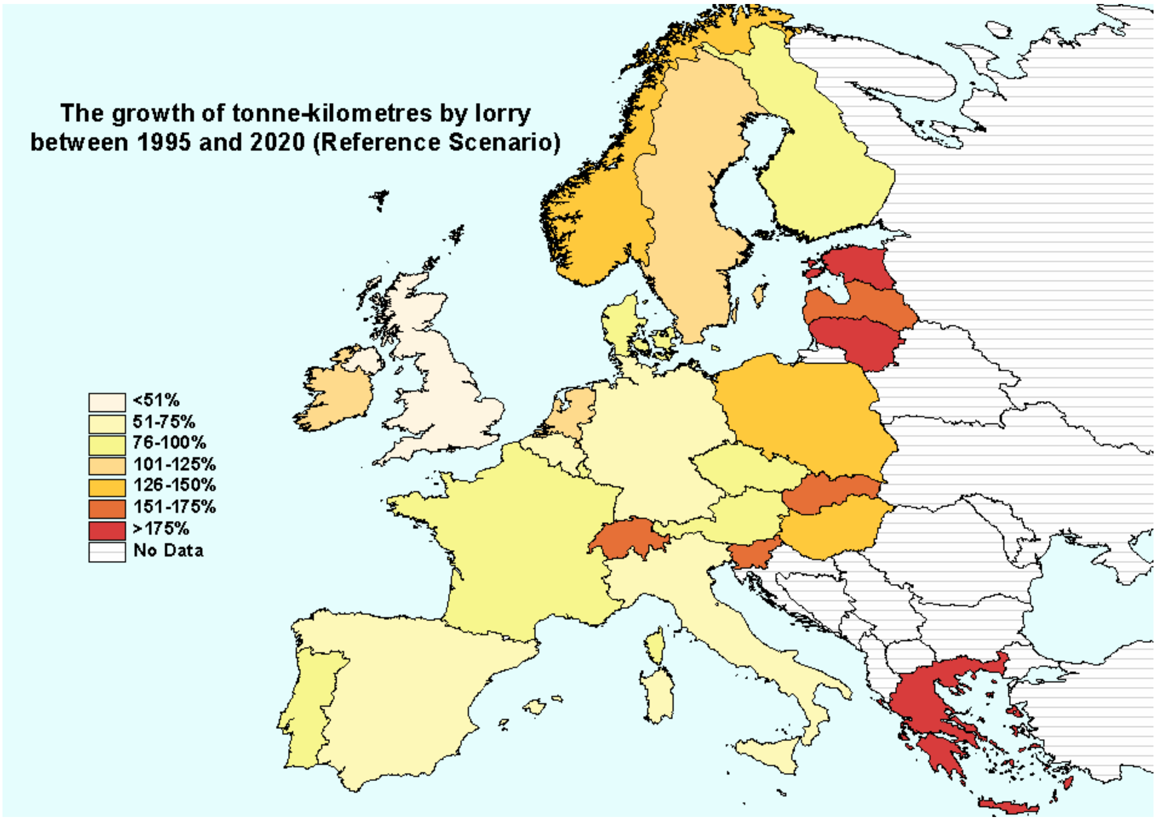

Table 1. policy measures and translation of policy measures for simulation in EXPEDITE.

Policy	**Model** **F=freight** **P=passengers**	**Simulation (for 2020)**
Intermodality	Meta-model F	Rail/combined/sea handling and storage cost –5%, -10%, or Travel time rail/combined/iww/sea –3%, -5%
	Meta-model P	Rail and BTM access/egress time –5%, -10% and Rail and BTM wait and transfer time –5%, -10%
Interconnectivity	Meta-model F	Rail/combined/sea handling and storage cost –5%, -10%, or Travel time rail/combined/iww/sea –3%, -5%
	Meta-model P	Rail and BTM access/egress time –5%, -10% and Rail and BTM wait and transfer time –5%, -10%
Fuel price increase	Scenes P	Variable car cost +10%, +25%, +40% and Air fares +10%, +25%, +40%
	Meta-model P	Variable car cost +10%, +25%, +40%
	Meta-model F	Lorry cost +10%, +25%
Congestion and road pricing	Meta-model P	Variable car cost +25%, +40% in area types 1, 2, 3 and 4
	Meta-model F	Variable lorry cost +25%, +40% in area types 1, 2, 3 and 4
Parking policies	Meta-model F	Lorry cost +25% for trips <100 km in/from area type 1, 2, 3 and 4
	Meta-model P	Car cost +25% in/from area type 1, 2, 3 and 4
Public transport pricing	Scenes P	Rail and coach cost –10%, -30%
	Meta-model P	Rail and BTM cost –10%, -30%
Infrastructure tariff	Meta-model F	Lorry cost +10%, +25% and rail cost +10%, +25%

Table 1 (continued). Policy measures and translation of policy measures for simulation in EXPEDITE

Policy	Model F=freight P=passengers	Simulation (for 2020)
New urban public transport	Meta-model P	BTM travel times in area types 1, 2, 3 and 4 –10%, -25%
Rail and fluvial interoperability	Scenes P	Rail times -5% and rail cost -5%
	Meta-model F	Rail/combined times -5% and cost -5%, and IWW times -5% and cost –5%
	Meta-model P	Rail times -5% and cost -5%
Market liberalization (rail)	Scenes P	Rail cost –5%, -10%
	Meta F	Rail cost –5%, -10%
Cost internalisation	Scenes P	Car cost +25 +40%, and Bus cost +10%, +25%, and Air fares +25%, +40%
	Meta-model P	Car cost +25%, +40%, and Bus cost +10%, +25%
Maximum speed limits	Scenes P	Car time +10%, +20%
	Meta P	Car time +10%, +20%
	Meta F	Lorry time +10%, +20%
Vignette, Eco-points, km charge	Meta F	Lorry cost +3%, +5%, +10% for trips above 200 km
Promoting housing densification	Meta P	Shift of population from area types 5-7 to 1-4
Promoting employment densification	Meta-model	Shift of employed population from area types 5-7 to 1-4
Sea motorways	Meta F	Sea time –10%, -20%
Harmonisation of inspections and controls	Meta-model F	Lorry cost +3%, +5% and lorry time +3%, +5%
Harmonisation of rules on speeding	Scenes P	Car time +5%, +10%
	Meta F	Lorry time +5%, +10%
	Meta P	Car time +5%, +10%
Deregulation for sea and IWW	Meta F	Sea and IWW cost –5%, -10%

Note:
The EXPEDITE meta-models for passengers and freight can also be used for simulations of car ownership changes and simulations for qualitative ('soft') factors (e.g. reliability). In the latter case the change in the soft factor needs to be translated into a change in model inputs, such as time and cost by mode, but results from stated preference valuation studies for a number of qualitative factors are available to do this.

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

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	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 liberalisation (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

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%

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