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The socio-economic impacts of transport pricing reforms

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Executive Summary

1. The GRACE project aims to support policy makers to develop sustainable transport systems by facilitating the implementation of pricing and taxation schemes that reflect the costs of infrastructure use. The previous deliverables of GRACE have focused specifically on the estimation of the external costs on the transport market. In order to understand the soci-economic impact of pricing traffic according to the marginal external cost we need to put the transport market in a broader economic context. In this deliverable we take five different approaches that each highlight another dimension of the socio-economic impact. Table 1-1 gives an overview of the research questions and methodologies used in this deliverable. All approaches have in common that pricing scenarios based on the GRACE estimates of external costs are used.

Table 1-1: Survey of research questions and methodologies used in this deliverable

sections	Research or Policy question	Approach
2.	What is the effect of implementing marginal social cost pricing on the composition of transport flows and on welfare?	Use of GRACE estimates in TREMOVE model for 27+4 EU countries
3.	What is the socio-economic effect of transport pricing in sensitive areas?	Test GRACE estimates with a general equilibrium model for Switzerland that contains a sensitive region (Alps) and a non sensitive region
4.	What are the regional employment effects of marginal social cost pricing?	Use the GRACE estimates in a multi-regional general equilibrium model for the EU to estimate the effects of alternative pricing policies
5.	How to implement marginal social cost pricing when the EU level does not know the marginal external cost at the member country level?	Theoretical analysis using the basic regulation model with asymmetric information
6.	Is a more general equilibrium approach to accident externalities necessary?	Theoretical model with a numerical illustration

2. What is the effect of implementing marginal social cost pricing on the composition of transport flows and on welfare?

2.1 TREMOVE was used to analyse three possible pricing reform scenarios. The three pricing reform scenarios vary in the complexity of the pricing reform that is simulated. The pricing reforms are principally based on marginal external cost information generated in the GRACE project. A model is required to analyse the impacts for three reasons: first some external costs (congestion) are a function of the volume of transport, second the ultimate effect of the pricing policy depends on the demand reactions and modal shifts, third the ultimate welfare effects will depend on the way the transport revenues are used.

2.2. The TREMOVE model represents the transport markets by country modules for 27 EU countries + Croatia, Norway, Switzerland and Turkey. In each country module, all passenger and freight modes are represented and a distinction is made between metropolitan, urban and non urban zones. Every transport mode has a simplified representation of all externalities. Road congestion is endogeneous and is represented via aggregate area speed flow functions, air pollution is represented more finely via a vehicle stock module, and other external costs are linked to activity by mode and type of vehicle. The model estimates the changes in transport demand, the modal split, the vehicle fleets, the external costs and the welfare level in reaction to changes in taxation, pricing and regulation policies.

2.3 The three pricing scenarios are summarized in Table 1-2. All scenarios have in common that all existing taxes, charges and subsidies on transport are abolished and that the non road modes cover their variable costs and marginal external environmental and noise cost. This implies for some countries and non road modes important price increases. Finally all policy scenarios are supposed to be implemented from 2010 onwards but only results for 2020 are reported.

Table 1-2: Pricing reform scenarios for TREMOVE II model

	Cars	Trucks
Scenario 1	use only fuel tax to cover total marginal external cost –	use fuel tax for climate change externalities and a flat km tax for all other externalities
Scenario 2	Use fuel tax only for climate change externalities and country and vehicle specific flat km tax for all other externalities	Use fuel tax only for climate change externalities and country and vehicle specific flat km tax for all other externalities
Scenario 3	Idem as scenario 2 but km tax is differentiated with respect to time and place	Idem as scenario 2 but km tax is differentiated with respect to time and place

2.4 In Table 1-3 the average marginal external cost for 2020 in the basecase equilibrium (before any reform) is reported. These values are based largely on GRACE results. Table 1-3 will be the basis for determining the levels of taxes in the 3 pricing scenarios.

Table 1-3: Averaged weighted marginal social external cost per passenger-km or tonne-km in euro's (2005) in the basecase in 2020

Modes	occupancy ratio or load factor	Infrastructure	Conges-tion	Climate change (high value)	air pollution	accidents	noise	total
Slow mode*	1.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Moped*	1.09	0.0000	0.0230	0.0034	0.0152	1.7779	0.0253	1.8448
Motorcycle*	1.09	0.0000	0.0308	0.0081	0.0113	1.0546	0.0206	1.1253
Car*	1.84	0.0000	0.0290	0.0093	0.0078	0.0188	0.0038	0.0688
Van*	1.42	0.0000	0.0442	0.0149	0.0145	0.0602	0.0043	0.1380
Bus*	16.28	(0.0000)	(0.0067)	0.0039	0.0053	(0.0844)	0.0030	0.1032
light duty truck**	0.78	0.0000	0.0533	0.0226	0.0227	0.0943	0.1517	0.3446
heavy duty truck 3.5-7.5t**	1.05	0.0000	0.0979	0.0394	0.0478	0.0922	0.0208	0.2982
heavy duty truck 7.5-16t**	3.51	0.0000	0.0312	0.0180	0.0223	0.0255	0.0200	0.1170
heavy duty truck 16-32t**	6.06	0.0058	0.0173	0.0098	0.0129	0.0140	0.0196	0.0795
Heavy duty truck >32t**	12.28	0.0027	0.0076	0.0063	0.0087	0.0064	0.0181	0.0498
metro and tram*	125.73	(0.0000)	(0.0000)	0.0007	0.0003	(0.0213)	0.0018	0.0242
passenger train*	184.36	(0.0013)	(0.0000)	0.0029	0.0058	(0.0000)	0.0038	0.0165
Plane*	-	(0.0000)	0.0000	0.0029	0.0071	(0.0006)	0.0044	0.0149
freight train**	738.62	(0.0013)	0.0000	0.0021	0.0043	(0.0008)	0.0026	0.0110
inland ship**	493.60	(0.0019)	0.0000	0.0042	0.0294	(0.0000)	0.0000	0.0355

*(pass/veh) or load** (tonne/veh) figures between brackets are put to 0 in the policy scenarios

2.5 For each of the 3 scenarios two variants are defined that help to understand the role of the use of the net change in transport revenues that result from the policy change. In most partial equilibrium models, the net change in tax revenues is added as a benefit to the changes in consumer surplus and producer surplus with a weight of 1. In TREMOVE, the value of extra tax revenue collected will depend on two factors: where it is taken away and how it is used. For the use of the tax revenues two variants are defined. In the first variant "general tax decrease", all net changes in transport tax revenues are used to decrease general taxes outside the transport sector. 1 € of extra tax revenues collected from non commuting transport and used to decrease general taxes is given a value slightly higher than 1 for most countries. This means that this general tax decrease generates a small extra beneficial welfare effect. In the second variant “labour tax decrease”, the change in transport tax revenues is used to decrease existing labour taxes. There is now a much stronger beneficial effect on the labour market, the value of the extra € ranges between 1.26 and 2.52. The reason is that taxes are shifted away from labour, alleviating directly the labour market distortion. The labour market distortion exists because income and social security contributions create a large gap between the private return to the supply of labour (net wage) and the social return to the supply of labour (gross labour cost to the employer). Not only the use of the extra tax revenue but also the type of transport where extra tax revenue is raised matters: ceteris paribus it is better to tax leisure trips than commuting transport because a tax on commuting transport is almost like a labour tax and therefore adding to the distortion on the labour market. Whenever tax revenues are weighed differently than consumer and producer surplus, marginal social cost pricing is no longer maximising welfare and this will show up in the results: there will be a bias in favour of scenarios generating more tax revenues. Finally, it is obvious, that if one knows that the extra transport tax revenues are used in bad transport infrastructure projects rather than for decreases in other taxes as assumed here, the value of the collected tax revenues is closer to 0 than to 1 and increasing taxes to reduce external effects in the transport sector loses its appeal.

2.6 The aggregate results (EU-27+4) are summarized in Table 1-4: revenues, welfare changes and volume changes for the year 2020 are reported. The first column reports absolute tax revenues (net of subsidies) in the transport sector. The second column reports welfare changes when the revenues are recycled in the economy via a decrease of general taxes. The third column gives welfare changes when the revenues are used to decrease existing labour taxes. The two last columns report changes in volumes of tonkm and passengerkm. The results per country are given in Appendix I.

Table 1-4: Aggregate revenue, welfare and volume effects of the pricing reforms for EU-27+4 for year 2020

In % of GDP	total revenues	Welfare change when general taxes are decreased	Welfare change when labour taxes are decreased	change in tonkm in % of reference	change in passkm in % of reference
reference	2.298	0	0	0	0
scenario 1	6.224	0.034	1.706	-10.7	-17.4
scenario 2	5.402	1.191	2.725	-11.0	-11.5
scenario 3	5.391	1.181	2.702	-10.8	-11.2

We draw 7 lessons from these scenario results:

a) it is clearly very difficult to use the fuel tax as the only instrument to address all the externalities of cars and motorcycles. Scenario 1 shows that this requires enormous increases in fuel taxes, large increases in tax revenues (factor 3) but only a tiny efficiency gain if we rule out the pure recycling effect of tax revenues to alleviate labour market distortions;

b) when a km tax for cars and trucks takes over as main pricing instrument (scenario 2), revenues are double those in the reference scenario and welfare improves strongly – overall transport volumes decrease by some 11% ;

c) the benefits of finer spatial and temporal differentiation (scenario 3 compared to scenario 2) give indeed higher congestion relief benefits but generate less revenues – because of the large weight given to the increase in tax revenues, the result is that scenario 3 generates a smaller welfare gain than scenario 2 if taxes are equal to marginal external costs – if taxes could be optimised in both scenarios scenario 3 would produce clearly better results than scenario 2;

d) it is well known that the introduction of a more refined (area and time based) charging and taxing regime increases the transaction costs (billing, enforcement etc.); this is not yet taken into account in the welfare computation and this needs to be checked region by region as a more refined pricing regime may only make sense in heavily congested areas;

e) the way the extra tax revenues are used is as important as the selection of the pricing reform scenario;

f) the welfare gains come mainly from a reduction of external accident costs, a reduction of external congestion costs and from a good use of the extra tax revenues;

g) the pricing reform policies suggested here are not yet a complete mix to address the different externalities, some externalities like accident externalities need more refined instruments like fines for speeding or alcohol in order to signal the social costs of drivers' behaviour.

What is the socio-economic effect of transport pricing in sensitive areas in Switzerland?

3.1 In this analysis, we evaluate the relative economic impacts on the Swiss economy of regionally differentiated transport pricing strategies reflecting the especially high costs of transport in a sensitive area like the Alps. We also look at cost recovery considerations within each transport mode, which is still a major concern for policy makers. In addition, the importance of the recycling of transport tax revenues to reduce existing distortionary taxes is examined.

3.2 Transport policy scenarios are simulated applying SwissTRANS, a multi-sectoral general equilibrium model of Switzerland introducing both, the Alpine region and the rest of Switzerland, and calibrated to an initial economic equilibrium in 2001. The model combines inter-sectoral linkages within regions together with linkages among regions. Transport per mode is represented in an aggregate way using aggregate congestion functions for road transport.

3.3 Simulation of different transport pricing scenarios in an economy-wide perspective suggests the following policy recommendations:

a) A change from the current pricing regime towards a marginal social cost pricing scheme that is regionally differentiated is beneficial for both the Alpine region and the rest of Switzerland. Though the impact is rather limited in terms of welfare, the policy debate should be oriented in this direction.

b) Regional transport and redistribution policies should not be considered separately as the latter may change the welfare analysis considerably.

c) Cost recovery objectives should not be an objective per se of pricing - average cost pricing as objective for rail and road can lead to inefficient policies in the rail and road sector; when compared to current pricing, average cost pricing results in welfare losses.

d) Additional transport revenues should be used to reduce existing distortionary taxes

e) Appropriate pricing of transit transport[1] is important as it plays a crucial role in the determination of the net welfare effect for Switzerland.

What are the regional employment effects of marginal social cost pricing?

4.1 The regional economic impacts of 3 policy scenarios of European-wide transport pricing on the regional welfare and (un)employment in Europe are computed. The scenarios are identical to the scenarios defined for the TREMOVE model: fuel taxes as the only instrument, a CO2 tax under the form of a (much smaller) fuel tax supplemented by a km charge differentiated by country and finally a CO2 tax under the form of a small fuel tax supplemented by a time and place differentiated km charge (cfr. Table 1-2 above).

4.2 The spatial computable general equilibrium model CGEurope represents Europe by more than 1200 regions. In every region there are immobile households that supply labour and mobile capital. They consume a local good and tradable goods produced by the other regions. They consume more of a good when its price decreases but they love variety and end up consuming a bundle of goods produced by the different regions. Every region produces one variant of the tradable good. Transport costs are one component of the costs of trading goods between regions. As there is imperfect competition for tradable goods, they are sold at decreasing average cost rather than at marginal cost. Labour markets are imperfect: wages do not equilibrate the market and there is unemployment. The unemployment is seen as the result of the efficiency wage hypothesis: higher unemployment reduces the real wages. The tax revenues are redistributed lump sum and are split equally between the origin and the destination region. . Compared to the TREMOVE and the Swiss general equilibrium model, this model introduces two new market distortions: imperfect competition on the tradable goods markets (prices above marginal costs) and unemployment.

4.3 The proposed EU-wide pricing reform scenarios have overall small negative effects on real income and on employment. The overall impact on real income equals -0.11% of GDP but this is before counting the benefits of lower environmental, accident and congestion relief that are of the order of 2 % or more of GDP according to TREMOVE results for the same scenario. The reason for the negative effects is the ultimately distortive nature of the increased

[1] Throughout the deliverable, the word “transit” is used to denote traffic passing through a territory and does not stand for public transport..

transport taxes and charges that come down to an increase in the prices on the market of tradable goods. In the CGEurope model, the presence of imperfect competition makes that prices of tradable goods are already larger than the marginal production costs, so adding the external costs tends to make the tradable goods more extensive than they really are. The spatial pattern of the welfare and unemployment effects of the pricing reform is characterized by a concentration of losing regions in the EU-27 periphery. The regions suffering the strongest losses of welfare and unemployment are located in the new member states. The precise mechanisms at work are complex as trade effects and returns to scale tend to balance each other. On the other hand it is logical that reforms that raise the price of transport affects most those regions that rely more intensively on international trade for their trade.

How to implement marginal social cost pricing when the EU level does not know the marginal external cost at the member country level?

5.1 This research focuses on one particular problem: the asymmetric information problem in the implementation of marginal social cost pricing. While the upper level (EU, or country) is in principle concerned with the welfare of all the EU citizens and wants social marginal cost based pricing, a lower level government (a member state or region) may prefer much higher transport charges to extract revenue from through traffic (called transit here) . This issue is present in the European policy debate: there are the high transit taxes of Switzerland and there is the fear of peripheral countries that road charges for trucks contain a monopoly margin. One of the solutions proposed by the European Commission is to cap the road toll to the average infrastructure costs.

5.2 A simple theoretical model is used to explore the asymmetric information problem. One transport link crossing a single country is used by transit and local traffic. The local government knows the external costs but the federal government does not. We consider two stylized cases of external costs. First constant marginal external costs that are independent of the volume of traffic but affect the local population only (some forms of air pollution or accident externalities on locals). Second, we consider external congestion costs that are a function of the volume of traffic and affect the local users and the transit users.

5.3 For external costs that do not affect the volume of traffic (air pollution etc), the federal government (here EU) can use two policy instruments to control the potential misuse of marginal external cost pricing by the member states. The first is an incentive mechanism (financial reward) that makes the member countries reveal the information correctly. This scheme is theoretically appealing but may be difficult to implement politically. The second is to impose a toll cap based on the federal government estimate of the marginal external cost. This can not result in perfect pricing but improves welfare compared to the case where the regions set the tolls they want.

5.4 For external costs that affect traffic volumes (congestion costs) there are three instruments available for internalization. The first instrument, rewarding truthful revelation, does not always work for external costs that affect the volume of traffic. The second policy, a cap based on the external cost estimate of the federal government can also work for congestion; it improves welfare but is not perfect. The third policy is a cap based on the average infrastructure expenditures for road. This requires a minimum of information to monitor for the federal level. If transit and local traffic are homogeneous and average infrastructure costs are constant (constant returns to scale in road capacity), this generates in principle optimal pricing and even optimal investment policies because it is in the region's interest to do so. This could be the theoretical justification of Eurovignet type of directives. When the composition of transit and local traffic differs (say more trucks in transit or in off peak), the scheme may not work as well. Then there exists the risk that trucks are overcharged as this is a way to make transit pay a disproportionate share of the infrastructure costs.

5.5 Overall we find that there is a need for federal control of regional tolling. This requires investment in knowledge of the possible range of external costs. For air pollution, accident and noise, the federal government could implement toll caps based on the estimated marginal external cost. For the external congestion cost, a cap equal to the average infrastructure cost could be an interesting instrument.

Is a general equilibrium approach to accident externalities necessary?

6.1 The marginal external accident cost that needs to be charged in a richer general equilibrium model has the following structure:

General equilibrium marginal external accident cost =

(1) Partial equilibrium external accident cost + (2) Correction for labour tax revenues + (3) Correction for change in mitigation activity + (4) Correction for the induced labour supply effects

Where

(1) the **Partial equilibrium external accident cost** represents the effect of one more carkm on general accident risk times [productivity value of sick days lost due to a change in the general accident risk + congestion time loss of an increase in accident risk + discomfort of subjective accident risk that remains after mitigation].

(2) the **Correction for labour tax revenues** equals the labour tax losses of the driver associated to the extra sick days of the driver in case of accidents

(3) the **Correction for change in mitigation activity** represents the fact that increased taxation of trips may reduce accident risks and thus the mitigation efforts by the households, as these efforts are often heavily subsidized, reducing these mitigation activities is in itself a gain

(4) the **Correction for the induced labour supply effects** represents the fact that increased taxation of commuter trips may decrease the supply of labour, as labour is already heavily taxed; this is itself a loss.

Not all terms point in the same direction: the second term (2) is typically positive but the third (3) and fourth (4) term may be negative.

If we distinguish between safe and dangerous driving we find that the marginal external accident cost of a kilometre driven is higher for dangerous driving because the general accident risk effect of dangerous driving is higher than for safe driving and also the correction for labour tax revenues is higher as dangerous driving also generates more sick days for the dangerous driver himself.

6.2 A numerical illustration of the partial equilibrium approach used in GRACE and the general equilibrium approach proposed shows that the differences are very small (<1%).

Overall policy conclusions for this deliverable

7.1 This deliverable has produced results on the socio-economic effects of implementing marginal social cost pricing in the EU. Best welfare results are obtained by using more refined pricing instruments than higher fuel taxes. Substitution of present fuel taxes by a combination of a lower fuel tax (equal to the CO2 damage) and a km charge differentiated by type of vehicle and country could already bring important welfare gains.

7.2 The benefits of going beyond the km charge differentiated by type of vehicle and country in the direction of regional and time variation have to be judged region by region. When the characteristics of the regions are very different in terms of external costs it is worthwhile differentiating their pricing.

7.3 Pricing transport according to the marginal social cost affects more the peripheral countries as they rely more on interregional and international transport services for their trade relations. In a labour market characterised by unemployment, unemployment in the peripheral regions could slightly increase.

7.4 Straight marginal cost pricing could generate suboptimal welfare and unemployment effects because there can be negative interactions with existing distortions on the labour market (commuting traffic and unemployment) and on the product markets. One of the ways to limit these negative side effects is to use the net additional tax revenues raised in the transport sector to reduce existing tax distortions on the labour market

7.5 The way the extra tax revenues are used is as important for the overall welfare effect as the selection of the pricing reform scenario itself. If the net revenues are allocated to inferior transport infrastructure projects, it is better not to raise extra tax revenues in the transport sector.

7.6 There is a need for the federal level (EU or lower) to control the implementation of external cost pricing to avoid misuse of monopoly positions. Caps on chargeable air pollution, noise and accident external costs and a cap on chargeable average infrastructure costs need to be considered.

Table of Contents

1 Introduction

1.1 Background

This deliverable has used a wide variety of approaches to look into the social and economic effects of using the external cost information in pricing policies. Table 1-1 gives an overview of the research questions and methodologies used in this deliverable.

Table 1-1: Survey of research questions and methodologies used in this deliverable

Chapters	Research or Policy question	Approach
2.	What is the effect of implementing marginal social cost pricing on the composition of transport flows and on welfare?	Use of GRACE estimates in TREMOVE model for 27+4 EU countries
3.	What is the socio-economic effect of transport pricing in sensitive areas?	Test with a general equilibrium model for Switzerland that contains a sensitive region (Alps) and a non sensitive region
4.	What are the regional employment effects of marginal social cost pricing?	Use the multi-regional general equilibrium model for the EU to estimate the effects of alternative pricing policies
5.	How to implement marginal social cost pricing when the EU level does not know the marginal external cost at the member country level?	Theoretical analysis using the basic regulation model with asymmetric information
6.	Is a more general equilibrium approach to accident externalities necessary?	Theoretical model with a numerical illustration

All chapters in this report have used as primary source for the marginal external costs the other deliverables of the GRACE consortium.

1.2 Division of Responsibilities

This deliverable has been coordinated by KULeuven (S. Proost, S. van der Loo). The authors of the different chapters and the corresponding task reports are given in Table 1-2.

Table 1-2: Authors of different chapters and task reports

Chapters	**Research or Policy question**	**Authors and availability of task reports**
2.	What is the effect of implementing marginal social cost pricing on the composition of transport flows and on welfare?	E. Delhaye, B. Van Herbruggen, O. Ivanova(TMLeuven),S.Proost (KULeuven) Task report 9.2
3.	What is the socio-economic effect of transport pricing in sensitive areas?	L. Cretegny, S.Suter (Ecoplan) Task report 9.3
4.	What are the regional employment effects of marginal social cost pricing?	J.Bröcker,A.Korzhenevych, N.Schneeckloth (CAU) Task report 9.4
5.	How to implement marginal social cost pricing when the EU level does not know the marginal external cost at the member country level?	S.van der Loo , S. Proost (KULeuven) A. de Palma, N. Picard (adpC) Task report 9.5 a Task report 9.5 b
6.	Is a more general equilibrium approach to accident externalities necessary?	E.Delhaye, S.Proost (KU.Leuven) Task report 9.6

2 The transport and welfare effects of a reform of transport pricing in the EU–27 +4

2.1 Objectives

The ultimate objective of better transport pricing is to improve the allocation of resources in the economy. Whenever every user pays the full cost of his trip to society, he will only take the trip when the value of the trip to him is larger than the cost to society. Implementing this principle in the transport sector is not easy because there are many external effects that are not taken into effect by the user. What is ultimately needed is to align the charges and taxes that every user pays with the external costs.

The goal of this chapter is to analyse three possible pricing reform scenarios with the help of the TREMOVE[2] model and the marginal external cost information generated in the GRACE project. The three pricing reform scenarios vary in the complexity of the pricing reform that is simulated. The results generalize and actualize the results of previous exercises of this type obtained with the TRENEN II model for a subset of EU countries (Proost et al. 2002 and ECMT)

The chapter is organised as follows. First, we briefly describe the TREMOVE model and the reference or baseline scenario. Next, we describe the policy scenarios in more detail. This is followed by a detailed computation of the corresponding changes in taxes and charges and their impacts on transport flows and economic welfare. We end with some conclusions.

2.2 The TREMOVE model

The TREMOVE model represents the transport activities in a country as an aggregate of the activities in three types of zones: metropolitan, urban and non urban. For each zone, one represents all modes of passenger transport and freight transport. Passenger and freight users have the choice between some 240 different types of modes and vehicles (mode, vehicle, timing etc.). Road freight and passenger transport interact via congestion and a distinction is made between peak and off peak traffic. The preferences of passengers differ in function of the motive (professional, commuting, leisure) and choices are made taking into account

[2] www.tremove.org

preferences, money and time costs. For freight, different types of transport (unitized, bulk..) are distinguished and modal choice is a function of the time and money cost of the different alternatives. The private cost of transport consists of the price set by the suppliers (equal to the marginal resource cost if not subsidized) plus all the taxes, charges and tolls. Urban public transport supply is characterized by a Mohring effect: an increase in demand allows to improve frequencies and to reduce waiting times. The capacity of the road infrastructure is represented via area speed flow functions.

The model computes equilibrium on each transport market (this means for each zone) via iterations on the time costs and the demand levels. The model is calibrated such as to match an exogenous unchanged policy or “reference” scenario. Of interest is that the model computes, for a given transport equilibrium, all the external costs and all tax and charge revenues. Because the model keeps track of the vehicle stock (additions and scrapping), it is specifically strong in tracking the air pollution costs. Welfare is defined as the sum of consumer surplus, producer surplus minus total external costs plus the value of tax revenue[3]. In our case the model is used for counterfactual analysis: what is the effect on welfare of modifying taxes, charges or regulations such that they better match the different external costs? The model covers 31 European countries (EU 27 + Croatia, Norway, Switzerland, Turkey).

2.3 The reference scenario

The model is first calibrated to an exogenous reference scenario, this calibration, together with the choice of elasticities of substitution, makes sure the revealed preferences of the users are built into the model. The model can then be used to estimate the impacts of policy scenarios on transport demand, the modal split, the vehicle fleets, the emissions of air pollutants and the welfare level. In the reference scenario – or baseline, we want to take into account the developments that are already decided on or are close to implementation. For this, the ASSESS Partial A forecast[4] is implemented in TREMOVE. This baseline was developed during the ASSESS project for DG TREN[5]. The ASSESS Partial A implementation scenario includes all measures already implemented or planned to be implemented before 2010 by the

[3] The value of extra tax revenue is parameterised and depends on who pays taxes and how it is used.
[4] Note that for trucks we use the assumptions in ASSESS Partial B, this means that there are only charges on motorways.
[5] De Ceuster G. et al (2005),

EC or by member states. White Paper measures include driver training, liberalisation of the freight rail market and freight infrastructure charges.

A detailed overview of the TREMOVE model and the reference scenario can be found in the task report 9.2.

2.4 Description of policy scenarios

This section describes the three policy scenarios. We assume that they are all implemented from the year 2020 onwards. Except for the VAT on for example insurance, maintenance and the fuel consumed by passenger cars, we set all existing taxes and charges, this is the subsidies on public transport, the registration tax, the ownership tax and the insurance tax, to zero. Changes in tax revenues are taken into account as part of the net welfare effect. However, the model does not take into account that the redistribution of tax revenues to consumers and firms via a reduction of non transport taxes can influence via income and substitution effects the transport decisions and the transport flows. This however, does not really matter for the relative performance of the policy scenarios.

The three pricing scenarios only differ for the road mode. To ease comparability we use the same policy- called the background policy - for the non road modes and public transport in all three pricing scenarios. We choose to have an internalization scheme for all modes as we are dealing with close substitutes like alternative transport modes for passenger transport or freight transport. It may be counterproductive to set taxes equal to the marginal external cost for only one mode, when the other modes are not priced at marginal cost.
The first section discusses this background policy that applies to the non-road modes. The other sections briefly describe the setup of the three scenarios for the pricing of the road modes.

Background policy for non road modes and public transport.

Prices for non road modes (and public transport by bus) cover their variable operation costs and contain a tax per passengerkm/tonkm that covers marginal external environmental and noise cost

The idea for all GRACE policy scenarios is to cover the variable cost and the marginal external environmental and noise cost for non road modes and public transport by the use of a tax per vehicle kilometre. We do not include the marginal external infrastructure and congestion costs for these modes as there is still discussion on the methodology and the magnitudes. The marginal external accident costs are also not taken into account, but they are small. Table 2-1 summarizes the marginal external costs which are taken into account in the background policy for non road modes and public transport.

Table 2-1 : Marginal external costs non road modes and public transport

	Social marginal external cost					
X means is taken into account in marginal external cost tax	**Infrastructure**	**Congestion**	**Climate change**	**Air pollution**	**Accidents**	**Noise**
Bus			X	X		X
Metro and tram			X	X		X
Passenger train			X	X		X
Plane			X	X		X
Freight train			X	X		X
Inland ship			X	X		X

As marginal external costs differ between modes and countries (task report 9.2), the tax is differentiated by mode and by country.

Scenario 1

- Differentiated fuel taxes for cars
- Flat km tax for trucks

Given the results of Deliverable 6 (Becker and Link (2007)) that warns against too complex pricing systems for road and the ease of implementation of fuel taxes we opt in this first scenario for a fuel tax for cars, vans, motorcycles, mopeds and a flat km tax for trucks as the main instruments to internalize (partly) the external costs of driving. Deliverable 6 shows that most people felt that an increased fuel tax would be a better way of paying for road use as it:

- avoids introducing a new, additional charge;
- minimises the number of service charges and transactions;
- is easy to administer and understand;
- is easy to 'keep tabs on' - making it easier to manage driving costs;
- is easy to respond to - the driver would know that, to pay less, he or she had to use less fuel and therefore drive less;
- involves immediate payment - no bills to pay, and no risk of building up unexpected debts etc.”

The main idea is that for cars, moped and motorcycle and van drivers the fuel tax covers air pollution and greenhouse gasses, congestion, accidents and noise. This may require higher diesel taxes as they are polluting. Moreover, they are more fuel efficient so that one needs a higher fuel tax than gasoline to cover the same per km external cost. As the external costs differ between countries, the fuel tax will also be different in the countries. This may lead to some tank tourism but in general the differences between neighbouring countries are small and even today fuel taxes are not harmonised over Europe. As all other existing taxes have been abolished this scenario implies a strong increase in fuel taxes compared to present levels. For trucks the goal is that the diesel tax covers the climate change damage and that the flat km tax – differentiated by country and by truck type – covers air pollution, congestion, accidents, noise and wear and tear. Note that wear and tear is only relevant for the large trucks (>16 ton). Observe that truck drivers pay the same fuel tax as car drivers. To overcome the problem that diesel trucks would pay twice, once via the fuel tax, which is set equal to the external costs of the car, and once via the km tax, we make diesel taxes largely deductible for trucks; only the climate damage part remains as tax.

Scenario 2

The fuel tax for cars, vans, mopeds and motorcycles is not the best mean to internalise the external costs of cars for two reasons. Firstly, it will require to set the fuel tax at a very high level to cover all external costs. Secondly, the relationship between fuel use and marginal external accident, noise, air pollution and congestion cost is not good. In general, a fuel tax is a good mean to internalise the external costs of greenhouse gasses, but not of other external costs. Hence we opted to introduce – as we did for trucks in the first scenario – a flat km tax for cars. This produces scenario 2:

- all road modes pay a fuel tax equal to the climate change damage and a flat km tax that covers all other external costs – the flat km tax is differentiated by type of vehicle and by country

Scenario 3

- all road modes pay a fuel tax equal to the climate change damage and a km tax that covers all other external costs – the km tax is differentiated by type of vehicle, by country and by time, by zone and by road type

The goal of this scenario is to come as closely as possible towards marginal social cost pricing by using a combination of a fuel tax and a km tax. The main difference with the second scenario is the level of differentiation. The fuel tax again only covers the climate damage of the road modes (excluding public transport). All cars, vans, mopeds, motorcycles and trucks are now subject to a km tax which covers air pollution, congestion, accidents, noise and infrastructure wear and tear. The km tax is differentiated in function of vehicle type, zone, road type, country and peak/off peak. .

These scenarios are evaluated with the TREMOVE model. Before turning to the results, we first detail the calculation of the marginal external costs and compare them with current tax levels.

2.5 The marginal external costs and the tax levels

In order to determine the level of the taxes we first calculate the marginal external environmental costs, the marginal external accident cost, the marginal external infrastructure cost and the noise costs associated with the different countries, vehicle types, regions and roads. The TREMOVE model is used in combination with the results of the detailed studies on marginal external costs of GRACE and UNITE. The calculation of marginal environmental and congestion costs is based on the outputs of the TREMOVE model, the marginal accident and infrastructure costs are based on GRACE estimates, the marginal external noise costs are based on UNITE[6].

We first briefly define the different external costs in Table 2-2 and then turn to the actual values. Note that this table also mentions possible sources for external costs which are not per se taken into account in the policy scenarios.

[6] UNITE (2003) does not provide results for external costs of noise for tram/metro. We have used ECMT (1998) data for this mode.

Table 2-2: Studies and models used for the calculation of the marginal social costs of transport

Type of social costs	Study/model used for its calculation	Short description of the methodology used
Environmental costs	TREMOVE model	Definition: Environmental damage caused by one more passenger or tonne km. Based on the TREMOVE emission factors and the estimates of monetary environmental costs from the Clean Air for Europe Programme project. TREMOVE covers both tank-to-wheel and well-to-thank emissions. Impact assessment and valuation are performed using the impact pathway approach. Methods of the impact assessment range from the use of simple statistical relationships, as in the case of occupational health effects, to the use of series of complex models and databases, as in the cases of acid rain and global warming effects.
Congestion	TREMOVE model	Definition: Extra time costs for all users caused by one more passenger (or tonne) km. The speed-flow relationships used for the calculation of the marginal congestion costs are based on the SCENES outputs for peak and off-peak time periods. We use the BPR functional form of the speed-flow relationships.
Accidents costs	GRACE INFRAS (2000)	Definition: The accident costs caused by one more passenger or tonnekm. In the GRACE calculations the external accident costs consist of the cost imposed on road users of the other categories and on society at large. The marginal external accident cost is calculated as in D8 of GRACE. The risks of an accident for cars, busses and trucks are based on IRTAD, CARE and WRS statistics. For moped drivers and motorcycles we used a correction factor based on relative injury rates (Elvik 2004). The accident cost consists of the VSL and the material costs and are based on the HEATCO project. The externality proportion is calculated using the CARE database. The risk elasticity is based on literature and the GRACE model. The calculations do not take into account the small proportion 'internal' material accident costs which depend on the social security system in each Member State, the – most probably negative – accident externality imposed on users of the same category and the – positive- costs of risk avoiding behaviour. For non-road modes we give the INFRAS (2000) estimates.

Noise costs	UNITE (2003) and ECMT (1998)	Definition: Noise damage associated to one passenger or tonne km. Local external costs include the damage to other users and the damage to the neighbourhood. Noise emissions of transport activities affect humans mainly in two ways: • negative physiological effects, e.g. change in heart rate, and blood pressure, inducing measurable increases in heart attack risk. • negative psychological effects, e.g. annoyance, disturbance of communication and recreation, insomnia, loss of (mental) productivity. For the valuation of noise, costs due to health impacts caused by exposure to noise were assessed using exposure-response functions. To this, costs due to amenity losses, based on studies quantifying a noise sensitivity depreciation index, were added. The calculations made in this report assume marginal noise costs are equal to average costs.
Infrastructure costs	GRACE	Definition: The short run marginal infrastructure damage related to an additional train/vehicle. This is the increased wear leading to increased routine maintenance and the damage to infrastructure leading to earlier periodic maintenance. There are three categories of infrastructure costs. Operation costs which are undertaken to keep the infrastructure open to traffic, but these do not vary much with volume. Maintenance cost for preventive measures to avoid degradation and renewal costs to bring infrastructure back in the original condition. The marginal costs are calculated by making the product of the elasticity of infrastructure costs with respect to volume and the average renewal and maintenance cost. The figures are based on the marginal cost case studies for road and rail performed in Deliverable 3.

We give the marginal external costs split according to their six components in Table 2-3: infrastructure, external congestion, climate damage, air pollution, accidents and noise. These are the results for the reference scenario in 2020. The external costs which are not taken into account in the policy scenarios are put between brackets.

The costs are weighted averages (weigted at pkm and tonkm) over all countries (EU 27+4) but differentiated by vehicle type. The vehicle types considered are passenger transport vehicles including car, moped, motorcycle, bus, coach and passenger train and the freight transport vehicles including light duty trucks, heavy duty trucks, freight train and inland shipping. The figures are given per passenger-km or per tonne-km. The first column gives information on the occupancy ratio/load factor. Note that in the EU 15 the occupancy ratio for cars is only 1.4.

Table 2-3: Averaged weighted marginal social external cost per passenger-km or tonne-km in € (2005) in the basecase in 2020.

Modes	Occupancy	Infrastructure	Conges-tion	Climate change	Air pollution	Accidents	Noise	Total
Slow mode*	1.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Moped*	1.09	0.0000	0.0230	0.0034	0.0152	1.7779	0.0253	1.8448
Motorcycle*	1.09	0.0000	0.0308	0.0081	0.0113	1.0546	0.0206	1.1253
Car*	1.84	0.0000	0.0290	0.0093	0.0078	0.0188	0.0038	0.0688
Van*	1.42	0.0000	0.0442	0.0149	0.0145	0.0602	0.0043	0.1380
Bus*	16.28	(0.0000)	(0.0067)	0.0039	0.0053	(0.0844)	0.0030	0.1032
light duty truck**	0.78	0.0000	0.0533	0.0226	0.0227	0.0943	0.1517	0.3446
heavy duty truck 3.5-7.5t**	1.05	0.0000	0.0979	0.0394	0.0478	0.0922	0.0208	0.2982
heavy duty truck 7.5-16t**	3.51	0.0000	0.0312	0.0180	0.0223	0.0255	0.0200	0.1170
heavy duty truck 16-32t**	6.06	0.0058	0.0173	0.0098	0.0129	0.0140	0.0196	0.0795
heavy duty truck >32t**	12.28	0.0027	0.0076	0.0063	0.0087	0.0064	0.0181	0.0498
metro and tram*	125.73	(0.0000)	(0.0000)	0.0007	0.0003	(0.0213)	0.0018	0.0242
passenger train*	184.36	(0.0013)	(0.0000)	0.0029	0.0058	(0.0000)	0.0038	0.0165
Plane*	-	(0.0000)	0.0000	0.0029	0.0071	(0.0006)	0.0044	0.0149
freight train**	738.62	(0.0013)	0.0000	0.0021	0.0043	(0.0008)	0.0026	0.0110
inland ship**	493.60	(0.0019)	0.0000	0.0042	0.0294	(0.0000)	0.0000	0.0355

*(pass/veh) or load** (tonne/veh)

It is clear that the highest marginal external cost is associated with the mopeds and the motorcycles. About 95% of their external costs consists of the accident costs. In general, the accident risk of a moped/motorcycle driver is about 8 times higher than for a car (Elvik 2004).

However, note that for all passenger modes the accident costs are the main component. Another mode with a relative high marginal external cost is the light duty vehicle. They also perform much worse than the other trucks. This is due to their lower load factor and to the fact that they drive more in congested areas. For trucks most externalities have more or less an equal share in the total external cost. The modes with the lowest external costs are the non-road modes such as train, metro&tram and inland waterways. This is due to their low accident and pollution costs and their high loading factor.

In task report 9.2 we give the marginal external costs country by country. If we compare the ‘old’ European countries with the 14 new member states, we see that the marginal external costs for cars in the EU15 (+Norway and Switzerland) are twice as large as in the 15 new member states. For trucks the estimates for the old EU15 are also slightly higher. These two results are mainly due to the external congestion costs. For mopeds, motorcycles and rail the level of the external costs is about the same. Note that instead of differentiating the costs by mode and by country, the marginal external costs also differ between time periods (peak and off-peak) and geographical zones (metropolitan, non-urban and other).

It is instructive to compare these marginal external costs with the tax levels in the background scenario and in the three policy scenarios. Note that in setting the taxes equal to the marginal external costs, it is important to take into account that marginal external costs depend on the volume and that the volume depends on the level of the tax. In the case of external congestion costs this implies that the optimal tax is lower than the marginal external cost measured before the introduction of the tax. Therefore, within TREMOVE the taxes are recalculated every year using external costs of the year before. Table 2-4, Table 2-5, Table 2-6 and Table 2-7 give the prices, the tax level and the marginal external costs for the reference and the three scenarios respectively for the year 2020. The price level is that of the year 2005.

In the economic optimum and in the absence of distortions in the rest of the economy, the prices cover all resource costs and the taxes should cover the marginal external costs. In the reference scenario (Table 2-4) we clearly see that the present taxes are lower than the external costs for all modes.. The first column denotes the price for the user. It includes the costs of repair, of purchase, labour, insurance, fuel, the user fees and the VAT. It does not include the existing taxes. They are shown in the next four columns. The last column shows the marginal external costs as in Table 2-3 Note that the column with the other taxes represents the taxes on registration, ownership and subsidies for public transport In the policy scenarios these other taxes are put equal to zero because the 3 policy scenarios only contain combinations of fuel taxes and differentiated km taxes.. In all 3 policy scenarios, we abolish all subsidies for the variable operation costs of public transport: in the reference scenario, the lines metro and passenger train show negative entries for the column other taxes.

Table 2-4: Reference scenario 2020

mode	price (incl VAT, exl taxes)	other taxes	fuel tax	km tax	total tax	Marginal External Cost
slow mode*	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
Moped*	0.0446	0.0018	0.0062	0.0000	0.0080	1.8448
Motorcycle*	0.2476	0.0147	0.0165	0.0000	0.0311	1.1253
Car*	0.2032	0.0148	0.0187	0.0000	0.0335	0.0688
Van*	0.1733	0.0127	0.0276	0.0000	0.0403	0.1380
Bus*	0.1077	-0.0478	0.0000	0.0000	-0.0478	0.1032
light duty truck**	0.2605	0.0227	0.0388	0.0000	0.0615	0.3446
heavy duty truck 3.5-	0.9349	0.0226	0.0557	0.0179	0.0962	0.2982
heavy duty truck 7.5-	0.2788	0.0070	0.0257	0.0057	0.0384	0.1170
heavy duty truck 16-	0.1586	0.0043	0.0144	0.0077	0.0264	0.0795
heavy duty truck >32t**	0.0619	0.0010	0.0000	0.0000	0.0162	0.0498
metro and tram*	0.2712	-0.1229	0.0000	0.0000	-0.1229	0.0242
passenger train*	0.2200	-0.1085	0.0000	0.0000	-0.1085	0.0165
Plane*	0.0948	0.0000	0.0000	0.0000	0.0000	0.0149
freight train**	0.0783	0.0000	0.0000	0.0000	0.0000	0.0110
inland ship**	0.0689	0.0000	0.0099	0.0053	0.0000	0.0355

* €/passengerkm

**€/tonkm

Note that in the policy scenarios the tax will not equal exactly the marginal external costs for three reasons. Firstly, not all marginal external costs are included in the tax. Secondly, the level of differentiation of the tax does not correspond with the level of differentiation of the external costs. For example, a fuel tax cannot differentiate between the congestion costs in the peak and the off peak. Finally, there is a lag in the TREMOVE model as the tax level in the year t is based on the marginal external costs of the year t-1.

Table 2-5: Scenario 1 for 2020

mode	price (incl VAT, exl	fuel tax	km tax	total tax	Marginal External Cost
slow mode*	0.0001	0.0000	0.0000	0.0000	0.0000
Moped*	0.0934	0.1554	0.0000	0.1554	1.5048
Motorcycle*	0.3686	0.2788	0.0000	0.2788	0.8136
Car*	0.2342	0.1004	0.0000	0.1004	0.0680
Van*	0.2055	0.1410	0.0000	0.1410	0.1369
Bus*	0.1108	0.0000	0.0101	0.0101	0.0933
light duty truck**	0.3011	0.2117	0.0000	0.2117	0.3460
heavy duty truck 3.5-	0.9370	0.0380	0.2577	0.2957	0.2958
heavy duty truck 7.5-	0.2790	0.0171	0.0986	0.1158	0.1158
heavy duty truck 16-32t**	0.1595	0.0094	0.0689	0.0783	0.0783
heavy duty truck >32t**	0.0618	0.0000	0.0026	0.0500	0.0500
metro and tram*	0.2661	0.0000	0.0121	0.0026	0.0214
passenger train*	0.2232	0.0000	0.0140	0.0121	0.0161
Plane*	0.0947	0.0000	0.0088	0.0140	0.0147
freight train**	0.0788	0.0000	0.0248	0.0088	0.0111
inland ship**	0.0700	0.0063	0.0437	0.0248	0.0262

* €/passengerkm

**€/tonkm

Remember that in the first scenario we had a fuel tax for cars , a flat km tax for trucks and user prices for for non road modes and public transport that cover the variable operation costs and the air pollution and noise costs. In Table 2-5 we show the resulting prices[7] and taxes for this scenario. For passenger road modes we see that the fuel tax is too low for mopeds and motorcycles and too high for the cars and vans. The reason for this is that the tax is set equal to the weighed average external costs of the road modes. Hence cars are paying partly for the large external costs of mopeds and motorcycles. This means that the use of only a fuel tax to cover all external costs is too rough as an instrument. An additional or other instrument, which can be differentiated between modes, will perform better. Moreover, using the fuel tax as the only instrument means that in order to internalise external costs, the fuel tax is 6 times higher than in the reference case[8]. The flat km tax for trucks makes that the total tax covers almost the full marginal social external cost.

The taxes for the non-road modes and public transport are too low for most modes as they only cover the external noise and environmental cost. Even so, this means that for rail about 75% (passengers) -79% (freight rail), for plane and inland ship 95% of the external costs are covered by the km charge. For bus, on the other hand, only 11% of the external costs are covered due to the fact that congestion and accidents, which do play a role for bus, are not taken into account.

In the second scenario we used a fuel tax to cover the external costs of greenhouse cases and a flat km tax, differentiated by mode, to cover the other externalities. We see (Table 2-6) that the resulting total taxes compared with the first scenario are now much higher for mopeds, motorcycles and vans and lower for cars. This is due to the better match with the accident externality. In the first scenario, cars paid too much while, for example, mopeds paid not enough. This discrepancy was due to the use of only one instrument, which can not be differentiated by mode.

The fuel tax in the second scenario is much lower than in the first scenario and even about 50% lower than in the reference case.

[7] Note that we also see a an effect on the user costs. The main reason for this is the effect of the policies on the fleet composition. For example, mopeds will drive less km and hence the fixed costs get a higher weight in the user price.

[8] Given that we have set all other taxes to zero, you already need to double the fuel tax if you want to keep the same level of taxation as in the reference case. Note that such a huge increase in fuel tax touches the boundaries of the confidence of the model.

Table 2-6: Scenario 2 in 2020

mode	price (incl VAT, exl taxes)	fuel tax	km tax	total tax	Marginal External Cost
slow mode*	0.0001	0.0000	0.0000	0.0000	0.0000
Moped*	0.1299	0.0032	1.4044	1.4077	1.4068
Motorcycle*	0.4344	0.0077	0.7766	0.7843	0.7846
Car*	0.2103	0.0091	0.0590	0.0681	0.0682
Van*	0.1897	0.0145	0.1216	0.1361	0.1360
Bus*	0.1111	0.0000	0.0101	0.0101	0.0946
light duty truck**	0.3297	0.0220	0.3211	0.3431	0.3429
heavy duty truck 3.5-7.5t**	0.9387	0.0380	0.2578	0.2958	0.2959
heavy duty truck 7.5-16t**	0.2797	0.0171	0.0987	0.1158	0.1159
heavy duty truck 16-32t**	0.1598	0.0094	0.0689	0.0783	0.0783
heavy duty truck >32t**	0.0619	0.0063	0.0437	0.0501	0.0500
metro and tram*	0.2662	0.0000	0.0026	0.0026	0.0214
passenger train*	0.2235	0.0000	0.0121	0.0121	0.0161
Plane*	0.0948	0.0000	0.0140	0.0140	0.0147
freight train**	0.0788	0.0000	0.0088	0.0088	0.0111
inland ship**	0.0700	0.0000	0.0248	0.0248	0.0262

* €/passengerkm

**€/tonkm

The idea behind the third scenario was to approximate as closely as possible marginal social cost pricing. This is clearly reflected in the tax levels which are now very close to the external cost (Table 2-7). Note that the resulting fuel tax is exactly the same as in the second scenario and that the resulting tax levels are very close to the tax levels of the second scenario. Note that we show the km tax in an aggregated way. If we differentiate the taxes with respect to the period, we see (task report 9.2) that the tax is higher in the peak than in the off peak due to the congestion costs. As it is close to the economic optimum, it can serve as a benchmark to compare the other scenarios.

The marginal external costs for road passenger modes are lower in the third than in the second scenario. This indicates a better internalisation due to the differentiation.

Table 2-7: Scenario 3 in 2020

mode	Price (exl taxes)	fuel tax	km tax	total tax	Marginal External Cost
slow mode*	0.0001	0.0000	0.0000	0.0000	0.0000
Moped*	0.1296	0.0032	1.4022	1.4055	1.4046
Motorcycle*	0.4337	0.0077	0.7748	0.7825	0.7828
Car*	0.2095	0.0090	0.0579	0.0670	0.0672
Van*	0.1884	0.0145	0.1200	0.1345	0.1343
Bus*	0.1110	0.0000	0.0101	0.0101	0.0946
light duty truck**	0.3281	0.0219	0.3178	0.3397	0.3395
heavy duty truck 3.5-7.5t**	0.9355	0.0379	0.2531	0.2910	0.2912
heavy duty truck 7.5-16t**	0.2785	0.0171	0.0971	0.1142	0.1143
heavy duty truck 16-32t**	0.1593	0.0094	0.0681	0.0775	0.0775
heavy duty truck >32t**	0.0618	0.0063	0.0434	0.0497	0.0497
metro and tram*	0.2649	0.0000	0.0026	0.0026	0.0214
passenger train*	0.2234	0.0000	0.0121	0.0121	0.0161
Plane*	0.0948	0.0000	0.0140	0.0140	0.0147
freight train**	0.0789	0.0000	0.0088	0.0088	0.0110
inland ship**	0.0701	0.0000	0.0248	0.0248	0.0262

* €/passengerkm

**€/tonkm

2.6 Results of the pricing scenarios

We use the version 2.6 of TREMOVE to asses the effects of the formulated scenarios and calculated taxes. The simulation horizon for the GRACE scenarios is set to the year 2030, where the implementation of the new tax policies starts from the year 2010. We show the results for the year 2020. The welfare analysis in TREMOVE is based on the analysis of four components. For each year, the total difference in welfare between the two scenarios (reference and policy scenario) is derived from

- the difference in aggregate utility level of all households (difference in consumer surplus)
- the difference in production costs for all freight users and transport service suppliers (difference in producer surplus)
- the difference in external environmental, infrastructure, noise, wear and tear and accident cost[9].
- the difference in the value of government tax revenues from the transport sector

Note that the way the tax revenues are used has a large impact on welfare. Imagine first the case where the extra tax revenue collected would be entirely wasted: then the value of all extra tax revenue would be 0. For each of the 3 scenarios two variants are defined that help to understand the role of the use of the transport revenues. In one variant "general tax decrease", all variations in revenues are used to decrease general taxes. In the second variant "labour tax decrease", the change in tax revenues is used to decrease existing labour taxes. 1 € of extra tax revenues collected from non commuting transport and used to decrease general taxes has a value slightly higher than 1 in most countries (ranging between 0.97 and 1.16)[10]. This means that this general tax decrease has a small extra beneficial efficiency effect. When the same tax revenues are used to decrease existing labour taxes, there is a much stronger beneficial effect: the value of the extra € ranges between 1.26 and 2.52. The reason is that taxes are shifted away from the distorted labour market. Whenever a € of tax revenue is collected from commuting transport, this is assimilated to a labour tax, when the revenue is used to reduce labour taxes; it receives a value of 1 as you replace a labour tax with a labour tax. However, when the revenue is used to decrease general taxes, its value is smaller than 1 as one substitutes a € with an efficiency cost of around one by a € with an efficiency cost much

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[9] The congestion (time) costs are taken into account in the calculation of consumer and producer surpluses through the use of generalised prices.

[10] The exact figures used, can be found in task report 9.2

larger than one. Whenever tax revenues receive a value different than one, marginal social cost pricing is no longer optimal and this will show up in the results..

Table 2-8 shows the effect of the three scenarios on the level of total revenues and the changes in welfare. The tax revenue doubles due to the policy scenarios compared to the reference case. Although, if the revenue is used to decrease the general taxes, the first scenario obtains only 3% of the welfare change in the second and third scenario. Moreover, this table represents the sum of all welfare changes and in the case of decreasing general taxes the welfare effect is even negative in many countries (task report 9.2). If the revenue is used to decrease labour taxes, the welfare gain increases sharply and is now positive in all countries for all scenarios. In this case the first scenario is able to capture about 63% of the welfare gain of the second and third scenario.
Table 2-9 and Table 2-10 show the gains in welfare as % of GDP and isolate the share of environmental and accident damages. The gains in congestion are already counted in the utility gains of households and cost savings of producers. The changes in utility of households and in production costs do not include yet the positive effect of redistributing the tax revenues. The latter effect is included in the value of tax revenues. The dominant factors are the savings in accident costs, the congestion effects (hidden in utility and cost changes) and the recycling effects of the revenues. The environmental cost savings exist but play a minor role.

Note that although theoretically not expected, we cannot really distinguish the gain in welfare in the second scenario from the third scenario. We would expect that differentiation (the third scenario) leads to higher welfare gains, while we even find a small decrease of 0.08%. The main reason is that the amount of extra revenue in the second scenario is higher than in the third scenario. Scenario 3 uses better targeted pricing instruments that give lower overall tax revenues. In the second scenario the tax is the same in the peak and the off peak. In the third scenario the tax is higher in the peak than in the off peak. However while the decrease – compared with the reference case- in passenger/tonkm off peak is lower in scenario 3 than in scenario 2, the decrease in the peak is much higher (Table 2-11), therefore the total revenues are lower. As tax revenues receive here a higher weight than consumer or producer surplus, pure marginal social marginal cost pricing can give a lower overall welfare value. If one can reoptimise the pricing in function of this difference in weight, optimal prices will be above marginal social costs and scenario 3, given that it has more optimising instruments available, can only perform better than scenario 2..

Table 2-8: welfare and revenue effect.

million €	total revenues	absolute change in welfare general	absolute change in welfare labour	change in % tonkm	change in passengerkm %
reference	415850	0		0	0
scenario 1	1131372	6220	310117	-10.7	-17.4
scenario 2	982005	216509	495300	-11.0	-11.5
scenario 3	979872	214632	491075	-10.8	-11.2

Table 2-9: welfare and revenue effect as a % of GDP.

% of GDP	revenues	welfare general	welfare labour
reference	2.298	0	0
scenario 1	6.224	0.034	1.706
scenario 2	5.402	1.191	2.725
scenario 3	5.391	1.181	2.702

Table 2-10: decomposition of welfare effect in scenario 2

	Labour recycling		General recycling	
	million €	*% of GDP*	*million €*	*% of GDP*
Sum of utility of households	-452,933	-2.492%	-452,933	-2.492%
Sum of production costs	-272,083	-1.497%	-272,083	-1.497%
Sum of external cost CO	0	0.000%	0	0.000%
Sum of external cost CO2	9,746	0.054%	9,746	0.054%
Sum of external cost N2O	23	0.000%	23	0.000%
Sum of external cost NOx	5,560	0.031%	5,560	0.031%
Sum of external cost PM	1,119	0.006%	1,119	0.006%
Sum of external cost SO2	56	0.000%	56	0.000%
Sum of external cost VOC	1,137	0.006%	1,137	0.006%
Sum of external cost noise	23,476	0.129%	23,476	0.129%
Sum of external cost accidents	375,979	2.068%	375,979	2.068%
Sum of external cost wear	1,480	0.008%	1,480	0.008%
Sum of cost of public funds labour	801,721	4.411%	522,930	2.877%
Sum of welfare labour	**495,300**	**2.725%**	**216,509**	**1.191%**
sum environment	17,641	0.097%	17,641	0.097%

The last two columns of Table 2-8[11] and Table 2-10 show the effect of the scenarios on the tonkm and passengerkm. Although taxes are, when averaged almost the same in the third scenario, the effect on the traffic volume is lower.

Table 2-11: change in tonkm and passengerkm

	absolute	Absolute (2020)				relative decrease (2020)			
	2005	Reference	scenario1	scenario2	scenario3	scenario1	scenario2	scenario3	
								peak	Off peak
slow mode	264746	327129	314265	317232	317582	-0.039	-0.030	-0.047	-0.026
moped	86456	167059	93029	42995	43110	-0.443	-0.743	-0.725	-0.746
motorcycle	76390	128206	83828	64332	64532	-0.346	-0.498	-0.499	-0.496
car	4118309	6591159	5532684	6021842	6067674	-0.161	-0.086	-0.121	-0.070
van	224088	373641	300692	310702	313830	-0.195	-0.168	-0.188	-0.152
bus	588108	626456	467188	472691	472669	-0.254	-0.245	-0.233	-0.249
light duty truck	49385	67874	54309	47197	47433	-0.200	-0.305	-0.356	-0.287
heavy duty truck 3.5-	50625	104104	96201	96015	96363	-0.076	-0.078	-0.119	-0.063
heavy duty truck 7.5-	62300	125522	114107	113872	114323	-0.091	-0.093	-0.135	-0.077
heavy duty truck 16-	520687	1063642	958066	956284	959462	-0.099	-0.101	-0.141	-0.087
metro and tram	47857	64170	56035	55577	55706	-0.127	-0.134	-0.142	-0.128
passenger train	371558	472883	351437	352975	353978	-0.257	-0.254	-0.254	-0.251
plane	240825	672909	584453	598231	599519	-0.131	-0.111	-0.115	-0.108
freight train	407949	473670	453862	453108	454594	-0.042	-0.043	-0.07353	-0.03373
inland ship	126780	186518	170413	170372	170615	-0.086	-0.087	-0.11862	-0.0787
heavy duty truck >32t	884407	1807745	1571264	1568274	1573263	-0.131	-0.132	-0.17088	-0.11893

This is due to the stronger substitution between peak and off peak in the third scenario. Also note that because of the high taxes, there is a very sharp decrease in the traffic volume of

[11] In task report 9.2 we decompose these effects for each country.

mopeds and motorcycles, which leads to a decline in accident cost and hence yields a welfare benefit.

Traffic volume of public transport declines as subsidies to variable operation costs are replaced by a tax in the scenarios.

The analysis of these three policy scenarios leads to the following conclusions.

a) it is clearly very difficult to use the fuel tax as the only instrument to address all the externalities of cars and motorcycles. Scenario 1 shows that this requires enormous increases in fuel taxes, large increases in revenues (factor 3) but only a small efficiency gain if we rule out the pure recycling effect of tax revenues;

b) when a km tax for cars and trucks takes over as main pricing instrument (scenario 2), revenues are double those in the reference scenario and welfare improves strongly – overall transport volumes decrease by some 10% ;

c) the benefits of finer spatial and temporal differentiation (scenario 3 compared to scenario 2) give indeed higher congestion relief benefits but generate less revenues – given the large weight given to the increase in tax revenues, the result is that scenario 3 generates a smaller welfare gain than scenario 2 if taxes are equal to marginal external costs – if taxes could be optimised in both scenarios scenario 3 would produce clearly better results than scenario 2;

d) the way the extra tax revenues are used is as important as the selection of the pricing reform scenario;

e) it is well known that the introduction of a more refined charging and taxing regime increases the transaction costs (billing, enforcement etc.); this is not yet taken into account in the welfare computation and this needs to be checked region by region as a more refined pricing regime may only make sense in heavily congested regions;

f) the welfare gains come mainly from a reduction of external accident costs, a reduction of external congestion costs and from a good use of the extra tax revenues.

3 The socio-economic effects of transport pricing in sensitive Swiss areas

3.1 Introduction

In the political debate on transport policy, higher transport taxes and charges are often mentioned as an appropriate approach to address increasing environmental costs in sensitive areas. In particular, because of its specific landscape and its vulnerable ecosystem, the Swiss Alpine region suffers a lot from transport-related pollution which is much higher per transport unit than in the rest of Switzerland. The introduction of a spatially differentiated transport pricing would reduce negative impacts of transportation in the Alps.

In our analysis, we evaluate the relative economic impacts on the Swiss economy of regionally differentiated transport pricing rules. We also look at cost recovery considerations within each transport mode, which is still a major concern for policy makers. In addition, the importance of the recycling of transport tax revenues to reduce existing distortionary taxes is examined.

The chapter is organised as follows: section 2 describes the model used. Section 3 gives the policy scenarios. Section 4 discusses the results and section 5 concludes. The model and the results are discussed in more detail in the task report.

3.2 The SwissTRANS Model

The SwissTRANS model is designed to analyse the economic impacts of transport policy within Switzerland. The current version of the model is a multi-sectoral computable general equilibrium (CGE) model of Switzerland.

The SwissTRANS model distinguishes two regions: the Alps and the rest of Switzerland. This allows taking account of the greater sensitiveness of the former to transport-related pollution. The model combines therefore inter-sectoral linkages within regions together with linkages among regions. In each region, consumers' demand is determined by budget-constraint optimization and producers combine intermediate inputs, and primary factors at least cost subject to given technology. Agents interact through commodity flows and labour supply. However, bilateral trade flows between regions are not explicitly represented. They are implicitly introduced assuming homogenous composites of regional commodities. The degree of mobility of regional goods and services is assumed to be controlled by an elasticity of substitution. In other words, lowering of a region-specific price induces substitution in favour of that region. As a consequence, national domestic prices of commodities and import prices are equalized across regions. On the contrary, primary factors are taken to be mobile between sectors but not across regions which results in a different price for each primary factor in each region.

SwissTRANS introduces fixed costs for transportation sectors and an endogenous representation of congestion for road transportation.

Empirical implementation of the SwissTRANS model requires an input-output table: the GTAP 6 database (2001 is the benchmark year) and additional data coming from the literature or Swiss statistics are used. In addition, we use the latest Swiss estimates on marginal costs which are drawn from the deliverable 5 of the GRACE research project (Suter and Lieb, 2006).

3.3 The Policy Scenarios

We distinguish between two transport pricing policies[12]: average cost pricing (AC) and marginal social cost pricing (respectively, AC and MSC.D in Table 3-1[13]). In addition we introduce two variants that allow a better understanding of the policy scenarios (Table 3-2). The first one is the marginal social cost pricing scenario but uniform across the Swiss regions (MSC.U). The second variant is to add the external cost charges on top of the existing taxation (MC).

In this analysis we consider for each scenario two different "recycling" instruments by which the government achieves budget neutrality. The reference instrument is the labour income tax as it is the most plausible to be used in reality. The alternative instrument is the social security transfers, which we assume is a distortion-free lump sum transfer mechanism. In both recycling policies, we assume a proportional redistribution policy to either labour income in

[12] The instrument for representing transport pricing policy in the model is a markup over marginal costs (i.e. transport-specific tax over variable operating costs).

[13] Hereafter, A refers to the Alpine region, P to the rest of Switzerland (i.e. Plain) and CH to Switzerland.

the case of the reference instrument or to consumption in the case of the alternative instrument.

The first policy scenario introduces average cost (AC) pricing for the two transport sectors, namely the road and the rail sectors. AC pricing is defined here as covering the infrastructure costs at the national level. This means that each of the two transport sectors covers its own fixed costs in Switzerland and there is no cross-subsidization between transport modes.

The second policy scenario introduces marginal social cost (MSC) pricing for both road and rail. The MSC pricing scenario is intended to make each transport user pay its marginal social cost. In other words, each different transport user pays not only for marginal operating and infrastructure costs but also for its marginal external costs such as accidents, congestion and environmental costs (air pollution, global warming and noise).

Table 3-1:

Percent rate of Markup over marginal cost in Policy Scenarios with Labour tax

	AC-P	AC-A	AC-CH	MSC.D-P	MSC.D-A	MSC.D-CH
Road own-supplied transport	6.68	6.68	6.68	6.38	10.23	7.04
Road purchased transport	6.68	6.68	6.68	8.19	16.98	9.86
Road transit transport	6.68	6.68	6.68	6.92	10.95	7.68
Rail purchased transport	280.85	280.85	280.85	19.42	38.30	23.76
Rail transit transport	280.85	280.85	280.85	19.42	38.30	23.76

The first variant is the MSC pricing scenario but applied uniformly across Switzerland. It assumes the government is not able to differentiate transportation services between the Alps and the rest of Switzerland and therefore imposes an identical MSC pricing system in both regions.

In the second variant, the objective is to evaluate the impacts on the economy when the government wants to charge users for external costs and congestion costs without lowering existing taxes and charges. This scenario has no theoretical justification. Nevertheless, it often appears in political discussions in which internalisation charges are proposed to be added on top of the existing taxation scheme. This scheme is thus considered as a politically feasible pricing scenario[14]. The result is a charge larger than the marginal external cost.

[14] The complete abolishment of fuel taxation present in the AC and MSC pricing scenarios is not considered as politically viable.

Table 3-2:

Percent rate of Markup over marginal cost in Sensitivity Scenarios with Labour tax

	MSC.U-P	MSC.U-A	MSC.U-CH	MC-P	MC-A	MC-CH
Road own-supplied transport	7.67	7.67	7.67	4.91	7.59	5.36
Road purchased transport	7.67	7.67	7.67	6.89	14.47	8.33
Road transit transport	7.67	7.67	7.67	5.45	8.55	6.04
Rail purchased transport	23.76	23.76	23.76	3.46	11.59	5.33
Rail transit transport	23.76	23.76	23.76	3.46	11.59	5.33

Markup values for the AC scenario in table 3-1 result from the structure of the Swiss economy in 2001 and constraining both road and rail modes to cover its own fixed costs across Switzerland. Regarding markup values for the MSC and MC scenarios, they are computed on the basis of Swiss marginal external costs drawn from the deliverable 5 in the GRACE research project (Suter and Lieb, 2006).

In particular, markup values for the MSC.D scenario show the clearly different regime of taxation between the two regions. As the share of variable costs in the Alps are smaller than the share of external costs, this results in a marked differential in the tax rates between the Alps and the rest of Switzerland. Note that the high level of taxation in the Alps for road purchased services comes from trucks which are generating more external costs than private cars.

3.4 Results

We discuss subsequently the macroeconomic results and the transport policy results.

Macroeconomic impacts

The impacts of the two pricing scenarios on key macro variables are presented in Table 3-3. The welfare measure is the most important indicator. We distinguish two measures of welfare. The first measure is a function of aggregate consumption[15] and leisure (given on the third and fourth lines) while the second measure incorporates the negative external effects such as transport accidents and environmental costs (air pollution, global warming and noise). The former comes directly from the model itself[16] whereas the latter is computed on the base of transportation volumes resulting from the equilibrium.

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[15] Aggregate consumption is a composite of all consumption goods in addition of the time spent in household-supplied transportation and the speed necessary for driving on the road (measure of congestion).

[16] In particular, we use an Hicksian money metric welfare index which corresponds to the Hicksian equivalent variation criterion. It allows us to know how much money consumers would need before a policy change to be as well off after the proposed policy change.

Table 3-3:

Macro Results in Policy Scenarios with Labour tax (% deviation from benchmark)

	AC-P	AC-A	AC-CH	MSC.D-P	MSC.D-A	MSC.D-CH
Welfare (leisure incl.)	-0.34	-0.25	-0.33	0.53	0.08	0.45
Welfare net of extern. costs	-0.33	-0.14	-0.30	0.47	0.27	0.44
Aggregate consumption	-0.91	-1.00	-0.93	0.91	0.19	0.78
Leisure	0.44	0.78	0.50	0.01	-0.07	0.00
Real GDP	-0.80	-1.33	-0.89	0.08	-0.15	0.04
Consumption	-0.84	-0.83	-0.84	0.81	0.12	0.69
Exports	1.84	1.68	1.82	-0.60	-0.16	-0.52
Imports	2.75	3.91	2.95	0.37	0.38	0.37
Real Exchange rate	0.07	0.07	0.07	-0.23	-0.23	-0.23
Real price of Labour	-1.04	-1.36	-1.09	0.69	0.20	0.60
Real rental rate of Capital	-1.43	-1.76	-1.49	-0.52	0.45	-0.35

Simulations of the two policy scenarios with the labour income tax as the revenue-recycling instrument show that only the MSC pricing scenario is beneficial for Switzerland. The reason is the adverse impact of the AC pricing on rail transportation (Table 3-5). This result clearly shows that balancing the financial part of the transport accounts should not be an objective *per se* of pricing as the accounts framework does not account for the loss of efficiency associated to average cost pricing when there are important fixed costs.

It is worthwhile to stress at this point that road transit is by far the main positive contributor to welfare for any scenario. Though road transit represents almost one-quarter of the total demand for road traffic in Switzerland, it is responsible for more than 75% of the national welfare gains. Welfare gains from transit are important for Switzerland as the charges paid by transit are an important net transfer from abroad.

Average cost pricing

The macroeconomic impacts for the AC pricing scenario may be summarized as followed. As a result of the significant increase in rail transportation markups and factor reallocation, the demand for primary factors decreases and hence their respective real price[17], which induces an increase in the demand for leisure. As marginal costs increase, domestic products are less competitive which implies an increase in imports. To restore the equilibrium in the balance of trade the Swiss franc depreciates and this encourages exports. The increase in rail transport prices produces a higher living cost in Switzerland which implies a decrease in consumption. Overall the Swiss economy declines.

[17] Real prices in each region are defined as nominal prices deflated by the true-cost-of-living index in the corresponding region.

From a regional point of view, there is not much difference between the Alpine region and the rest of Switzerland since the AC pricing scenario implies a uniform markup rate across the regions. Nevertheless, the welfare net of external costs is less negative in the Alpine region as the drastic reduction of rail transportation services also reduces strongly the external costs.

The government budget balance implies a decrease in the labour income tax in both scenarios mainly because of the transit revenue. The reduction is 2.32% for the AC scenario while it equals 2.73% in the case of the differentiated MSC scenario. In the case of a redistribution to agents with social security transfers, there is a larger loss in welfare for the AC scenario and a smaller gain in welfare for the differentiated MSC scenario[18].

Marginal social cost pricing

Turning to the differentiated MSC pricing scenario, one would expect that the internalisation of the external costs would make the households better off compared to the status quo. Although this is true in a partial equilibrium setting, this may not hold in a general equilibrium framework because of secondary effects. This is however not the case in the present study as each region increases its welfare level.

The high level of taxation in the Alps leads to a substantial decline in the production of transportation services, which results in a decline of the real wage and an increase in the rental rate of capital[19]. This results in a shift of production to the rest of Switzerland. When the revenue-recycling instrument is the labour income tax, the impact on real wage becomes positive in the Alpine region as the tax on labour income is reduced to keep the government budget balanced. However the negative impact on the balance of trade outweighs the increase in consumption resulting in a negative real change in the Alpine GDP.

In the rest of Switzerland, relative net-of-tax production prices of transportation services increase following the reallocation of these services from the Alps towards this region. Competitiveness thus declines leading to a drop in exports and an appreciation of the Swiss

[18] This result follows from the implied assumption that the marginal cost of funds (MCF) for the labour income tax is greater than the MCF for the social security transfers (which is assumed to be one by definition).

[19] This result is known as the Stolper-Samuelson Theorem, which is the proposition of the Heckscher-Ohlin Model that a decrease in the relative price of a good (here the net-of-tax production price of transportation services) lowers the real price of the factor used intensively in that industry (here labour is accounted for 77% in the road sector and 75% in the rail sector) and raises the real price of the other factor (here capital is accounted for 23% in the road sector and 25% in the rail sector).

franc to restore equilibrium in the balance of trade. Nevertheless, the change in real GDP in this region is positive due to the significant increase in consumption.

The comparison of aggregate welfare between a uniform and a differentiated MSC pricing shows that the overall welfare gain from differentiation is positive. As expected, in terms of regional impacts, it leads to a small positive impact on Alpine welfare with a substantial amelioration when adding the benefit of the reduction of the negative externalities (respectively 0.08 and 0.27 in Table 3-3). On the other hand, the impact on welfare for the rest of Switzerland is high, somewhat smaller when account is taken of the external effects (respectively 0.53 and 0.47 in Table 3-3).

It should be noted at this point that the redistribution of the transport tax revenues matters a lot. The current underlying assumption is a proportional redistribution to either labour income or to consumption. The redistribution of tax revenues can have a large impact on regional welfare: in the case of social security transfers the net welfare effect for the Alpine region is twice as high as in the rest of Switzerland.

When the external costs are added on top of the existing taxation, and tax revenues are redistributed via lower labour taxes, the welfare effect is not very different from the MSC scenario. When social security transfers are used to balance the government budget, the impact is however negative. Consequently, raising road transport prices above marginal social costs may increase welfare, if the revenue from transport pricing is used to cut existing distortionary taxes[20].

Impacts on transport prices and transport demand

Because road taxes cover more than the average infrastructure costs, the AC pricing scenario implies a reduction in the overall taxation on road transport and a substantial increase in the overall taxation on rail transport. As a result, the money price of domestic car and truck transport falls, while that of train increases considerably (Table 3-4). The price for road transit transport increases because transit cars and trucks do not pay the annual vehicle fees and are

[20] Similar results have also been derived in a partial equilibrium framework (Cretegny, Springer and Suter, 2007).

assumed not to refuel in Switzerland, which means that they do not benefit fully from the abolishment of existing taxes[21].

In terms of impacts on the transport demand (Table 3-5), the AC pricing scenario leads to a significant drop in rail transport services and a small reduction in road transport services with the exception of road purchased transport which rises. The reason is the very high level of rail prices inducing a model shift from rail to road.

Table 3-4:

Real price of Supply in Policy Scenarios with Labour tax (% deviation from benchmark)

	AC-P	AC-A	AC-CH	MSC.D-P	MSC.D-A	MSC.D-CH
Road own-supplied transport	-2.26	-2.57	-2.32	-1.29	-0.21	-1.10
Road purchased transport	-3.93	-4.16	-3.97	-5.17	1.14	-4.32
Road transit transport	5.62	5.28	5.57	5.43	9.47	6.19
Rail purchased transport	202.33	201.36	202.16	2.30	16.18	3.97
Rail transit transport	205.15	204.19	204.98	4.64	19.16	7.92

Under the MSC pricing scenario, all existing taxes related to operating costs are abolished and each transport user pays its marginal social cost, which means that mark-ups are different not only regionally but also with respect to transport users. The consequence of this policy in the Alpine region is an increase in prices for both modes except own-supplied transport. The latter user sees a reduction in its price because the abolition of the annual vehicle fees and the fuel tax is enough to compensate the Pigouvian tax[22]. Similarly, in the rest of Switzerland, the money price of domestic car and truck transport falls. The opposite applies for rail transport as the existing taxation is low. It is also the case for road transit transport since they do not fully benefit from the abolishment of existing taxes.

The general increase in transport prices in the Alps reduces the demand for transport for all users except for own-supplied transport which increases as its price declines. Following the shift in production towards the rest of Switzerland, the domestic demand for transport increases in this region. At the same time, there is a modal shift from rail to road as the latter is more competitive. The demand for transit transport declines for both modes since transit through Switzerland becomes more expensive.

[21] Our results suggest therefore a conservative view of the positive change in welfare as the demand for transit would not be as negative as it is in the present case and thus would imply an increase in the transit revenue.

[22] The level of the price change is also sensitive to the fuel price elasticity. As we assume a lower bound of the long run elasticity, our results represent thus a conservative view of the positive change in welfare.

Table 3-5:

Volume of Supply in Policy Scenarios with Labour tax (% deviation from benchmark)

	AC-P	AC-A	AC-CH	MSC.D-P	MSC.D-A	MSC.D-CH
Road own-supplied transport	-1.58	-2.56	-1.75	1.67	0.38	1.45
Road purchased transport	11.29	10.66	11.17	18.21	-22.52	10.46
Road transit transport	-1.04	-1.03	-1.04	-1.07	-1.77	-1.21
Rail purchased transport	-78.87	-78.85	-78.86	6.56	-51.32	-6.75
Rail transit transport	-15.26	-15.26	-15.26	-0.73	-2.65	-1.17

At this point it is interesting to compare the MSC pricing scenario with the political scenario which consists in charging transport users for external costs and congestion costs without lowering existing taxes. The impact on national transport volumes of this latter policy[23] is a modal shift from road to rail transport as the price of road transportation is more expensive than the price of rail transportation. Though this is the case at the regional level, there is also a shift of the transportation services from the Alps towards the rest of Switzerland. As a consequence, rail transport increases significantly in the rest of Switzerland.

Impacts on transport account figures including external costs

Transport accounts are an important monitoring instrument as they allow summarising all financial as well as non-financial transport costs and revenues into a simple table. However they are not suitable for a correct cost-benefit analysis since they do not include all elements included in a social welfare.

The AC pricing scenario ensures a financial cost coverage ratio of one only for Switzerland as a whole. The consequence for road is a cross-financing of the Alpine region's infrastructure costs by the rest of Switzerland. The reason is the lower share of own-supplied transport in the Alpine region.

[23] This scenario corresponds to the current Swiss transport policy strategy which aims at the *ferroutage* of the transalpine traffic.

Table 3-6:

Road Account in Policy Scenarios with Labour tax (mio. of Swiss francs)

	AC-P	AC-A	AC-CH	MSC.D-P	MSC.D-A	MSC.D-CH
Financial costs	5'284	1'235	6'519	5'184	1'177	6'360
Infrastructure costs	5'284	1'235	6'519	5'184	1'177	6'360
External costs	3'732	1'538	5'272	3'908	1'433	5'341
External accident costs	988	250	1'238	1'032	249	1'281
Air pollution	1'350	624	1'975	1'417	563	1'980
Global warming	970	205	1'176	1'015	198	1'213
Noise	424	459	884	444	423	866
Congestion time costs	854	147	1'001	892	145	1'037
Revenue	5'359	1'160	6'519	5'666	1'870	7'535
Infrastruct.-related taxes	5'359	1'160	6'519	5'666	1'870	7'535
Cost recovery ratio (%)	101	94	100	109	159	118

The impact of the AC pricing scenario on the costs and revenues for road transportation results from two opposite effects. On the one hand, road purchased transport increases but on the other hand the use of private cars decreases. This translates into a reduction in infrastructure costs as people tend to travel more in buses than in private cars, and into an increase of external costs as trucks are substituted to rail transportation. It is also interesting to note that both external accident costs and congestion time costs decrease while other environmental costs increase. The reason is the marginal cost per vehicle-kilometre, which is larger for passengers than for freight in the case of accident and congestion but the other way around for the other environmental externalities.

Regarding the rail account, the higher prices lead to a rise in infrastructure-related taxes but also to a significant drop in financial costs due to the considerable decline in demand for rail transport.

Turning to the MSC pricing scenario, external costs and congestion time costs decline at the national level for rail transport while they increase for road transport.

Table 3-7:

Rail Account in Policy Scenarios with Labour tax (mio. of Swiss francs)

	AC-P	AC-A	AC-CH	MSC.D-P	MSC.D-A	MSC.D-CH
Financial costs	3'359	1'000	4'360	7'229	1'361	8'590
Infrastructure costs	2'520	750	3'271	3'084	796	3'880
Supplier operating costs	839	250	1'089	4'144	565	4'710
External costs	31	31	62	151	70	221
External accident costs	2	1	3	11	1	12
Air pollution	14	13	27	70	29	98
Noise	15	18	32	71	40	110
Revenue	3'359	1'001	4'360	4'962	789	5'752
Infrastruct.-related taxes	2'520	751	3'271	818	224	1'042
Other taxes	839	250	1'089	4'144	565	4'710
Cost recovery ratio (%)	100	100	100	69	58	67

The rationale is that higher transport taxes in the Alpine region increase not only the alpine price of transportation but also the national domestic price. As a result, part of the tax burden is shifted to the rest of Switzerland through the demand for transport. In addition the shift in the provision of transport services from the Alpine region towards the rest of Switzerland implies that the Pigouvian taxes rates do not correspond any longer to the external costs caused by transport users. This is true in particular for road transport which explains why external costs and congestion costs increase in the MSC pricing scenario.

3.5 Conclusion

Reforming transport policy plays an important role in current political discussions as policy makers face increasingly unsolved environmental issues. Simulation of different transport pricing scenarios in an economy-wide perspective suggests the following policy recommendations:

- *Environmental policies are beneficial for both the Alpine region and the rest of Switzerland*

A change from the current pricing regime in transport towards a marginal social cost pricing scheme is beneficial for both the Alpine region and the rest of Switzerland. Though the impact is rather limited in terms of welfare, the policy debate should be oriented in this direction. Our results also suggest that a transport pricing policy aiming at charging users for external costs without lowering existing taxation may be welfare improving as long as the recycling of transport tax revenues is used to reduce distortions of existing taxes.

- *Regional transport and redistribution policies matter*

The differentiation in the case of MSC pricing is justified with the argument of differences in external costs in the Alps and in the rest of Switzerland. Though the welfare loss is significant for the Alpine region, we find that differentiation of tax rates across both regions compared to a uniform taxation does improve national welfare, but not significantly. Nevertheless, an appropriate redistribution policy may increase existing welfare gains in the Alpine region without harming too much the rest of Switzerland.

- *Cost recovery objectives should not be an objective per se*

Average cost pricing as objectives for rail and road can lead to inefficient policies in the rail and road sector.

- *Additional transport revenues should be used to reduce existing distortionary taxes*

Though this effect is rather limited in the case of AC and MSC pricing scenarios because of the small additional revenues, it does significantly alter positively the conclusions in the case of the *politically-feasible* transport policy as it generates substantial additional revenues.

- *Appropriate pricing of transit transport contributes significantly to the Swiss welfare*

Due to the geographical position of Switzerland, road transit represents a significant share of total traffic demand. It is therefore by far the main positive contributor to welfare gains in any scenario under consideration as domestic households benefit from foreign additional revenues without bearing the tax burden.

4 Effects of transport pricing reform on regional employment

4.1 Introduction

In this chapter we deal with the regional economic impacts of 3 policy scenarios of European-wide transport pricing on the regional welfare and (un)employment in Europe. The policy scenarios are different ways to internalize the marginal external costs computed in the GRACE consortium. The scenarios are identical to the scenarios defined for the TREMOVE model: only fuel taxes, a km charge and time and place differentiated km charge. The spatial computable general equilibrium model used has been extended with imperfect regional labour markets, mobile capital and a distribution mechanism for the tax revenues.

Section 2 explains the CGEurope model. Section 3 gives an overview of the policy scenarios and the computation approach. Section 4 shows the welfare and employment effects of the policy scenarios.

4.2 The model used

CGEurope is a spatial general equilibrium model for a closed system of regions covering the whole world. The basic CGEurope model was applied in the IASON, in the FUNDING project and is also, in an extended version part of the TRANS-TOOLS software package[24]. In this project the model is extended to introduce three elements that are missing in the basic model: imperfect labour markets, capital mobility, and revenue-generating components of transport costs. We summarize the basic model structure and explain the extensions made.

All model regions are treated separately and are linked through endogenous trade, the regional coverage is the whole of Europe divided into NUTS-2 regions (in case of EU-27) or regions of comparable size for the rest of Europe. One region is capturing the rest of the world. The model is comparative-static, which means that for each scenario, two equilibria are compared, one with and one without a policy measure in place.

In each region there is assumed to dwell a set of households, owning a bundle of immobile production factors, which is used by regional firms for production of goods. We distinguish between two types of goods, local and tradable. Local goods can only be sold within the

[24] More information can be found in task report and in Bröcker (2002) and in Bröcker et al. (2004)

region of production, while tradables are sold everywhere in the world, including the own region.

Producers of local goods use factor services, local goods and tradables as inputs. The output of locals is assumed to be completely homogeneous, and is produced under constant returns to scale. Firms take prices for inputs as well as their output as given, and they do not make any profits. Instead of directly selling this output to households or other producers, firms can use it as the only input needed to produce tradables. The respective technology is increasing returns to scale. Tradable goods are modelled as being close but imperfect substitutes, following the Dixit-Stiglitz (1977) approach. Different goods stem from producers in different regions. Therefore, relative prices of tradables do play a role. Changes to exogenous variables make these relative prices change and induce substitution effects. For producers of tradables, only input prices are given, while the output price can be set under the framework of monopolistic mark-up pricing. Due to free market entry, however, profits are driven to zero, as they are in the market for locals.

Households are assumed to act as utility maximizers, taking all prices as given. Utility emerges from consumption of local goods and a composite of tradables, consisting of all, regionally produced and imported variants. Utility is modelled such that households appreciate a higher number of variants of tradables. The same income spent on more diverse variants means higher utility for the households. In other words, they share the "love for variety". When there is perfect price flexibility, the regional factor supply is always fully employed.

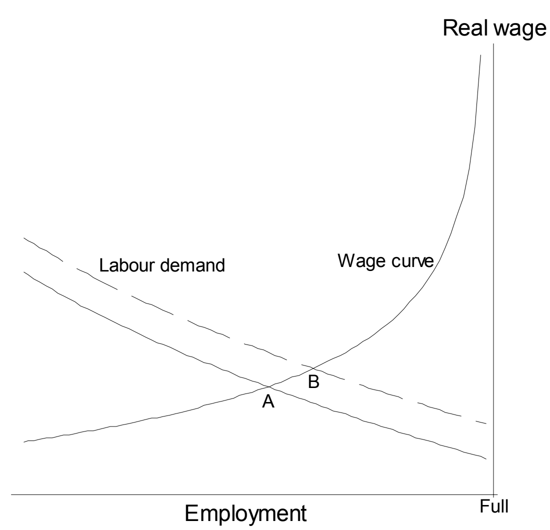
Two features that give the CGEurope model its spatial dimension are:

- the distinction of goods, factors, firms and households by location, and
- the explicit incorporation of trade cost for goods, depending on geography as well as national segmentation of markets.

Two stylised facts about the European economies that were not present in the basic CGEurope model, but are added to this version, are unemployment and factor mobility. Also when considering pricing in transport it is important to take care of the revenue generated in a consistent way. In this section we explain how these elements are incorporated into the spatial CGE model.

Following Blanchflower and Oswald (1994), we replace the conventional labour supply curve with a regional wage-fixing curve. A way to provide an intellectual rationale for the wage curve is by appealing to efficiency wage theory. The well-known characteristic of efficiency wage analysis is that firms set pay in an environment where the wage influences productivity. In equilibrium, firms try to maximize profits and workers choose how hard to work. If the costs of shirking at work are low, employees put in little effort. The outside rate of unemployment plays a role, because it determines the ease with which a fired worker can get another job. In a highly depressed labour market, employees are frightened of losing their jobs, and so put in high effort even if pay is comparatively low. Put differently, a marginal rise in unemployment leads to a corresponding marginal fall in the level of wages. The reason is that firms can reduce pay slightly while maintaining a motivated workforce. Unemployment is a discipline device: when it is high the generosity of workers remuneration can be low. Hence there is an efficiency wage interpretation of a negative dependence between wages and unemployment. The coefficients of the wage curve vary among the countries, in Denmark a 10% increase in the unemployment rate decreases the average real wage by 2%, in Latvia the same increase in unemployment would generate a real wage decrease of 52%. In general the labour markets in the new member states react very differently.

Figure 4-1: Labour market response



To see how the infrastructure pricing policy affects the response in the regional labour market, consider Figure 4-1. In this example, improved accessibility increases demand for region's output, causing regional factor demands to increase. Labour demand schedule shifts outwards, and the equilibrium moves from point A to point B. In contrast to fixed employment assumption, here only a part of adjustment is done by wages, the degree of rigidity set by the exponent appearing in the wage curve equation. The rest of adjustment is accomplished by the increase in employment level.

A second innovation, in comparison with the basic model, is to assume that the regional capital stock is mobile interregionally. It can move (following higher return) to other regions, within countries as well as between countries. We assume that there is a single rental clearing the market for this homogeneous factor. The total stock of mobile factor is assumed to be fixed, capital used in another region generates income flows to the region owning the capital in the benchmark equilibrium.
An additional amount that has to be added to the household's income is the revenue generated by transport taxes and charges. We assume here that half of revenue is collected by the authorities in the origin region, and half – in the destination region. Then we assume that the revenue collected in all regions of a country is added up and redistributed within this country proportional to regional GDP.

4.3 The data and policy scenarios used

The comparative statics experiment for each scenario is carried out for the years 2010 and 2020. To describe the future benchmark economic situation we need a consistent database for a recent year, as well as a prediction of benchmark equilibrium for the period until 2020.
The source of national accounts and international trade data for 34 European countries is the GTAP Version 6 Data Package, with base year 2001. This source ensures consistency between data on value-added structure, GDP, and trade structure. Information on regional level is taken from REGIO database of EUROSTAT with the same base year. We also need data on transport distances between all the regions in order to calibrate interregional trade matrix. These data are calculations of transport costs (in minutes), based on the network database of Spiekermann and Wegener (used in IASON project, see Bröcker et al. (2004)), which contains data for all major links in Europe, including their specific characteristics of speed limits and likelihood of congestion.

For calibrating the model for the years 2010 and 2020, GDP and population growth projections by the European Commission were used for the EU countries, and the growth rate estimates from the PRIMES project for the non-EU countries

The policy scenarios are the same as the scenarios in the TREMOVE model (see 2.3 in this report). In order to desaggregate the non regional pricing scenario results of TREMOVE to the level of trade flows within regions, the SCENES model is used. It is this SCENES outcome that is used as input for the spatial general equilibrium model. For Switzerland, the same procedure is followed but the external cost data are taken from ECOPLAN (see section 3 of this report).

4.4 Results of the scenarios

We model the effects of the transport cost changes on the welfare and unemployment rate of representative households in each region using the CGEurope model described in the preceding section. The results are interpreted as the impact of the policy measure in the future year taken in isolation. The welfare gains from reduced pollution, noise and accident fatalities are not taken into account. In the welfare measurement, we do not account for possible welfare losses (gains) due to reduced congestion and leisure time reduction (increase) coming along with a changing level of employment.

The majority of regions experience negative effects from all three scenarios. The overall weighted effect on real income in the study area is also negative, but not exceeding -0.11%. This is to be corrected for gains in congestion, environment and accident costs of the order of more than 2%(computed in TREMOVE, see Table 2-10). The reason for the negative real income results is that the pricing policy, although generating a lot of revenue, is distortive in nature, and thus causing welfare losses. This policy adds to distortions already present in the model in the form of imperfect markets (monopolistic competition in tradables and imperfect labour market). These distortions lead to disintegration effects like reduced product diversity and thus lower welfare. In addition, by our assumption in the regions that generate or attract little traffic the amount of revenue collected is low.

Table 4-1: Average welfare effects of the 2020 scenarios by country group, % of real income, excl.accident and environment benefits

	Scenario 1	Scenario 2	Scenario 3
EU15	-0.03	-0.04	-0.03
NMS12	-0.97	-0.83	-0.62
EU27	-0.10	-0.11	-0.08

The difference between the 3 scenarios is not very strong. Nevertheless, scenario 1 with the highest pricing imposed seems to bring the largest negative impact on the welfare (excl.accident and environment benefits), while the consecutive reduction of road charges in scenarios 2 and 3 reduces welfare losses, most significantly in the new member states. Figure 4-2 gives the regional welfare effects for 2020 in the scenario 2 (flat km tax, differentiated by country).

The most negative effects quite expectedly accrue to the peripheral regions of northern Sweden and Finland, Baltic States, Ireland, Scotland, Bulgaria, Greece and southern Spain. The country-specific pricing schemes in the background policy scenario also lead to the fact that Poland, Czech Republic, Slovakia, Slovenia. Hungary, as well as the Netherlands also suffer considerable welfare losses. On the other hand, the regions with strong market potential and a lot of traffic seem to even gain from the proposed pricing scheme. This effect is visible in Denmark, northern Germany, Austria, northern Italy, southern France and England.

The effects on regional unemployment are shown in Figure 4-3. They are moderate and in most cases do not exceed 0.2 percentage points of benchmark unemployment rate. The exception is the set of regions in Poland, Slovakia, and Latvia, that in the baseyear data were characterized by high unemployment rates. These regions suffer from an increase of unemployment rate by up to 0.87 % points. These results could change if for example the revenue were used differently: to finance infrastructure projects in these regions or to reduce existing taxes on labour?

Figure 4.2: Welfare effects (excluding environment and accident benefits) of scenario 2 in2020

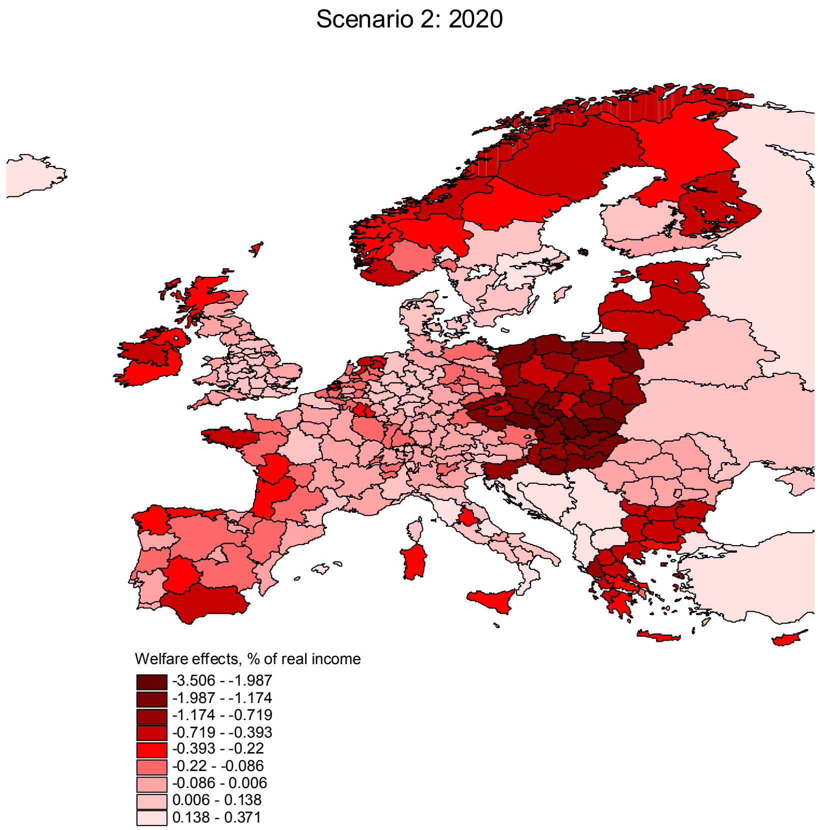
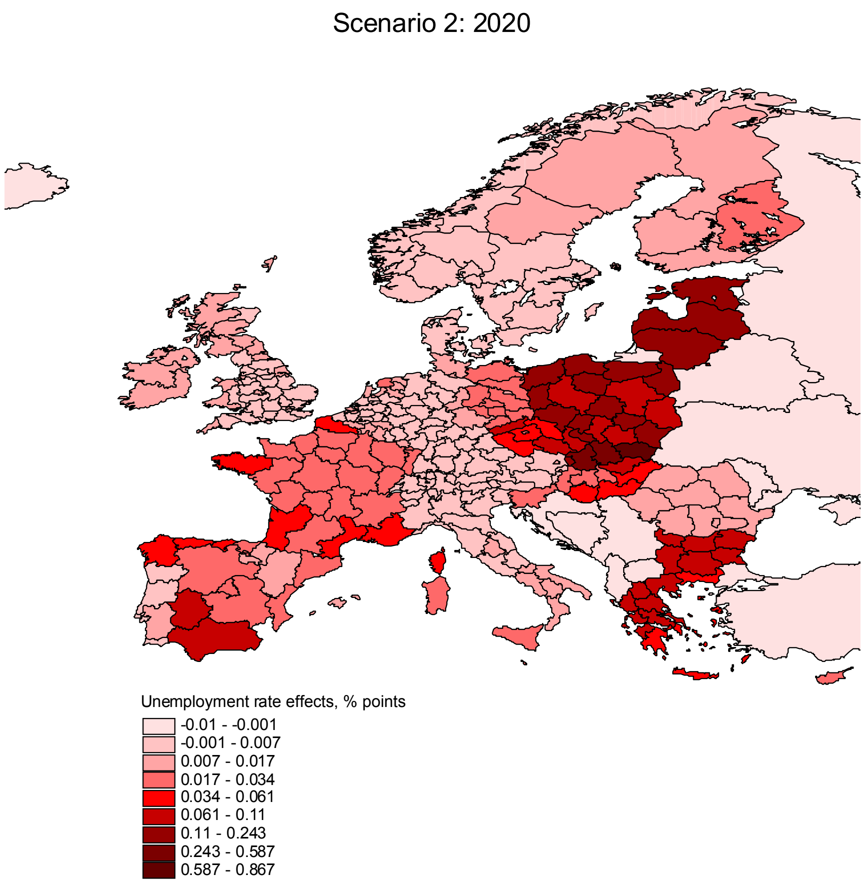


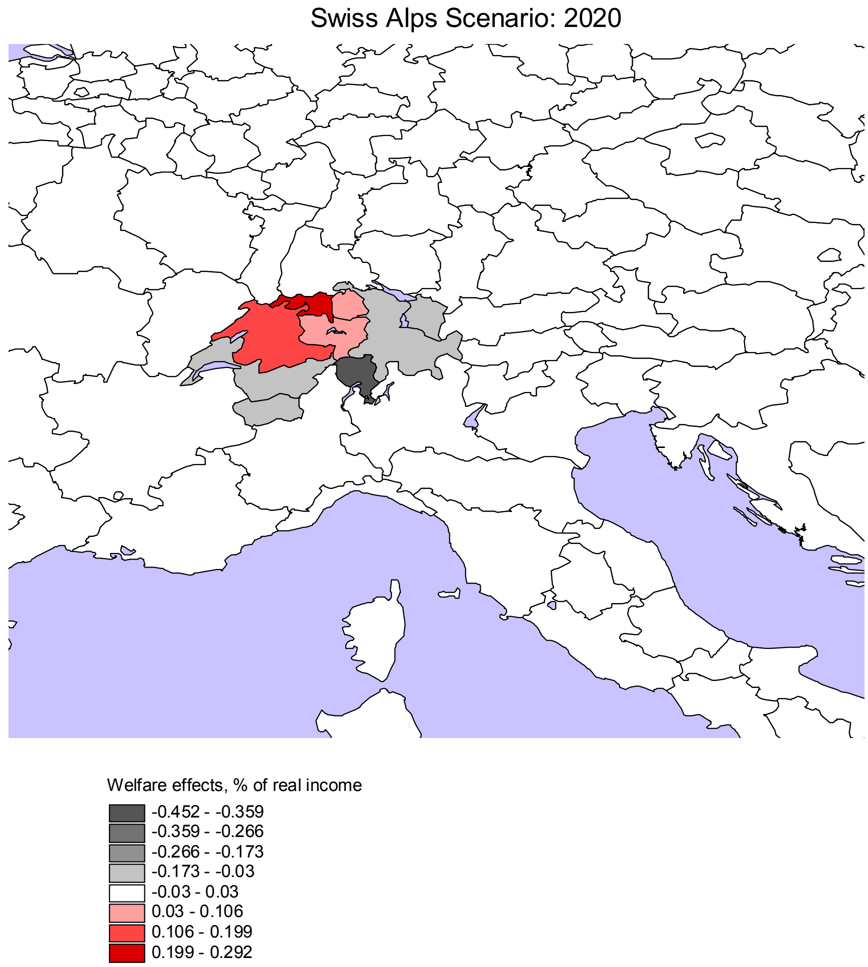
Figure 4-3: Unemployment effects of scenario 2 in 2020



4.5 Swiss Alps results

The regional welfare effects for 2020 of the Swiss Alps scenario (scenario 2) are shown in Figure 4.4. The unemployment effects are negligible. The difference to the results of the SwissTRANS model is that one cannot make a clear statement that the scenario policy package is beneficial to all regions. While it is true that some regions (mostly non-Alpine ones) enjoy welfare gains, the others suffer losses, which may be small although. The overall weighed effect of the scenario on Switzerland is +0.05% of real income.
The difference in the predictions of welfare effects may be explained by the fact that in the SwissTRANS model the revenue is used to reduce existing taxes. In the CGEurope results the redistribution of revenue is based on GDP, and thus richer regions gain the most. This could be changed if the revenue were used to subsidize the Alpine regions.

Figure 4.4: Welfare effects of scenario 2 for the Swiss regions in 2020



5 Transport pricing reform with different levels of government

5.1 Introduction

A well known result of economic theory is that efficiency requires prices equal to the marginal social cost. This result is only valid in a first-best setting where one ideal perfectly informed government corrects the market prices for external effects. Whenever authority is divided among different levels of governments that have conflicting objectives one obtains uncoordinated pricing and investment policies. This problem is relevant for EU – member state conflicts as well as for coordination problems within one country. The issues raised by the decentralization of transport policy are much more general and complex than we model them here; they are surveyed in De Palma and Picard (Task report 9.5.b).

This chapter focuses on one particular problem: the asymmetric information problem in the implementation of marginal social cost pricing. While the upper level (EU, or country) is in principle concerned with the welfare of all the citizens and wants social marginal cost based pricing, a lower level government (a member state or region) may prefer much higher transport charges to extract revenue from transit. This problem is well known. It has been empirically validated for state gasoline taxes in the USA by Levinson (Levinson (2002). De Borger et al (2005, 2007) studied the competition of different regions or countries for transit tax revenues. These papers did not address the asymmetric information issue: local or country governments may have (or pretend to have) better information on the precise marginal external costs that need to be charged to transit traffic.

This issue is present in the present European policy debate: there is the debate on the high transit taxes of Switzerland and there is the peripheral countries' fear that road charges for trucks contain a monopoly margin. One of the solutions used by the European Commission is to cap the road toll to the average infrastructure costs.

In this chapter we use a simple theoretical model to explore the asymmetric information problem. One transport link crossing a single country is used by transit and local traffic. The local government knows the external costs but the federal government does not. We consider two stylized cases of external costs: constant marginal external costs that are independent of the volume of traffic but affect the local population only (some forms of air pollution or accident externalities on pedestrians) and external congestion costs that are a function of the volume of traffic and affect the local and the transit users.

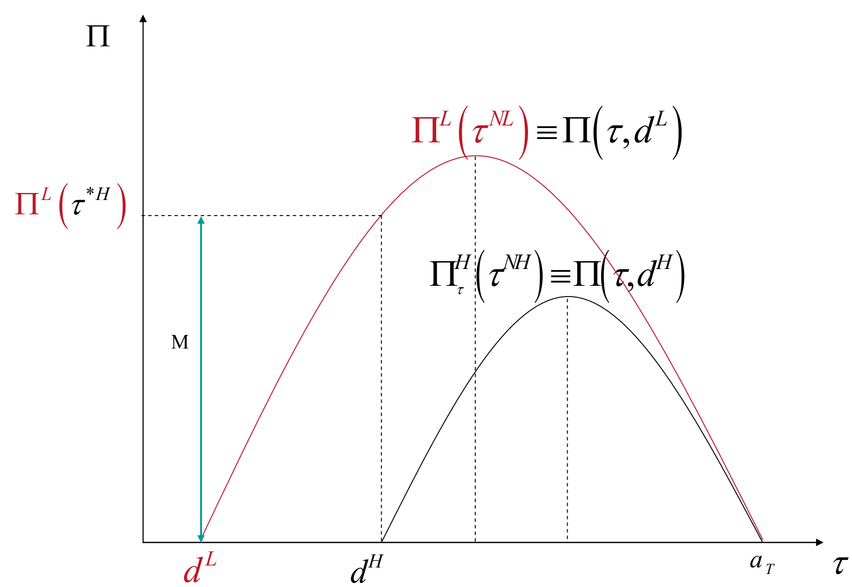
In section 2 we analyze the case of unknown but "constant" marginal external costs. In section 3 we analyze the more difficult case of external costs of the congestion type. Section 4 draws some policy conclusions.

5.2 Constant marginal external costs

Asymmetric information problems require a very precise specification of the uncertain information. The simplest case is where the constant marginal external cost per km can take only two values: High or Low[25]. The local government knows whether it is H or L but the federal government does not know if it is H or L.

The issues and results can best be illustrated with the help of Figure 5-1.

Figure 5-1: Pricing with asymmetric information on the constant marginal external cost



The local government, if unconstrained, will charge a toll that is higher than the marginal external cost as it wants to extract revenues from the transit traffic. Figure 5-1 reports on the Y axis the welfare level of the region $\Pi^L(\tau)$ that depends on whether external costs are H or L and depends on the toll τ charged. When the region has a high external cost, the maximal welfare level it can achieve is lower than when it has a low external cost: the top of the

[25] The assumption that the marginal external cost can only take two values can be relaxed to three values or even a distribution of possible values without changing the basic intuition behind the problems that can occur when one wants to implement marginal external cost pricing under asymmetric information.

parabola is higher for the $\Pi^L(\tau)$ function than for the $\Pi^H(\tau)$ function. In the absence of any constraints, the local government will charge τ^{NL} or τ^{NH} (that correspond to local welfares that are on the top of the two parabolas). The federal government would prefer to charge a lower toll equal to the marginal damage: this corresponds to the left crossing of the parabola with the X-axis : d_L and d_H . The federal government can ask the local government to report its marginal external cost and allow a maximum toll in function of the answer of the local government. If the local government has a high marginal external cost, the best it can do is to report this high marginal external cost d_H.

Reporting a low marginal external cost can not be a good strategy for the local government because the federal government would than impose a toll cap d_L that is even lower than the real marginal external cost d_H. The outcome is in this case perfect pricing from a federal point of view.

Things are more difficult when the local government has low marginal external costs. Then it will not necessarily report this truthfully and may have an interest to report to be a High environmental cost region. What will happen if it reports to be High cost country? Then the federal government will impose a toll d_H . This toll will be lower than τ^{NH} but higher than d_L .and generate an extra toll revenue for the local government equal to M. If there is a lot of transit traffic, one can expect that the low external cost region has an interest to report itself as a high cost region and charge in this way tolls that are too high.

Corrective federal policies

What can the federal government do about this? They can obviously try to narrow down the uncertainty in the marginal external cost estimates but there are also two other possible policies. The first is to reward the low cost region for truthful reporting by a federal transfer that compensates the local government for its loss of potential revenues. The federal government has an interest to do this because this allows having an efficiency gain (correct pricing) on the transport market. This solution has the same efficiency as the case where there would be no uncertainty on the marginal external cost[26].

The second federal solution is to impose a cap on the external cost toll. The toll cap could be a weighed average of the low and high estimate of the external cost. The average toll cap is a less efficient solution than a federal transfer for correct reporting. Compared to the case with truthful reporting, (assuming equal probability for L and H) the efficiency loss is equal to

[26] We disregard the extra efficiency costs of collecting federal tax revenues to pay the transfer.

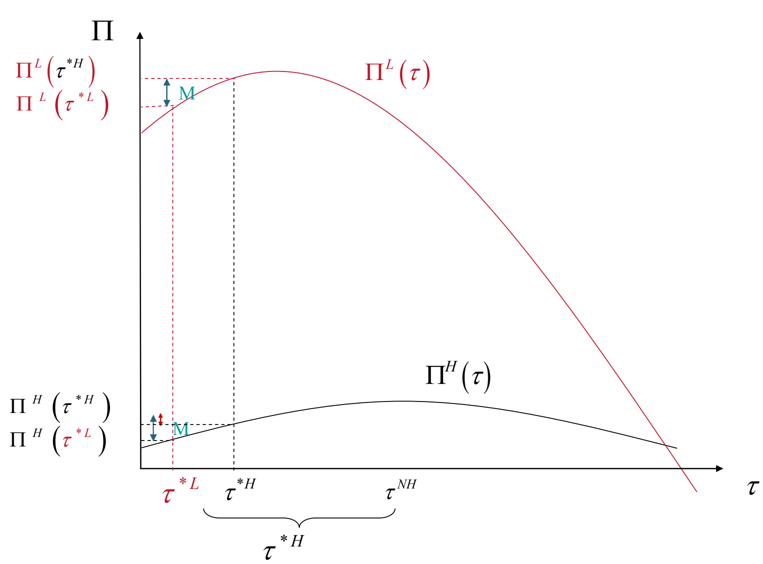
$\frac{1}{8}(d^H - d^L)(D^L - D^H)$ (where the last term is the difference in the optimal levels of traffic with perfect pricing in the Low and High external cost case). If the elasticity equals -1 this means that the loss of welfare of imposing an average cap is proportional to the square of the difference in marginal external cost estimates.

5.3 Case of external congestion costs

The problem can again best be understood using Figure 5-2. We report again the local welfare functions $\Pi^L(\tau)$ and $\Pi^H(\tau)$. It is important to note that, for any given toll level, the slope of the local welfare function is smaller in absolute terms in the high congestion cost case. The reason is that in the high congestion case there are simply less cars on the road so an increase of the toll will generate a smaller increase in revenue. Consider now again the information the local government will give to the federal level. Whenever the region has a high external congestion cost, the best it can do is to report this truthfully to the federal government because the region prefers an even higher toll than τ^{*H}, claiming to be Low congestion region can never be worthwhile in this case.

When the region has a low external congestion cost and transit traffic is important, it may have an interest to misreport itself as a high external congestion cost region because this can increase its revenues from transit traffic: on Figure 5-2, we have $\Pi^L(\tau^{*H}) > \Pi^L(\tau^{*L})$.

Figure 5-2: Pricing with asymmetric information on the external congestion cost



Corrective federal policies

What policies are available to the federal government in order to improve this situation? We consider three types of policies: a reward for correct reporting, the use of a toll cap equal to the average marginal external cost and a toll cap equal to the average infrastructure cost.

This time a financial reward for correct revelation may not be feasible because it may even induce the high cost region to start to report itself as a low cost region. This can be seen on Figure 5-2: the financial compensation M needed to induce the low cost region (upper left part of the figure) to report the truth is so large that also the high cost region has an interest to lie and pretend to be a low cost region (see lower left part of Figure 5-2).

The use of a toll cap equal to the average external congestion cost is feasible but implies clearly efficiency losses as in the case of air pollution.

A toll cap equal to the average infrastructure cost is a more promising policy. Congestion costs can be decreased by extending capacity. If there are constant returns to scale in road infrastructure extension, we know from the cost recovery theorem that tolls equal to the marginal external congestion cost cover the infrastructure costs (de Palma, Lindsey, 2007). Take again the case of a region that faces a lot of transit and that can charge the transit traffic but can also invest in road capacity. In the unconstrained case it will charge too high tolls and the capacity level will be adapted to the volume of traffic. What will be the effect of a toll cap equal to the average infrastructure expenditure? It can be shown that the local government will choose the optimal capacity level and that, as a consequence, also the toll will be chosen optimally.

This is a very strong result: the federal government needs only to monitor the average infrastructure cost to make sure the pricing and investment policies are optimal. What is the intuition behind this result? To understand the result we need to refer first to the cost recovery theorem that in the case of local traffic only, tells us that a toll equal to the marginal external congestion cost together with optimal capacity decisions end up in a break even situation. Add now transit traffic. As long as transit traffic is tolled in the same way as local traffic, the best the local government can do is to follow the same policy for total traffic as it would do for local traffic only because tax exporting possibility is blocked by the federal government.

The strong result only works when transit and local traffic are homogeneous: they have the same external congestion cost. This is not necessarily the case: transit may have a higher proportion of trucks. In this case the local government can have an incentive to charge much more the trucks than the cars and makes the (mainly foreign) trucks pay a disproportionate share of the infrastructure costs.

5.4 Policy conclusions

The problem identified in this chapter is at the heart of many debates on the pricing of freight transportation and of passenger transport in some regions. All member countries that have the possibility to extract revenues from transit traffic will tend to do so. Marginal external costs that are not very precisely defined are a good opportunity to do this.

For external costs of the air pollution type the federal policies that can be pursued are either a compensation for truthful reporting or a cap on the toll in function of the average marginal external cost. The latter policy is less efficient.

In the case of uncertain external congestion costs the federal policy options are different. A financial compensation for truthful reporting may not work at all because it may induce all the regions to lie. A cap based on the average marginal external cost is feasible but less efficient. Because congestion can also be addressed by extending the road, a toll cap equal to the average infrastructure cost may be an interesting alternative. If all traffic is homogeneous this guarantees optimal pricing and investment. Whenever traffic is not homogenous extra constraints are necessary to avoid misuse of the tolling by transit countries.

6 Modelling the road accident externalities in a general equilibrium context

6.1 Introduction

The exact formulation and estimation of road accident externalities is a difficult problem. In this chapter we try to formulate the external accident problem in a more general equilibrium model. This offers opportunities to overcome some of the difficulties encountered in a partial equilibrium context. Section 2 compares the partial and the general equilibrium context. Section 3 describes briefly the model set up. Section 4 reports the numerical estimation of the different components of the general equilibrium model. Section 5 concludes.

6.2 Comparing the traditional and general equilibrium approach to accident externalities

Up to now accident costs are treated in a simple way in most applied transport models.
A graphical illustration can help.

Figure 6-1: The traditional formulation of the external accident cost

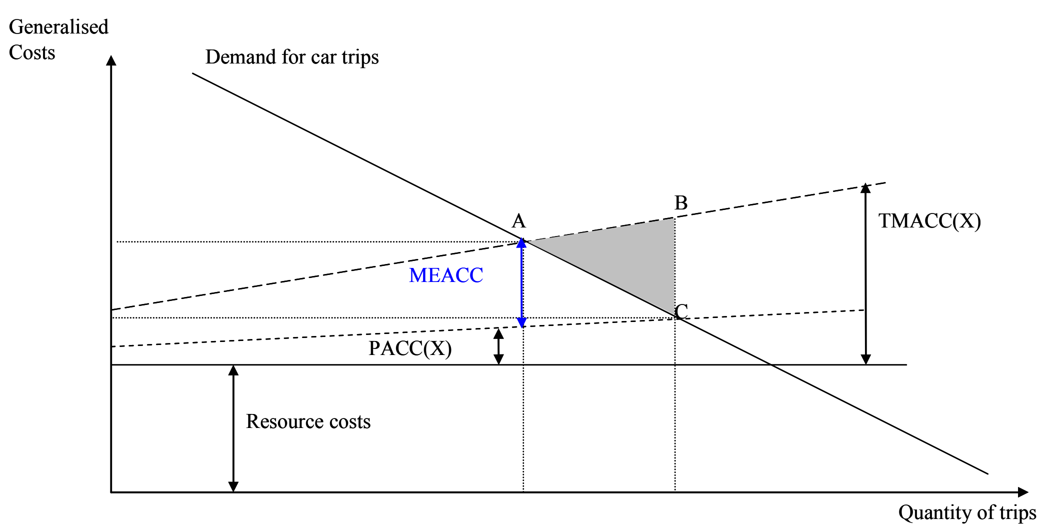


Figure 6-1 represents the transport market with the demand for car use on a given stretch of road for a given period. The car user pays the resource cost of his car use plus his own accident costs. Assume that there is no insurance[27] and no congestion. This gives an equilibrium generalised price gp^0 and an equilibrium volume X^0. The total marginal accident cost $(TMACC)$ equals the private average accident cost $(AACC)$ plus the increase in average accident cost that is imposed on all existing road users (see equation (6.2))

$$TACC(X) = AACC(X) \cdot X \tag{6.1}$$

$$TMACC(X) = \frac{\partial TACC(X)}{\partial X} = AACC(X) + \frac{\partial AACC}{\partial X} X \tag{6.2}$$

$$MEACC(X) = AACC(X) + \frac{\partial AACC(X)}{\partial X} X - PACC(X) \tag{6.3}$$

The marginal external accident cost equals the total marginal accident cost minus the private accident cost $(PACC(X))$. The optimal externality tax is in this case simply equal to $MEACC(X)$ and leads to the optimal volume X^1 and a generalised price gp^1.

The welfare gain of charging this external cost would be area ABC: the benefit of avoiding trips X^1 to X^0 whose social costs were higher than the benefit for the road users.

Applying this partial equilibrium framework raises many empirical questions. To cite just a few: what happens to the average accident costs when the traffic volume (or composition) changes, what are the privately perceived accident costs? A survey of these questions can be found in Lindberg (2006).

Our ambition is different. We want to know how we can apply this external cost framework in a more general model of the economy. In a certain sense we see the marginal external cost computation in partial equilibrium models as a reduced form of a more general model. This more general model is necessary to tackle questions like risk compensation[28], mitigation measures, use of tax revenues, loss of labour tax revenues due to injuries, etc.

[27] Including insurance would complicate the model as insurance also influences the behaviour and hence the accident cost. In order to take up insurance we would need to model insurance in great detail and this is out of the scope of this work.

[28] Risk compensation means that an individual will accept a given level of risk in a given activity. If their perceived level of risk alters, their behaviour will compensate to place them back at their accepted level of risk. Adams J. (1985) was the first to apply this idea to a wide variety of road safety measures.

In our more general approach we model the feedback effect of accidents on the behaviour of consumers and the government in a more complete way. Accidents may have an impact on (i) avoidance, (ii) mitigating activities by the transport users, (iii) congestion, (iv) labour productivity, and (v) the government budget.

(i) Avoidance, also known as risk compensation in the literature, comes at a cost for the driver. For example, if traffic is denser he will drive slower to reduce the accident risk but this means loosing time. Or he may have to pay much more attention and can not enjoy fully his favourite radio programme. These costs are not taken into account in the partial equilibrium framework.

(ii) Mitigation means investing in measures that reduce the potential effect of an accident. Think for example of wearing a helmet, etc. or of subsidised hospital care. How this type of behaviour affects the marginal external accident cost and whether subsidies are justified is difficult to see in a partial equilibrium framework.

(iii) If an accident happens, this may cause a road block which causes congestion and hence creates a time cost.

(iv) If the accident risk decreases, the number of sick days and time spend in traffic decreases and hence total available time increases and both labour and leisure increase.

(v) The government budget is influenced by the accident risks via the transport taxes, via the subsidies for mitigation measures, via public investments in road infrastructure and by the decrease in labour taxes in case of injuries. When tax money is costly, it is not obvious how to include this in a partial equilibrium approach.

Once we have a more general approach to accident externalities, we can also assess more consistently the effect of other instruments than external accident cost pricing as there are a km tax, a fine on speeding, regulation, subsidies for mitigation measures and public investments in road infrastructure etc.

6.3 The model used

A very simple general equilibrium model is used with one type of representative households. The household derives utility from leisure, general consumption, safe and dangerous (fast) driving and from its health status.

The health status is negatively affected by the general accident risk and by mitigation measures the household can take (better hospital care, safer car, etc.). The general accident risk is a function of the quantity of safe and dangerous driving and on the public investments in road safety.

The household chooses how much to work and whether to drive safely or dangerously. Safe driving has a lower accident risk for the driver but is also slower. Whenever a driver is involved in an accident, he looses sick days and his health status is decreased.

Government levies labour taxes and taxes on safe and on dangerous driving.

6.4 What corrections are necessary to the partial equilibrium computation of marginal external accident costs?

The marginal external accident cost that needs to be charged in our richer general equilibrium model has the following structure:

General equilibrium marginal external accident cost =
(1) Partial equilibrium external accident cost + **(2) Correction for labour tax revenues + (3) Correction for change in mitigation activity + (4) Correction for the induced labour supply effects**

Where

(1) the **Partial equilibrium external accident cost** represents the effect of one more carkm on general accident risk times [productivity value of sick days lost due to a change in the general accident risk + congestion time loss of an increase in accident risk + discomfort of subjective accident risk that remains after mitigation].

(2) the **Correction for labour tax revenues** equals the labour tax losses of the driver associated to the extra sick days of the driver in case of accidents

(3) the **Correction for change in mitigation activity** represents the fact that increased taxation of trips may reduce accident risks and thus the mitigation efforts by the households, as these efforts are often heavily subsidized, reducing these mitigation activities is in itself a gain

(4) the **Correction for the induced labour supply effects** represents the fact that increased taxation of commuter trips may decrease the supply of labour, as labour is already heavily taxed; this is itself a loss.

Not all terms point in the same correction: the second term (2) is typically positive but the third (3) and fourth (4) term may be negative.

The marginal external accident cost of an extra kilometre driven is higher for dangerous driving because the general accident risk effect of dangerous driving is higher than for safe driving and also the correction for labour tax revenues is higher as dangerous driving generates more sick days for the dangerous driver himself too.

6.5 A numerical illustration

In order to get an idea of the importance of taking into account general equilibrium effects in the calculation of the marginal damage of speeding and driving we calculate the partial equilibrium marginal damage and the general equilibrium damage. Note that we only take into account injuries – hence we do not consider deaths nor accidents with only material losses.

We assume that the average household drives 12500 km/year complying and 2500 km/year speeding[29]. The average speed complying is set at 60 km/h; the average speed violating is set at 78 km/h. We set the amount of mitigation measures equal to the average hospital costs of a traffic accident, this is 2119 euro. The current accident risk (av) equals 0.0000000521 (NIS 2006). The assumptions with respect to the current tax levels can be found in Table 6.1; the elasticities are discussed in the task report.

Table 6.1: tax levels

tax	Level	Source
τ_X	0.032981	Expected fine per km of dangerous driving X - Own calculations based on Belgian Household budget survey
τ_Z	0.027909	Tax on driving “safely” Z - Own calculations based on Belgian Household budget survey
τ_L	0.400279	Tax on labour - Own calculations
τ_M	0.80	Subsidy on medical mitigation expenses – Own assumption

Furthermore we assume that speeding attributes 3 times as much to the accident risk as driving compliant. The marginal cost of public funds equals 1.1534 .

We assume that people stay 6 days in hospital after an accident (van Kempen, SWOV 2007-02) and that every euro spend on mitigation decreases the number of days with 0.02.

[29] Own calculations based on Belgostat (2006), NIS (2006), FDS Economy (2005), Sartre (?).

We assume that health (H) depends on the 'initial' value of life, 2 million euro, the value of the expected losses, 2082 euro (own calculations based on HEATCO), the accident risk and the medical expenses.

Combining all these assumptions we can report on the relative importance of the differences between the partial and the general equilibrium approaches in Table 6.2

Table 6.2: Difference between partial and general equilibrium definitions of the external accident costs.

Euro/veh km	**"Safe" driving**	**"Dangerous" driving**
General equilibrium marginal external accident cost =	0.03498	0.52135
+ Partial equilibrium marginal external accident cost	0.03472	0.52094
+ correction for labour tax revenues (sick days)	0.00004	0.00021
+ correction for subsidised mitigation activities	0.00027	0.00125
+ correction for the induced labour supply effects	-0.000007	-0.00003
% deviation between partial and general eq estimates	<1%	<1%

We see that the differences between the partial and general equilibrium approaches are very small. There are many uncertainties in the parameters used but also sensitivity studies on the different values did never produce an important difference between the partial and general equilibrium approach.

This means that the partial equilibrium approach covers the most important aspects of the external accident aspects. Important in the definition of the partial equilibrium approach is that the sick days are counted at gross wage cost.

The general equilibrium approach is clearly not necessary for the estimation of the optimal pricing of road use but is probably necessary to have a full assessment of other policies to address accidents: road investments, enforcement of traffic regulations etc.

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WRS: Work Road Statistics published by International Road Federation

Appendix I: TREMOVE Detailed tables 2020 by country

Table A.I.1: Effect on revenue (€/year)

Country	Revenues						
	Reference scenario revenue	scenario revenue			% change		
		scenario 1	scenario 2	scenario3	scenario 1	scenario 2	scenario3
AT	5211	14698	13500	13451	182	159	158
BE	6519	23204	21437	21325	256	229	227
CH	6586	14855	14138	14003	126	115	113
DE	92672	159481	149649	149218	72	61	61
DK	7775	9150	8513	8472	18	9	9
ES	32759	90741	83382	83278	177	155	154
FI	8654	11723	10630	10588	35	23	22
FR	50425	167099	154476	152552	231	206	203
GR	4314	21344	15225	15212	395	253	253
IE	4451	7368	6664	6652	66	50	49
IT	40245	241736	176079	176088	501	338	338
LU	280	1593	1505	1483	468	437	429
NL	19173	36161	34510	34434	89	80	80
NO	7976	10692	9903	9856	34	24	24
PT	6346	16388	12879	12874	158	103	103
SE	9548	16203	15134	15053	70	59	58
UK	70994	118128	109721	108377	66	55	53
BG	2632	7605	6587	6671	189	150	154
CY	483	768	669	680	59	38	41
CZ	3388	15598	13011	13233	360	284	291
EE	808	1732	1430	1459	114	77	81
HR	883	6723	5237	5280	661	493	498
HU	1221	8689	6898	7003	611	465	473
LT	1502	3466	2807	2859	131	87	90
LV	776	2165	1771	1803	179	128	132
MT	211	200	194	195	-5	-8	-8
PL	11928	37027	30470	30952	210	155	160
RO	5192	17742	15360	15652	242	196	201
SI	605	3281	2525	2556	442	317	322
SK	1417	8245	7421	7470	482	424	427
TR	10875	57566	50281	51143	429	362	370
total	**415851**	**1131372**	**982005**	**979872**	**227**	**178**	**179**

Table A.I.2: change in welfare general and welfare labour (€/year)

Country	change in welfare general			change in welfare labour		
	absolute change in welfare			absolute change in welfare		
	scenario1	scenario 2	scenario 3	scenario1	scenario 2	scenario 3
AT	-2051	-1820	-1828	4134	4152	4102
BE	-4370	-2959	-3447	16909	18300	17633
CH	1038	-526	-476	2861	1232	1249
DE	-11094	-15353	-17927	49919	43865	40826
DK	-270	290	230	231	781	696
ES	-8424	1266	1392	7766	16661	16753
FI	-849	115	-146	1236	1941	1629
FR	-25347	-13958	-12889	26419	38014	38101
GR	-1558	7686	7686	2561	10648	10644
IE	-649	-144	-183	734	1140	1093
IT	65950	184311	184111	137916	240665	240464
LU	81	-33	-25	632	515	513
NL	333	920	530	12176	12776	12324
NO	-639	156	140	135	913	877
PT	-954	4372	4375	1803	6441	6443
SE	-977	-373	-470	2466	3110	2957
UK	-2985	-2923	-2832	8880	8811	8496
BG	-1201	2055	2066	100	3198	3209
CY	45	66	65	115	115	115
CZ	-1761	3313	3316	1511	6126	6130
EE	-29	302	301	218	486	485
HR	1017	4222	4221	2546	5492	5491
HU	-166	3296	3299	1813	4937	4941
LT	-144	911	909	380	1295	1294
LV	-59	619	619	315	911	911
MT	7	0	0	1	-7	-7
PL	-2802	8365	8343	3905	13798	13776
RO	-1630	5889	6222	1694	8831	9171
SI	-184	1543	1543	518	2103	2104
SK	0	1444	1446	1901	3193	3195
TR	5893	23456	24042	18321	34857	35461
total	**6220**	**216509**	**214632**	**310117**	**495300**	**491075**

Table A.1.3: change in passengerkm/tonkm (%)

Country	change in tonkm			change in passengerkm		
	scenario1	scenario 2	scenario 3	scenario1	scenario 2	scenario 3
AT	-4.75	-4.73	-4.63	-8.83	-8.62	-8.49
BE	-9.93	-10.00	-9.48	-13.41	-12.28	-11.71
CH	-8.02	-7.85	-7.71	-5.24	-6.73	-6.55
DE	-6.99	-7.02	-6.94	-6.64	-7.03	-6.63
DK	-7.99	-8.36	-8.27	-2.20	-0.97	-0.41
ES	-10.26	-10.32	-10.16	-13.70	-11.37	-10.98
FI	-6.02	-6.13	-5.08	-3.86	-2.36	-1.53
FR	-11.79	-12.02	-11.06	-15.14	-13.63	-12.16
GR	-2.97	-3.00	-2.87	-31.80	-19.98	-19.64
IE	-9.76	-9.90	-9.84	-5.80	-4.68	-4.39
IT	-3.97	-5.01	-4.85	-41.52	-26.30	-26.14
LU	-20.50	-20.52	-19.96	-10.27	-11.54	-11.33
NL	-22.97	-22.94	-22.92	-2.75	-2.53	-2.05
NO	-12.61	-12.78	-12.67	-2.55	-0.70	-0.12
PT	-5.37	-5.89	-5.83	-21.35	-12.45	-12.15
SE	-4.45	-4.43	-4.29	-5.29	-4.86	-4.51
UK	-5.65	-6.38	-5.01	-6.45	-6.21	-5.33
BG	-17.74	-18.40	-18.37	-24.66	-14.50	-14.41
CY	-10.28	-10.20	-10.19	-5.30	-5.19	-5.19
CZ	-17.25	-18.12	-18.05	-29.17	-16.14	-15.99
EE	-7.51	-7.85	-7.84	-13.49	-8.69	-8.63
HR	-14.34	-14.93	-14.73	-40.89	-24.84	-24.59
HU	-13.91	-14.73	-14.67	-32.13	-19.89	-19.79
LT	-10.45	-10.92	-10.91	-19.52	-10.08	-10.03
LV	-7.29	-7.66	-7.65	-24.75	-13.60	-13.52
MT	-2.01	-2.17	-2.16	-2.27	-2.89	-2.89
PL	-13.67	-14.29	-14.27	-22.42	-12.40	-12.34
RO	-12.87	-13.46	-13.45	-30.48	-17.90	-17.22
SI	-10.30	-10.86	-10.63	-35.16	-19.78	-19.57
SK	-20.95	-21.43	-21.42	-30.86	-19.42	-19.35
TR	-19.45	-20.04	-20.00	-30.72	-20.26	-19.82
total	**-10.71**	**-11.04**	**-10.84**	**-17.37**	**-11.54**	**-11.21**