Marginal Cost Pricing Implementation Paths in Interurban transport Evaluation of Welfare Effects

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In this paper the results of modelling case-studies carried out in the MC-ICAM project are presented. These case-studies are still in progress, so the results presented here are preliminary results. Moreover, this paper only includes the findings of three of the five case-studies that are carried out in the field of interurban transport. The other two case-studies still need to be completed.

1 INTRODUCTION

Background and objectives of MC-ICAM

Empirical and theoretical analyses based on welfare economics have typically focused on the derivation of optimal transport prices. Almost no attention has been paid to the question how these prices should be implemented. Therefore, whilst the principle that charges should be introduced gradually in steps is generally agreed among the policy makers and public at large, almost no attention has been paid to the question how these implementation steps should be defined. Phasing-in the implementation of marginal cost pricing is an area with little if any previous research, theoretical or empirical.

Project MC-ICAM is about the implementation of marginal cost based pricing in transport. The project covers intramodal, intermodal and intersectoral aspects. It focuses on the so-called phased approach to implementation. The goal is to produce new insights and concrete results to be used when revising transport pricing and taxation policies in Europe as an essential element of the EU's Common Transport Policy.

Background and objective of the modelling of interurban transport in MC-ICAM

The MC-ICAM project is organised in three stages: conceptual analyses, case studies and modelling case studies. In the first stage, various issues relating to both charging and use of revenues were identified and analysed at a conceptual level. In the second stage, case studies were carried out that, through literature reviews and surveys, explored modal-specific distortions, barriers and constraints to marginal social cost pricing (MSCP). In the final stage of the analysis modelling case studies are done over the domains of urban and interurban transport respectively. In these case studies the quantitative impacts of alternative implementation paths of MSCP are investigated by means of real-world simulation modelling. This paper focuses exclusively on the interurban modelling. The results of all the work done in MC-ICAM are fed into a final activity, which summarises the policy implications of the project.

The objective of the modelling of interurban transport in MC-ICAM is to compute the welfare effects (costs and benefits; at the regional, country and European levels) related to implementation steps, and in relation to all major interurban modes.

Approach

Five parallel simulation modelling case-studies have been carried out. In three of them, large, existing, dynamic network models were used (SMILE, SCENES and PINGO/NEMO). In two case-studies new, more aggregate, models were developed.

2 CASE-STUDIES AND MODELS

1. Optimal road freight taxes given constraints in the rest of the economy (KUL1 model)

This case-study's objective was to determine, in a general equilibrium context, the optimal pricing reform of road freight transport (generating externalities like congestion) given pricing constraints for the rest of the economy. There are three types of pricing constraints considered: imperfect pricing of passenger transport, existence of labour taxes and taxation or not of freight intensive consumer goods. For this objective a general equilibrium model was built that focuses on the derived effects of road freight taxation on the other distorted markets (here labour, passenger transport and consumption of freight intensive goods).

2. Pricing of road freight under tax competition (KUL2 model)

This case-study's objective was to experiment with the pricing of freight transport by road when road hauliers can take different routes and different governments tax the routes. This is an exploration of the potential problems associated to the introduction of road pricing for trucks. For this objective a partial equilibrium network model was built where one government taxes part of the network and other governments tax other parts. The focus is on the road freight market and we ignore interactions with other modes.

3. Interurban freight transport in the Netherlands (SMILE model)

In this case-study the SMILE (Strategic Model Integral Logistics and Evaluation) model was used to analyse implementation paths for marginal cost pricing of freight transport. The model can analyse the impacts of economical developments, international trade and logistic behaviour on the transport flows in the Netherlands via different modes. It is a partial model: consumption and production are exogenous. This case-study focused on the welfare effects of practical implementation paths, with special attention being paid to transport volumes per mode and the welfare effects of different degrees of geographical differentiation.

4. Freight and passenger transport in Europe (SCENES model)

The SCENES model of Europe is a strategic model covering Europe at the NUTS 2 level for both freight and passenger transport including all main transport modes (road, rail, air and water). It covers interurban movements in detail. This case-study focused on the welfare effects of practical implementation paths, with special attention being paid to transport performances per mode, the welfare effects of charging different types of roads (motorways, all roads) and the welfare effects of charging only freight transport versus charging both passenger and freight transport.

5. Interurban freight transport in Norway (PINGO/NEMO modelling system)

In this case-study two complementary models were used. PINGO is a Spatial Computable General Equilibrium model for Norway and NEMO a real network model for road, train and waterborne freight transport in Norway. Together, these models were used to calculate the welfare effects of practical implementation paths, with special attention being paid to different ways of using the revenues (redistribution to consumers or use in the public sector).

In table 1 the strengths and limitations of the different models are summarised.

Table 1: Strengths and limitations of the simulation models used.

Model(s) used	*Strengths*	*Limitations*
KUL 1 *(task 8.3)*	Road congestion; Interaction between passenger and freight Optimisation of charge levels	Unimodal No other externalities than congestion No network
KUL 2 *(task 8.3)*	Road congestion; Interaction between passenger and freight Tax competition between countries Network	Unimodal No other externalities than congestion
SMILE *(task 8.2)*	Modal competition Network Logistic decision making	Only freight Inelastic production/consumption No optimisation of charge levels Revenue use not modelled
SCENES *(task 8.4)*	Modal competition Interaction between passenger and freight Pan-European network	Congestion not modelled No optimisation of charge levels Revenue use not modelled
PINGO/NEMO modelling system *(task 8.5)*	Modal competition Network Elastic demand Revenue use	Only freight No optimisation of charge levels

3 IMPLEMENTATION PATHS INVESTIGATED

The three case-studies in which the dynamic network models were used (SMILE, SCENES and PINGO/NEMO) evaluated the following implementation paths defined in MC-ICAM deliverable 6:

1. Do nothing;
2. The first best alternative;

3. "Existing EC plans[1]";
4. "Only road pricing for freight transport";
5. "Only road pricing, all traffic" (only analysed with the SCENES model).

For computability reasons, the implementation paths modelled here are exogenous, rather than sequences of second-best optima (as implementation paths were defined in the theoretical framework of MC-ICAM).

Ad 1: Do Nothing

The implementation path Do Nothing means a prolongation of current policies.

Ad 2: First best alternative

A first-best optimum is an allocation defined by quantities of goods, including passenger and freight transport volumes, that maximises welfare given the prevailing technology such as vehicle fuel consumption and emissions, and the capital stock including transportation infrastructure. This definition encompasses externalities if their costs are internalised in the decisions of agents who generate them. In a first-best situation we assume that the only constraints are the inevitable technical constraints. In this situation, optimal prices are equal to marginal cost (MC-ICAM Deliverable 2).

The way in which the first-best alternative is modelled in the different case studies largely depends on two factors:

- *Data availability*: modelling marginal cost based pricing measures requires a lot of information on a very disaggregate level. At the most disaggregate level (e.g. a single trip) only very limited allocation of cost can be made; furthermore the availability of information at the lower levels of disaggregation is very country-specific, and
- *Capabilities/characteristics of the model used* (see table 1).

Ad 3: Implementation path "Existing EC plans"

In this implementation path, in 2005/2006, kilometre charges are introduced for road transport while no changes are made in the pricing for rail or water. After 2015 there is full marginal cost coverage for all modes (see table 2).

[1] Implementation path based on communication with the Commission Services

Table 2: Implementation path: "Existing EC plans".

Phases ***Key dimensions & second-best constraints***	***Phase 1*** ***(short term, 2005/2006)***	***Phase 2*** ***(long term, 2015)***
Road	Kilometre charge for commercial traffic. Could be a simple charge per country; however, differentiated by environmental performance and by axle weight. Possible charges for accidents and noise. Higher charges on environmentally sensitive zones. Fuel taxes may be partly replaced by the new kilometre charges.	Full marginal social cost coverage. More differentiation regarding place of driving to reflect environmental costs, noise and congestion costs. Fuel tax only to cover CO2. NB: still only commercial traffic!
Rail	No changes (only infrastructure charges)	Introduce external costs, air pollution, and noise in the charges.
Water	Introduce differentiated charges by vessel type, on emissions and noise, but in a revenue neutral way.	Environmental costs, but no longer in a revenue neutral way. Climate change cost, either in fuel taxes or separate climate change charges.

Ad 4 Implementation path "Only road pricing"

This implementation path is a variation on the previous one. It is a policy alternative in which only commercial road traffic is charged for its marginal social costs. The phasing of the different steps and the motivation for the road charges are the same as in the previous implementation path (see table 3).

Table 3: Implementation path: "Only Road Pricing".

Phases ***Key dimensions & second-best constraints***	***Phase 1*** ***(short term, 2005/2006)***	***Phase 2*** ***(long term, 2015)***
Road	Kilometre charge for commercial traffic. Could be a simple charge per country; however, differentiated by environmental performance and by axle weight. Possible charges for accidents and noise. Higher charges on environmentally sensitive zones. Fuel taxes may be partly replaced by the new kilometre charges.	Full marginal social cost coverage. More differentiation regarding place of driving to reflect environmental costs, noise and congestion costs. Fuel tax only to cover CO2. NB: still only commercial traffic!
Rail	No changes (only infrastructure charges)	No changes (only infrastructure charges)
Water	No changes	No changes

Ad 5 Implementation path "Only road pricing, all traffic"

This is yet another variation on the implementation path "Existing EC plans carried out". It is the same as the above IP, except that both passenger and freight traffic are charged. This implementation path is modelled with SCENES but not with SMILE and PINGO/NEMO, because these only include freight transport.

In the case-studies carried out by KUL no specific implementation paths were modelled. Instead, the modelling work carried out in these case-studies focused on mechanisms and interactions which are the weak points of the dynamic network models. These include congestion effects in general, the effect of imperfect pricing in other markets on optimal road freight charges, and un-harmonised (or even opportunistic) behaviour of different governments, each taxing different parts of the interurban transport network. So the KUL case-studies did not model individual implementation paths, but focused on specific dimensions of the pricing system (see following section).

4 KEY DIMENSIONS OF PRICING SYSTEMS INVESTIGATED

On top of the evaluation of the practical implementation paths, each case-study made a deeper analysis of the impacts of a limited number of specific key dimensions of pricing systems. These key dimensions of a pricing system (representing the barriers and constraints), identified in earlier MC-ICAM work, include:

I. The *coverage or scope of the pricing system*: the number of market segments that can be priced i.e. features such as geographical or spatial coverage, modal coverage, user groups covered, externalities covered.

II. The *composition and level of pricing measures*: the types and combinations of prices or charges / taxes used, maximum tolls / price caps, minimum total revenues / budget constraints, etc..

III. The *degree of differentiation of pricing measures* can mean differentiation of prices (taxes, tolls) over relevant sub-markets: in space (i.e. spatially / geographically; over links and nodes in networks), in time (temporal = dynamic, peak / off-peak), and across users (non-anonymous / discriminatory).

IV. The *rules and principles governing revenue use*: the allocation of revenues generated – for instance – the use of revenues for the lowering of distortionary taxes elsewhere in the economy, or the use of targeted compensation schemes aimed at those groups affected most strongly by the taxes.

The focus per case-study is summarised in table 5. This focus is based on the starting point to make use of the specific strengths of the different simulation models while taking into account the limitations of the models.

Table 4: Focus of the modelling work in different case studies.

Key dimensions	*KUL 1*	*KUL 2*	*SMILE*	*SCENES*	*PINGO/NEMO*
I. Coverage or scope of the pricing system	Road freight and passenger transport, based on UK data	Road freight and passenger transport, in Belgium and surrounding countries	Freight transport via road, rail and inland waterway in the Netherlands	Freight transport via road, rail, inland waterway and sea; and passenger transport via car, coach, rail and air in Europe.	Freight transport via road, rail and sea in Norway
II. Composition and level of pricing measures	Optimal congestion charges	Congestion charges for road freight differing per country	All externalities. Effects of overcharging, undercharging	All externalities.	All externalities.
III. Degree of differentiation of pricing measures	-	-	Effects of different degrees of geographical differentiation	-	-
IV. Rules and principles governing revenue use	Revenue used to reduce labour tax or increase lump sum subsidies	-	-	-	Revenue redistributed to consumers or used in public sector

5 METHODOLOGY

Choice of parameter values

Local values were used for the Marginal Social Costs. A cross-case-study check was done to assure that the values used were broadly comparable.

Scenarios

The scenarios (assumptions regarding exogenous variables) used for the modelling with the dynamic models (SMILE, SCENES and PINGO/NEMO) consist of two components: (1) an economic component: assumptions about the economic development in the next 20 years; (2) a technological component: assumptions about the technological developments in the next 20 years (e.g. emission factors).

Existing (available) economic scenarios were used. For the technological component scenario assumptions were made specifically for MC-ICAM.

Assessment of welfare effects

The format of the output is harmonised between the case-studies. Nevertheless, the welfare functions differ per case-study. The KUL1 and KUL2 models include no other externalities other than congestion. In SMILE and SCENES consumption and production are exogenous; in these case-studies revenues and induced consumption changes are not included in the analysis and in the welfare function. The PINGO/NEMO modelling system can model revenue redistribution endogenously, which makes it possible to account for the effect that consumption and thereby transport activities increase as a result of redistribution of the revenue from MSCP.

Table 5: Components included in the welfare function (analysis) in the different case-studies.

	KUL1	***KUL2***	***SMILE***	***SCENES***	***PINGO/NEMO***
Consumption changes	X	X			X
Resource cost	X	X	X	X	X
Time cost	X	X	X	X	X
Emissions/safety/noise			X	X	X
Infrastructure cost			X	X	X
Congestion	X	X	X	X	
Revenue use	X	X			X
Costs of regulation					

Time horizon

The time horizon chosen for the work is 2020 (for PINGO/NEMO: 2022).

The results of the case-studies using the dynamic models are presented for this year in order to make comparisons possible (under the same exogenous conditions). On top of that, results are presented for in-between years (between now and 2020) for some practical implementation paths, like the implementation paths “Existing EC plans” and “Only road pricing”.

6 RESULTS PER CASE-STUDY

Optimal road freight taxes given constraints in the rest of the economy (KUL1 model)

In this case-study a static general equilibrium model was used which was calibrated to aggregate UK data. The case-study focuses on road freight transport and the only externality in the model is congestion.

It was shown in this case-study that, if road congestion is important and freight and passenger taxes are below the marginal external cost, an increase in the road freight taxes in the peak period increases welfare.

The welfare-optimising charge for freight transport depends, inter alia, on (1) whether or not passenger transport is also charged, and (2) on the recycling instruments (what are the revenues used for). These two dependencies were analysed.

1. Do we need a higher or lower freight tax when passenger taxes are increased?

In Figure 1 we investigate the sensitivity of the results with respect to the passenger transport tax (which amounts at its benchmark value to 35%). In this alternative, revenues are recycled through labour tax reductions. We plot the change in social welfare as a function of the tax on freight (a range from 60 % to 110 % is considered) for three different levels of the passenger transport tax. The benchmark level of the passenger tax is given by the middle of the three curves. The two other curves show social welfare when passenger transport excise taxes are (i) one-half of the benchmark level (the lowest curve), and (ii) double the benchmark level (the highest curve).

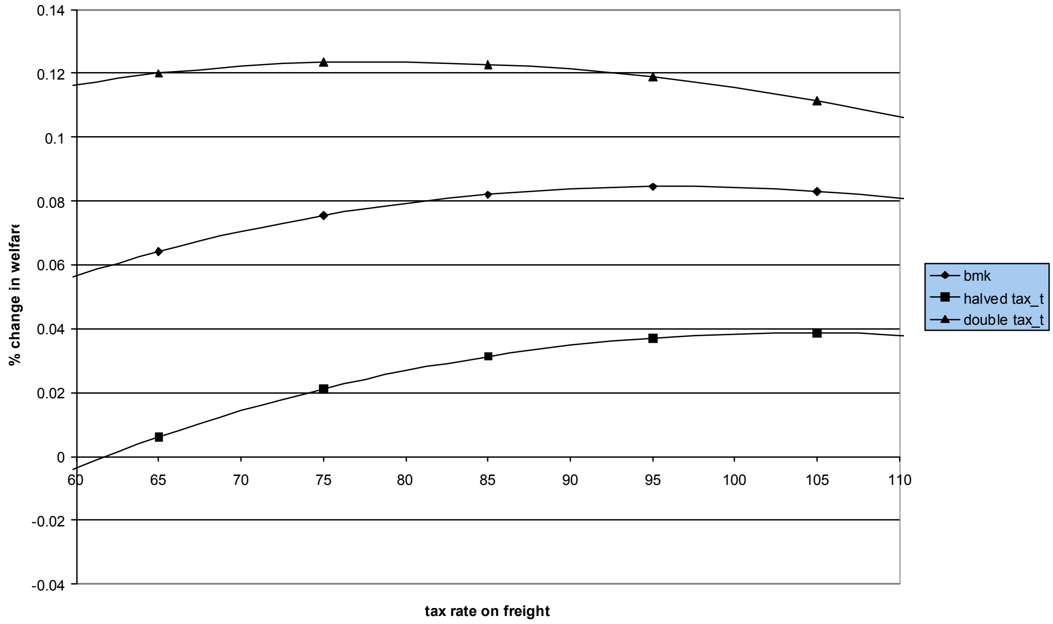


Figure 1: The impact of different levels of passenger transport taxes.

Two findings stand out from the results reported in Figure 3. First, the welfare gain of a given freight tax reform rises with the level of the passenger tax. This reflects the fact that, over the range of freight transport taxes considered, raising the tax on passenger transport is still welfare improving. Second, it is found that the higher the rate of passenger transport taxation, the lower the optimal freight tax. For instance, doubling benchmark passenger taxes reduces the optimal freight tax to approximately 80 per cent, while halving passenger taxes increases the optimal freight tax to 105 per cent.

2. Does the optimal freight tax depend on the use of the tax revenues?

Figure 2 shows that optimal freight taxes and welfare levels are higher when revenues are recycled via labour taxes. The differences between recycling instruments are considerable. Recycling via the lump-sum instrument raises welfare only marginally compared to labour tax recycling. Moreover, the optimal freight tax rate amounts to less than 65 per cent for lump-sum recycling as compared to about 95 per cent in the case of recycling through the labour tax.

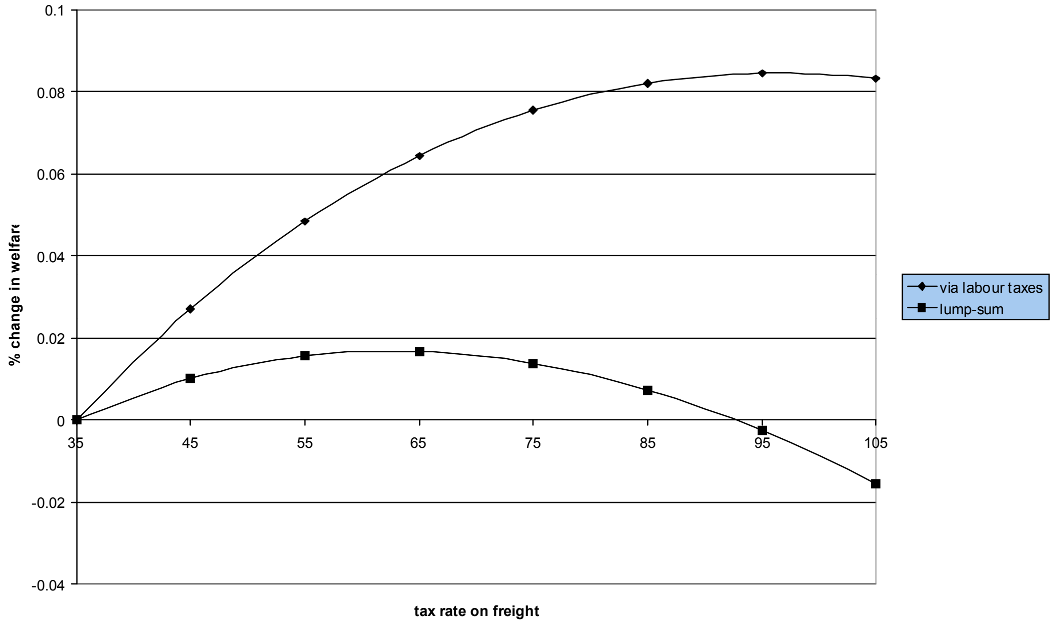


Figure 2: Freight transport tax reform: comparing the effects of lump-sum and labour tax recycling of the tax revenues.

An increase in the freight tax remains desirable when the tax revenues are used to increase the lump sum subsidies. The welfare gain of a freight tax increase is in this case only 20 to 30% of the welfare gain one can achieve when revenues are used to reduce labour taxes.

Tax competition effects (KUL2 model)

Unfortunately the results of this case-study were not available at the time of writing.

Interurban freight transport in the Netherlands (SMILE model)

Transport indicators

Without any policy changes (Do Nothing), the total transport performance (measured in tkms) increases by 55% between the years 2000 and 2020. The transport performance of all modes grows, but the modal shares of inland waterway (IWW) and rail slightly increase at the expense of road transport (by 0.5% and 0.7% respectively). In absolute terms road transport accommodates most of the growth. Technological developments will lead to reduced environmental and safety cost per kilometre, but due to the increased demand for transport total externalities still increase (especially marginal infrastructure cost).

In the different pricing implementation paths we see a 0.2% to maximum 1% lower total transport performance in 2020 compared to the Do Nothing policy (see table 6). Road gains additional market share under all implementation paths. This is due to the fact that charging the social marginal cost for all modes results in relatively high increases of transport cost for rail and inland waterway. Another important factor is that the externalities of road transport decrease faster than those of the other modes as a result of improved technology for road transport, resulting in lower charges for road transport under the MSCP principle. Thirdly, geographical differentiation of charges makes some road transport links cheaper, namely those through less densely populated areas.

Along the implementation path "Existing EC plans", we see a minor dip in the development of road transport performance in 2006, when the pricing regime changes for road transport. In 2016 when all modes are charged the full marginal cost, IWW and rail transport suffer a loss of modal share of 2.3% and 0.5% respectively. In case only road is charged (first road charging under marginal cost and around 2015 full marginal cost pricing for road), IWW and rail do lose their shares.

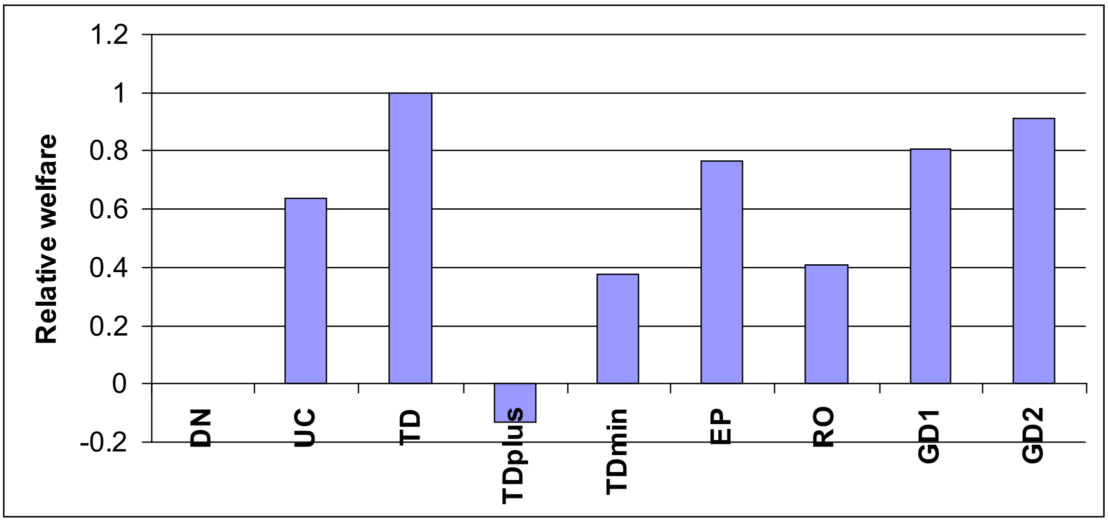
Table 6: Transport performance in 2020 per implementation path/alternative.

Implementation paths/alternatives			*Transport performance (tkm)*			
Short	*Case*	*Description*	*Total*	*Road*	*IWW*	*Rail*
DN	*Do Nothing*	Current situation, no changes	100	100	100	100
UC	*Undifferentiated Case*	Optimal pricing per mode, no regional differentiation	99,1	102,7	84,9	87,3
TD	*Total Differentiation*	Optimal pricing per mode with regional differentiation (25% to 200%)	99,2	103,0	86,5	82,8
TDplus	*TD plus 10%*	As TD, but with charges 10% higher than MSC	99,0	102,8	86,4	82,2
TDmin	*TD minus 10%*	As TD, but with charges 10% lower than MSC	98,8	102,6	86,0	83,0
EP	*Existing Plans*	Existing EC plans carried out	99,0	102,3	86,9	86,4
RO	*Road only*	Optimal pricing only for road with regional differentiation	99,8	100,3	99,7	95,6
GD1	*Gradual Differentiation step 1*	Differentiation ranges from 75% to 133%	99,1	103,0	84,6	83,2
GD2	*Gradual Differentiation step 2*	Differentiation ranges from 50% to 167%	99,0	103,0	85,8	82,9

Welfare effects

Full internalisation of external costs with geographical differentiation of charges (TD: the alternative coming closest to the first-best optimum) leads to the highest welfare gain. This is illustrated in figure 3, which depicts the relative welfare gain (difference between Do Nothing and Total differentiation) per implementation path in 2020.

Figure 3: Relative welfare level in 2020 for all implementation paths.



In the implementation path UC (undifferentiated case) there is no geographical differentiation of charges: the charges are equal to the average marginal external costs in the Netherlands. In the Total Differentiation implementation path the emission and noise charges are differentiated per region, depending on the population density per region. Depending on the population density the charge varies between 25% and 200% of the average marginal emission and noise costs. Two implementation paths with limited (in-between) levels of geographical differentiation were also modeled, one with a range of 75% to 133% of the average marginal noise and emission cost (GD1) and one with a range of 50% to 167% (GD2). The relative welfare gains are illustrated in figure 4.

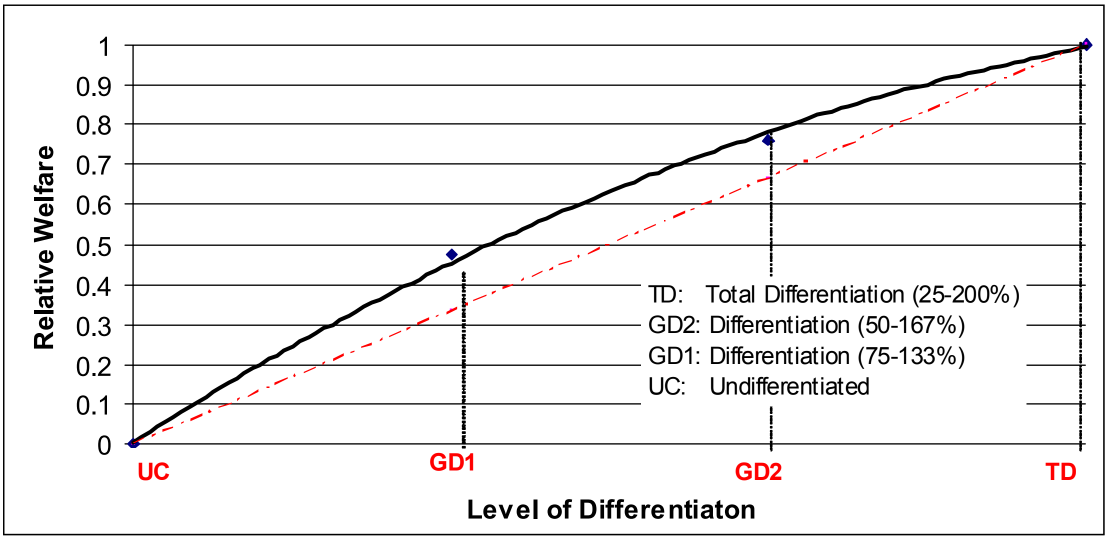


Figure 4: End states (2020) of implementation paths with different degree of regional differentiation of charges for emission and noise.

The results show that the first step towards full differentiation is the most rewarding in terms of welfare gain, but the effect is just a little different than linear.

Another outcome shown by figure 3 is that, if the charges implemented are higher than the actual marginal social costs (TDplus), the welfare effect is negative, compared to not implementing any charges (the Do Nothing alternative). In case charges are equal to (TD) or lower than (TDmin) marginal social cost, welfare effects are positive compared to no charges. This implies that thorough insight in the actual marginal social cost is crucial, and that undercharging is less costly in terms of welfare loss than overcharging.

The implementation path "Existing EC plans" has positive welfare effects, but not as positive as implementing full social marginal cost pricing at once (TD; the first-best alternative). This implies that a shock effect leads to higher welfare gains.

In case only road is charged (RO: first road charging under marginal cost and around 2015 full marginal cost pricing for road), welfare effects are still positive compared to no charges at all, but less than Existing plans. The welfare effect of the road-only pricing implementation path amounts to about 50% of the welfare effect of the Existing Plans implementation path in which all modes are charged for their marginal social costs.

The revenues in the different implementation paths differ considerably. The revenues are the highest in case of undifferentiated internalisation of marginal social cost (yielding almost 50% more revenues than in the Do Nothing policy). Since the use of revenues is not modelled in the SMILE model this aspect has not been included in the welfare function used.

Freight and passenger transport in Europe (SCENES model)

Unfortunately the results of this case-study were not available at the time of writing.

Interurban freight transport in Norway (PINGO/NEMO modelling system)

Transport indicators

The sum of total freight transport on road, railways and water in Norway (tkms) increases for all the implementation paths (Figure 5).

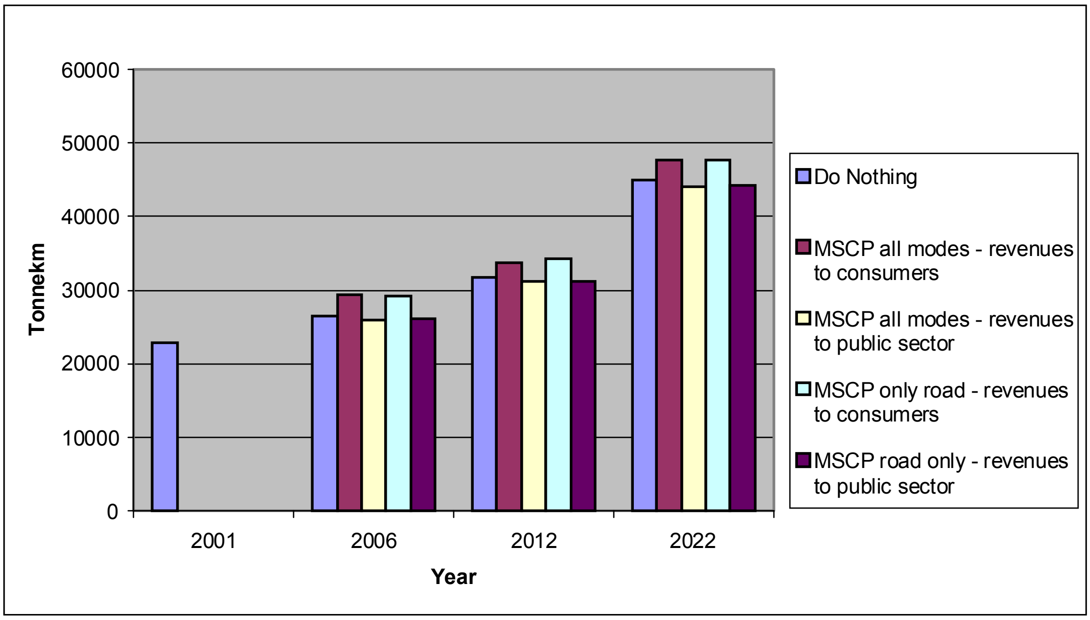


Figure 5: Total yearly tkms in Norway along the implementation paths.

The increase is the largest if MSCP is applied to all modes and revenue is redistributed to the consumers. This generates the greatest increase in consumer endowments, which in turn causes an increase in demand for commodities and transport. The second largest increase in transport (tkms) is found in case MSCP is applied to road vehicles only and revenue is redistributed to the consumers. The relatively small differences between the paths compared to the changes in the level of transport in general (from 2001 to 2022) is in part due to the expected future economic growth and the fact that a great share of the externalities are already internalised along the do-min path as existing transport taxes.

The do-min path modal split (in tkms) changes slightly in favour of road transport (Figure 6). The reason for this development in the do-min situation is due to greater advances in fuel efficiency for road vehicles than for the other transport modes, where waterborne transport is assumed to have the least developments.

The effects of the MSCP implementation paths on the modal shares relative to the do-min path is initially an increase in waterborne transport and a reduction in road transport. The reason is that MSCP pricing initially increases transport costs for road transport. This changes, however, towards the end of the period (2001-2022), where road transport increases relative to do-min path, which is due to the favourable improved technology for road transport that gives less transport taxes for road transport while the MSCP principle is applied.

Thus MSCP is in favour of waterborne transport in the short run, whereas the combined effects of both MSCP and the assumed improvement towards more environmentally friendly transport technology have effect that the mode choice becomes more in favour of road transport, train remains more or less unaffected and waterborne transport is reduced. Increasing share of consumption of commodity groups with high external cost per tkm (i.e., general cargo) contributes, however, to high overall external costs per tkm in future years.

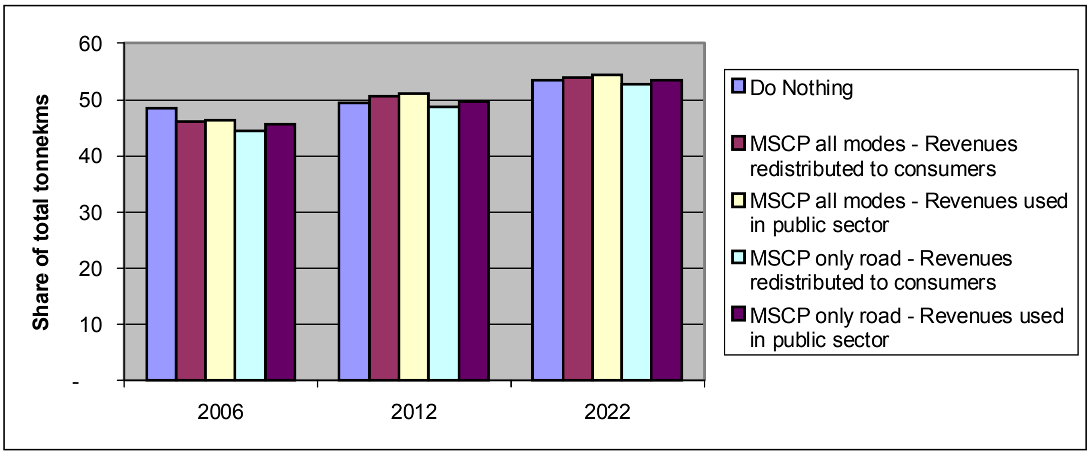


Figure 6: Share of total tkms by lorry along different IPs.

Both the MSCP pricing and the improved technology jointly cause a general reduction in external costs per tkms over time. But the fact that the MSCP is differentiated by urban and rural area also has the effect that especially road transport is directed outside urban areas to avoid the higher taxes there, which increases distance by road and tkm.

Welfare effects

A measure for evaluation of overall welfare effects constitutes effects on household utility[2] plus external costs of freight transport plus revenue redirected as funds for unspecific use in public sector (with a shadow cost of zero). In cases when revenue from

[2] The effect on household utility is measured in terms of altered consumption, where altered consumption is caused by altered income or price changes. Consumption and household utility are not affected by altered savings.

MSCP is redistributed to consumers, it is added as income that affects consumption and thus household utility.

This case study shows, in general, that the effect of marginal social cost pricing (MSCP) upon household utility is negative when the revenues are canalized to the public sector and positive in case revenue is redistributed to the households (Table 8), with both negative and positive effects accelerating over time during the implementation period (2001-2022).

The positive effect that revenue redistribution to the consumers have on household income available for consumption and savings outweigh the negative effect that MSCP makes transported commodities more expensive and in turn that expensive commodities have a negative impact on consumption. It is noticed, however, that the loss in consumer surplus along implementation paths where the revenue is used in public sector is quite small compared to the revenue retrieved. This difference is in part due to the compensating effect that the people save relatively less than they consume while their total income for consumption and saving is reduced. The difference is also explained by the fact that PINGO is based on the assumption that employment is a fixed resource per county and that we assume no changes in unemployment, which have the effect that the equilibrium price on labour increases as the price on all transported inputs increases. Less saving and increasing prices on labour compensates hence increasing prices on transported commodities. Hence the households' consumption is only slightly negatively affected by MSCP in situations where the revenue is redirected to the public sector.

It is also noticed in Table 8 that there is an external cost increase for the implementation paths with MSCP of road, rail and water and revenue redistributed to consumers. This is explained by the great increase in household income along this path and thereby increases in consumption and transport demand. Hence, along this implementation path the negative effect on external costs of increasing demand for freight transport is not sufficiently compensated by the increasing efficiency in the transport sector of applying MSCP.

The MSCP effect on household utility is stronger in cases when all modes are covered by it, than in the case when only road transport is covered.

Table 7: Total welfare effect and its composition under different implementation paths for 2022 (Million Euro per year).

	Revenue is redistributed to consumers		*Revenue is redistributed and used in the public sector*	
	MSCP only for road	*MSCP for road, rail and water*	*MSCP only for road*	*MSCP for road, rail and water*
Consumer surplus	165	461	-28	-85
Revenues	0	0	1301	1508
External costs	98	-145	299	287
Total	263	317	1572	1710

The total effects of MSCP upon performance of the country include not only its effects upon households' utility but also upon the environment and the public sector. The results show that MSCP reduces the external costs of transport if the revenue is used unspecified in public sector, whereas redistribution to the consumers lead to increased demand for goods and thus increased transport and external costs.

Despite the negative influence upon households' utilities when revenue is canalized to the public sector, the total welfare effects of MSCP implementation are quite significant at the last stage of all the IP's, indicating efficiency of MSCP. The positive welfare effect of road only pricing is smaller than if all modes are charged their external cost, but still amounts to 83% (revenue redistributed to consumers) or 92% (revenues used in public sector) of the effect if all modes are priced (see figure 7).

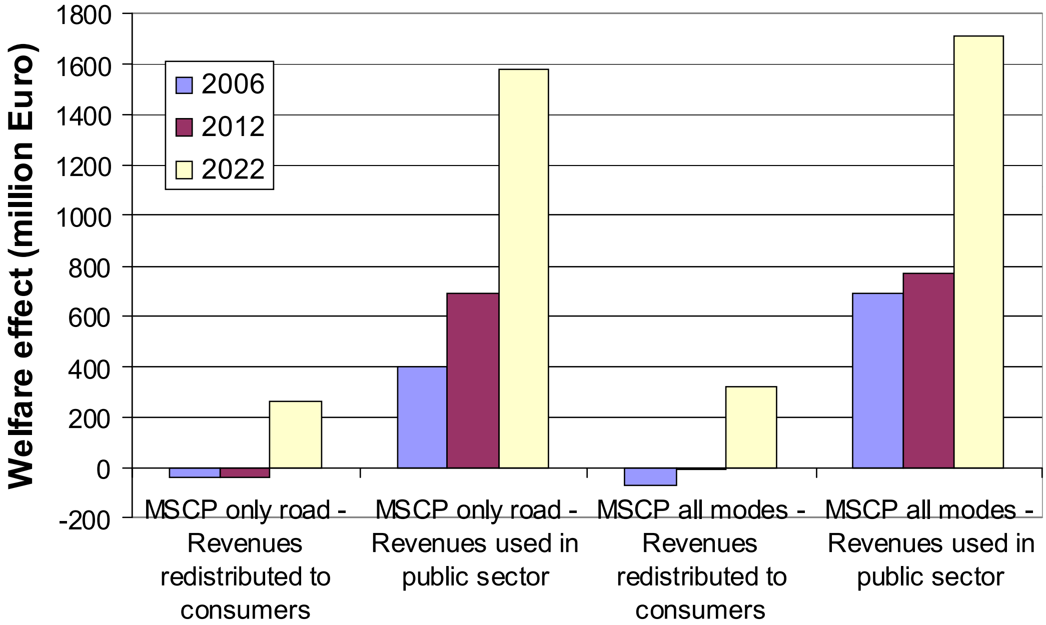


Figure 7: Development of total welfare measure along the four implementation paths for Norway (million Euro per year).

7 CONCLUSIONS

Conclusions on implementation paths evaluated in all case-studies

Do nothing (= no new policies)

Total transport performance increases. The modal shares remain more or less the same, which means that road transport accommodates most of the growth in absolute terms. Externalities per tkm decrease, but total externalities increase due to the growing transport volume.

"Existing EC plans"

Compared to the Do Nothing alternative, the modal share of road transport first decreases, due to the introduction of road pricing in 2006. Then, owing to technological developments (decreased externalities per road-tkm), road transport shows a stronger growth than the rail and water modes. After 2015, when full social marginal cost pricing is introduced, road transport continues to grow while the water and rail modes lose their market shares. One important factor contributing to this increase of road transport is that (especially road) traffic patterns change as a result of geographical differentiation of charges, which makes routes through less densely populated and less congested areas more attractive.

The development of total transport performance depends on the use of revenues: If the revenues generated by pricing are redistributed to consumers, consumption increases, which leads to a growth in demand for transport. If revenues are used in the public sector, total transport performance increases slightly less than in the Do Nothing path.

Compared to the Do Nothing alternative, the total external costs are higher in 2020 in case revenue is redistributed to consumers, due to increased consumption and traffic. If revenues are used in the public sector, in which case traffic decreases, externalities are lower.

The overall welfare effect compared to the Do Nothing alternative is positive. The effect is higher when revenues are used in the public sector than when they are redistributed to consumers.

"Only road pricing for freight transport"

Up to 2015 this implementation path is identical to the previous one. From 2016 on, only road is charged full social marginal cost.

Compared to the Existing Plans path, the modal shares of non-road modes remain stable after 2015. Compared to the Do Nothing alternative, the road mode gains some market share, due to the geographical differentiation, which makes some routes cheaper than in the Do Nothing alternative.

Conclusions concerning the key dimensions of pricing systems

Coverage or scope of the pricing system

The modes included in the case studies were road, rail and water (PINGO/NEMO: sea, SMILE: inland waterway). Marginal social cost pricing for only road yields a positive welfare effect. This effect is smaller than when all modes are priced, but the effect is still considerable. This suggests that pricing road as a first step in an implementation path is a big step from a welfare perspective.

Composition and level of pricing measures

The results of the modelling work with KUL1, suggests that the optimal freight tax is lower the higher is the rate of passenger transport taxation. This finding may have relevant policy implications for a stepwise introduction of congestion pricing on both passenger and freight transport. Suppose that it is currently not yet feasible, for political or technical reasons, to introduce congestion pricing in passenger transport and that the authorities start out by introducing an optimal freight tax, conditional on the current benchmark passenger tax rate. If taxing passengers becomes acceptable later on and the authorities decide to increase passenger transport taxes, then from a welfare viewpoint it may be desirable to accompany this tax change with a simultaneous reduction in freight transport taxes.

For acceptability reasons, it might be preferable to charge freight transport under the price level which optimises welfare if only freight transport is charged. The price level chosen could for instance be the price level which optimises welfare if both freight and passenger transport are charged a congestion charge.

The case-study for the Netherlands showed that the only pricing case where the welfare effect proved to be negative (compared to Do Nothing) was if charges are higher than the actual marginal social cost. In case charges are equal to or lower than marginal social cost, welfare effects are positive compared to no charges. This implies that overcharging is to be avoided. Given the uncertainties in marginal external cost values, a careful approach to setting charge levels seems necessary.

Degree of differentiation of pricing measures

The SMILE results suggest that the welfare effect increases almost linearly with increased geographical differentiation of charges. The first steps in differentiation yield higher marginal benefits than the last steps. For phasing of pricing measures, this implies that, every step towards further differentiation creates welfare gains, which going towards full differentiation, become a bit smaller.

Under full geographical differentiation, the share of road transport is higher than in the Do Nothing implementation path. This is so even for the case in which only road is charged. This is due to the fact that geographical differentiation makes some road transport links cheaper, namely those through less densely populated areas. In case only road is charged, a reduced degree of geographical differentiation might lead to a reduced growth of road transport. Further modelling exercises should be done to further explore this.

Rules and principles governing revenue use

The modelling work done both in the UK-based (KUL1) and Norwegian (PINGO/NEMO) case-studies show that the way in which the revenues are used has a dominant impact on both the optimal price level and the level of welfare.

KUL1 shows that, if the tax revenues are used to increase the lump sum subsidies, an increase in the freight tax remains desirable. The welfare gain of a freight tax increase is in this case only 20 to 30% of the welfare gain one can achieve when revenues are used to reduce labour taxes. The Norwegian case-study shows that the welfare gain of MSCP is 5 to 6 times higher in case the revenues are used in the public sector than in case the revenues are redistributed to consumers.

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