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How using the Revenues of the German HGV motorway system efficiently and equitable under different regulatory frameworks and institutional settings?

Lessons from the EC-funded research project REVENUE

Topic:

Regulation / Public Private Partnerships in road infrastructure management

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Extended Abstract

Aims and structure: In January 2005 finally the German HGV motorway charging system (Lkw-Maut) went successfully in operation. Since the initial start planned for summer 2003 numerous technical as well as managerial and organisational problems had to be removed. One of the most striking organisational issues was the distribution of the funds collected by the system between the various modes of the transport sector and the general budget, which was controversially discussed between the federal government and the state representatives.

In front of the background of a more or less politically motivated allocation rule of the toll revenues to road (50 %), rail (38 %) and IWW (12 %) the paper aims to investigate different allocation principles, including the earmarking of parts of the revenues to maintenance activities and the transfer of funds to the state budget. Further, the impact of different pricing regimes and of private sector involvement will be looked at.

It is thus the aim of this paper to identify superior allocation schemes. The different variants will be compared over a longer period of time (2000 to 2020) based on neo-classical welfare measures as well as by analysing selected economic indicators.

Approach: The paper presents the results of case study 4.2 of the EC-funded research project REVENUE (Use of Transport Pricing Revenues). Within this project a simple partial equilibrium model called MOLINO was developed, which is based on neo-classical theory. This model is applied to the German case. But as the numerous shortcomings of such models are well known, the all-European system dynamics platform ASTRA (Assessment of Transport Strategies) is run in parallel in order to generate a second set of scenario outputs for benchmarking reasons.

Results: The results show that both models coincide in some respect, which is the more cautious judgement of the positive welfare effects of charging users by average infrastructure costs. Further, both models tend to recommend to use the revenues for the road sector rather than for cross-subsidising the railways. Further, there is a clear statement towards the use of a reasonable proportion of revenues for maintenance measures instead of an excessive construction of new capacity.

However, in the major question raised by the REVENUE case study, whether revenues are to be earmarked to the transport sector or whether they should be granted to the public hand, the two models fundamentally disagree. According to neo-classical theory MOLINO assumes the state to be the best fund manager available, ASTRA sees severe problems of reducing the innovation and development power of the economy by extracting money out of it and using if for tax reduction purposes.

Further, the paper will discuss issues of private capital involvement and the role of different pricing schemes for the question of revenue use.

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Claus Doll and Wolfgang Schade

1 Introduction: The REVENUE project

In September 2003 the REVENUE project was started. It aims at finding answers to the question of how to allocate the revenues of transport pricing from an economic point of view. Therefore, the project started with identifying the appropriate theoretical foundation. In this step the neo-classical theory was extended to the question of optimal investments, institutional arrangements and private capital involvement. Furthermore, additional light was put on the mutual relation between the philosophies of general equilibrium and system dynamic models as tools for efficiency analysis. The working step was concluded with the definition of a simple partial equilibrium model called "MOLINO", which includes all theoretical aspects discussed throughout the theoretical work.

The REVENUE project has applied the theory to a set off inter-urban and urban case studies. Two of these exercises deal with the recently implemented HGV motorway charging systems in Germany: Case Study 4.2 has dealed with the economic efficiency and equity of several charging systems on a theoretical level and case study 4.7 has looked at the issue of the acceptance of various pricing and regulation schemes within the haulage business. In this paper the efficiency question will be addressed by presenting the results of case study 4.2.

2 Design of the German HGV motorway toll system

In September 2000 the commission on transport infrastructure financing set in by the German government has published its final report (Pellmann 2000). The commission there strongly recommends making today's tax-based infrastructure financing systems fit for the future by promoting the user-pays-principle. This recommendation has, among other reasons, emerged from the enormous

investment deficit in the federal transport networks, which will lead to considerable losses in service quality in the medium to long run. In particular, in periods of tight public budgets the tax-based financing mechanisms will not be able to make up for these investment deficits and thus will create even higher obligations for future generations.

The federal government followed these recommendations and immediately tendered the electronic toll collection system and in parallel launched a study calculating the HGV motorway tariffs (Rommerskirchen at al. 2002). As the result between the controversial discussions between federal government and the state representatives the toll system was designed as follws:

- Roughly 20 % of the toll revenues are granted to the toll operator for operating the charging technology.
- The remaining 80 % of revenues are allocated solely to the federal transport networks (out of these: 50 % for the federal road network, mainly motorways, 38 % for the federal rail network, 12 % for inland waterways).
- The allocation of revenues to particular investment projects will be carried out by the state-owned Transport Infrastructure Financing Society (Verkehrsinfrastrukturfinanzierungs-Gesellschaft VIFG). the VIFG was 1founded in October 2003.
- The subject of compensating the German haulage business is still a matter of discussion between the EC and the MoT; currently the toll is reduced by 2.6 Cent until a final decision is taken by the EC.

In January 2005, the Toll Collect consortium finally managed to get the HGV system started without any problem. Thanks to the agreement on revenue use the level of acceptance among hauliers' organisations is high and after several months in operation it shows up that the projected revenue of 2.8 thousand million Euro per year will be met. However, alternative policy design options have not been investigated in detail.

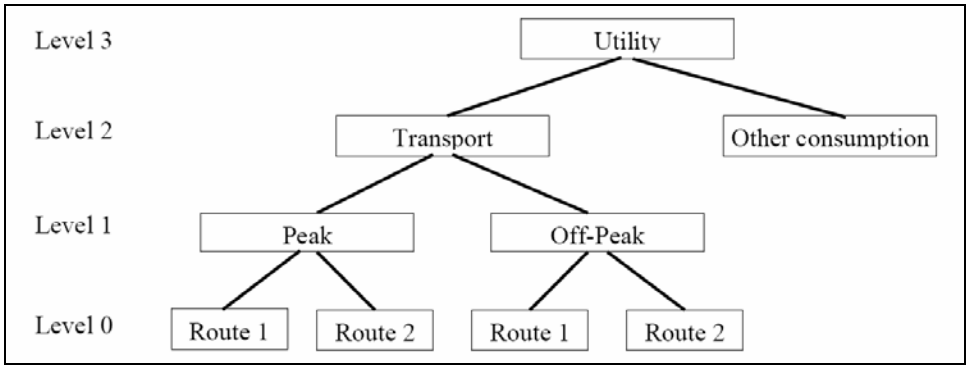
3 Assessment methodology

The question of economic efficiency has been addressed by applying the MOLINO model developed within the REVENUE project (Proost et al. 2004) and the ASTRA system dynamics model (Schade 2004). The MOLINO model was used to answer in detail questions on the allocation of revenues

collected from road pricing and the design of a possible multi-modal transport fund in front of different pricing and regulation scenarios.

The MOLINO model is a partial equilibrium model based on neo-classical welfare theory running over a maximum of 40 periods. It models two competing single-link infrastructures, two modes, passenger and freight transport, two time periods (peak vs. off-peak) as well as two different types of users (low vs. high income) and types of goods traffic (local vs. transit). The interaction between transport and the rest of the economy are computed by elasticities of substitution while the inner-transport interactions are computed by CES-functions. The welfare-implications of public investments or surpluses are controlled by parameters on investment efficiency and the costs of public funds. Figure 1 presents the structure of the MOLINO model.

Figure 1: Structure of the MOLINO model



The MOLINO model was specified such that the actors subject to pricing are those directly using the transport infrastructures (transport service operators, train companies or hauliers) rather than the final users (passengers or freight forwarders). In order to be able to let MOLINO internally compute marginal social cost prices for the use of transport infrastructures the pre-defined set of actors had to be re-defined as follows: Infrastructure owners charge the costs of new capacity provision to the network operators who bear the duty of maintenance and renewal and pass on their costs to the service operators.

The ASTRA (Assessment of Transport Strategies) is a system-dynamics model implemented under the Vensim platform. It consists of several 10 000 partly differential equations organised in eight modules for population, transport, regional economy, macro-economy, trade, environment, vehicle fleets and welfare. It runs for the EU-15 countries differentiated into 64 geographical zones. The model was designed and extended by several EU research projects in order to assess complex transport-related policy packages over a longer period of time.

With these specifications the regulatory frameworks tested against the status of transport policy in the year 2000, which was characterised by the existence of the comparably low time-based Eurovignette motorway charge for heavy lorries have been defined along several research questions: These six questions and the corresponding design of regulation schemes are listed in turn:

Scheme 1. Maintenance versus new construction: If funds would entirely be earmarked to the motorway sector, which would be the preferred distribution between capacity extension and maintenance, replacement and repair?

This question has been tackled within the framework of the current setting of the HGV motorway and rail track access charges. Current taxes are left unchanged as the toll level already considers the part of fuel taxes which can be seen as earmarked for transportation purposes. Road toll revenues are distributed according to the current scheme 50 % to road and 50 % to rail and IWW. Within this framework the research question is answered by varying the share of each mode's additional income used for new construction activities between 25 % and 75 %.

Scheme 2. The level of cross subsidisation: If funds would be earmarked to the transport sector (current state), which would be the preferred allocation between the modes?

Here the general framework of case 1 is maintained. The share of expenditures used for new capacity provision is set to 50 % for all modes and, in order to shed light on the research question, the share of road pricing revenues going to rail and IWW was varied between 25 % and 75 %.

This question was also addressed by the ASTRA model comparing a case of full earmarking of revenues to the road sector to a 50 % subsidisation of rail.

Scheme 3. The share of general budget contributions: If no earmarking rules are specified, which is the preferred allocation of funds for the transport sector and which share of revenues may be passed over to the general budget?

Also this case was analysed in front of the background of the current charging and regulation scheme. Within the transport sector 50 % of revenues are used to subsidise rail/IWW and within each mode 50 % are used for new capacity provision measures. The share of funds transferred from transport to the public hand was varied significantly between 0 % (full earmarking of revenues to transport) to 100 % (no earmarking at all).

The ASTRA model has addressed this case by comparing the full use of revenues for lowering direct taxes to the above-mentioned cases of full earmarking within the transport sector.

Scheme 4. Effect of different pricing rules: Is the question of setting pricing rules more important than the decision how to use the revenues and which is the preferred pricing rule from the welfare perspective?

To answer this very fundamental question the current HGV charging regime is compared to a scenario where all road vehicles are charged for average infrastructure costs on all road types and to a marginal social cost pricing regime applied to all modes. In the latter case current taxes are abolished as the user charges now are composed of marginal infrastructure, congestion and environmental costs. In all cases the operators of road networks and the rail network investor are still public while, as in the previous cases, the rail network operator is a private company with public support. In all three cases revenues are fully earmarked to transport and within the transport sectors revenues are used according to question 3.

Scheme 5. Public versus private administration: Would decision rules be different if road operation and investment would be managed by a private company?

Usually it is assumed that private companies carry out investment and maintenance activities more efficiently, but on the other hand demand for a considerable profit share. In this case it was assumed that due to the profit margin and for different depreciation and investment principles the private road operators take charges which are 50 % above the private ones. As it is most likely that private operators will also charge passenger cars, the scenario of charging all road vehicles on all network parts was chosen in order to address the above research question. To concede a particular level of decision-making power to the state two different levels of cross-subsidisation were considered: Full earmarking to the road sector and 50 % transfer to rail and inland waterways.

Scheme 6. Motorways versus trunk roads: Should congestion, accidents and environmental problems on the secondary road network be fought by investing in these hotspots (on secondary roads) or by increasing motorway capacity and comfort?

While the five research questions before have been studies on the basis of the multi-modal setting of MOLINO the final one was subject to the multi-road-level specification. The regulatory framework chosen was that of the current HGV motorway charge with public administration, 50 % use of revenues for new investments while all revenues flow back into the road sector. Only the share of revenues transferred from the motorways to the secondary road network is varied between 0 % and 75 %.

Table 1 gives an overview of the charges levied in the different regulation schemes. Besides the final MSCP case, in which MOLINO computes the charges internally, the tariffs have been set externally according to current tariffs or according to the results of infrastructure cost accounting studies (Rommerskirchen et al. 2002). In particular remarkable is the fact that the marginal social cost prices computed by the model are four to eight times higher than the respective average costs!

Table 1: User charges by regulation scheme in the multi-modal case

Transport market	**Traffic condition**	**Transport mode**	**Scenario**				
			Base case	**ACP HGVs on motorways**	**ACP all road users public**	**ACP all road users private**	**MSCP all modes**
Passenger transport (€ / 100 pkm)	peak	road	0.000	0.000	1.881	2.257	20.065
		rail	2.500	2.500	2.500	2.500	10.820
	off-peak	road	0.000	0.000	1.881	2.257	12.458
		rail	2.500	2.500	2.500	2.500	9.720
Freight transport (€ / 100 tkm)	peak	road	0.000	0.583	1.545	1.854	14.675
		rail/IWW	0.554	0.554	0.554	0.554	6.505
	off-peak	road	0.000	0.583	1.545	1.854	10.797
		rail/IWW	0.554	0.554	0.554	0.554	1.622

ACP: Average cost pricing, MSCP: marginal social cost pricing, public / private: form of administration of road operation and investment and rail/IWW investment.
Source: Doll 2005.

4 Selected results: Comparison of allocation schemes

4.1 Welfare results using the MOLINO model

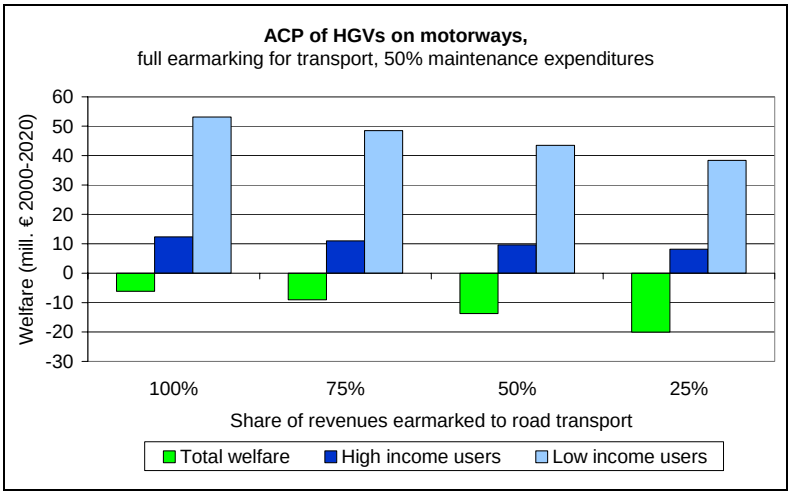
The MOLINO model is run for a period of 20 years from 2000 onwards. The results are then given as the discounted sum of annual welfare for the society in total as well as separately for low and for high income users. For each scenario the payments of the transport fund either to the modal networks or to the public hand have been calibrated such that the fund is just empty in the year 2020. This procedure averts that the welfare measures are determined by the available surplus or the deficits at the end of the planning horizon.

The MOLINO output show the remarkable results that in most cases total welfare, which includes the costs of firms, environmental aspects and user costs, decrease when road pricing is introduced while in the same time the partial welfare measures for the transport users increase. The results of the computations for the six research questions are presented in turn.

Scheme 1. Maintenance versus new construction: The results show, that the society as a whole, including the public preference for a clean and safe transport sector, agents' profit and loss accounts, public debt, user costs and benefits, etc., clearly prefer to spent revenues for maintenance rather than for the provision of new capacity, entailing all the problems with induced traffic, land occupancy and entailed future financing needs. However, from the users' perspective the decision would be different. Due to increased network speeds by new capacity projects this variant is to be preferred. But the preference here is less expressed than the contrary preference for maintenance activities calculated for the entire society. These results visualise the a-priori expectations that in the medium- to long-run the neglecting of network maintenance entails even more expensive future rehabilitation programmes in order to maintain the service quality at a sound level.

Scheme 2. The level of cross subsidisation: Contrasting the previous case, here the results for the society as a whole and for the two user groups are pointing into the same direction with a similar order of magnitude. It is found that the revenue use for the road sector is more beneficial than the subsidisation of mass transport (rail/IWW).

Figure 2: MOLINO results: Road mass transport subsidisation



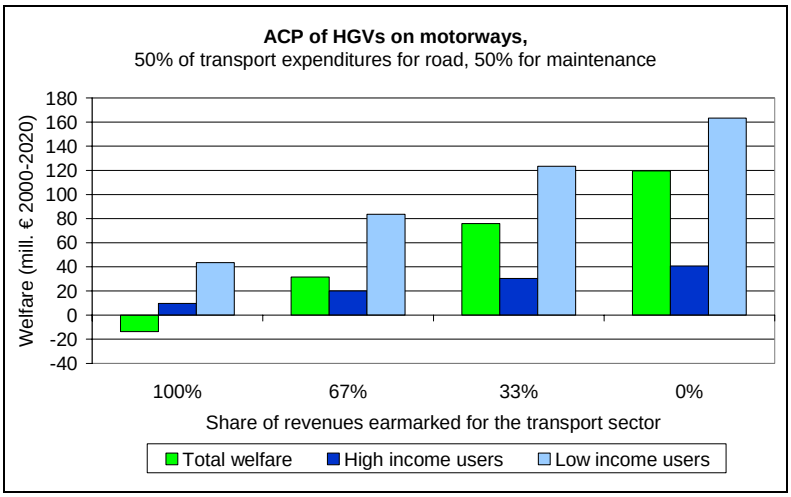
Source: Doll (2005)

The explanation for this behaviour of the MOLINO model is rather straightforward: The calibrated speed-flow curves for roads consist of a slightly higher slope than the rail curves and the specific investment costs road is lower than in the rail and IWW sector. Both assumptions are realistic and in total do not outweigh the environmental benefits from demand shifts to rail and IWW.

Scheme 3. The share of general budget contributions: This question constitutes the main concern of the present case study. MOLINO as well as the ASTRA model assume that the central government re-distributes the road pricing revenues by lowering direct taxes. Due to the given capabilities of the models used and according to the scope of the REVENUE project, alternative forms of spending public money, e.g. for education or health care, are not considered.

For the society as a whole as well as for the users MOLINO finds the central government to be the much better beneficial of pricing revenues than the transport fund. According to the current tax structure in Germany well-off users profit most by this re-distribution process as they would gain an over-proportional share of tax-reductions. Apart from the legal problems of using transport revenues for the public budget in EC law, this might raise serious equity and acceptability problems. The comparison of Figure 2 and Figure 3 shows impressively that, according to the model results, the question of how many revenues to earmark for the transport sector is much more decisive than concerns about the spending of revenues within the transport sector.

Figure 3: MOLINO results: Earmarking for transport vs. public sector support



Source: Doll (2005)

A sensitivity analysis for the above research question using the Swiss value for the marginal costs of public funds (MCF) of 1.35 reveals that the direction and the signs of the results remain unchanged, but the magnitude of results for the society in total is clearly less expressed compared to the use of the MCF-value proposed by Kleven and Kreiner (2003) for Germany.

Scheme 4. Effect of different pricing rules: The MOLINO model concludes with a value of total welfare of 3'000 million Euro, which is roughly twenty times above the already extremely positive result of transferring all revenues to the state found under research question 3. The consequence of this result is, that it is not the type of revenue spending that matters, but the underlying pricing principle.

However, the sensitivity of these results to the value for the costs of public funds is enormous. Using the Swiss value as in the previous case lets the MSC pricing scheme even lead to negative results of total welfare. Respectively, the recommendations following from these results can only be vague.

Scheme 5. Public versus private administration: The results found by the MOLINO model are rather surprising: Under the two different settings of using all revenues for road and of subsidising rail/IWW with 50 % of the revenues, private network operation and ownership performs worse than a public administration. This holds for users as well as for the society in total. Also astonishing is the

result that under private control cross-subsidising rail/IWW turns out to be somewhat less disadvantageous than earmarking all revenues to road.

The reason for this behaviour is the result of the profit and loss accounts. As the fund in all cases is designed such that it balances out after 20 years, the accounts of agents in some cases runs negative. In particular for private agents this constitutes a major problem, which is accounted by the MOLINO model.

Scheme 6. Motorways versus trunk roads: The MOLINO outputs show that this question is of minor importance. Total welfare suggests keeping all revenues inside the motorway sector while the user results alone in contrary prefer to invest into the trunk road system. The reasons for this discrepancy are the higher external costs of HGVs for air pollution, noise and accidents on the more sensitive trunk road system. So, for environmental and safety reasons it is better to "lock" heavy traffic inside the motorways.

4.2 Long-term economic impacts assessed by the ASTRA model

To pay tribute to the complexity of the interrelationship between transport policy and economic development in a changing environment the MOLINO results have been benchmarked with some outputs of the ASTRA system dynamics model. ASTRA was developed throughout several EC studies between the 4th and the 6th RTD framework programme. The system dynamics approach is based on evolutionary economics and aims at showing the development path of complex systems and their reaction on changing conditions. The version of the ASTRA model used in this study covers the EU-15 member states, where each country is subdivided in four functional zones. The transport sector is disaggregated into several modes, commodities and travel purposes and distance bands on each O-D relation. The economic module consists of input-output tables by 25 sectors.

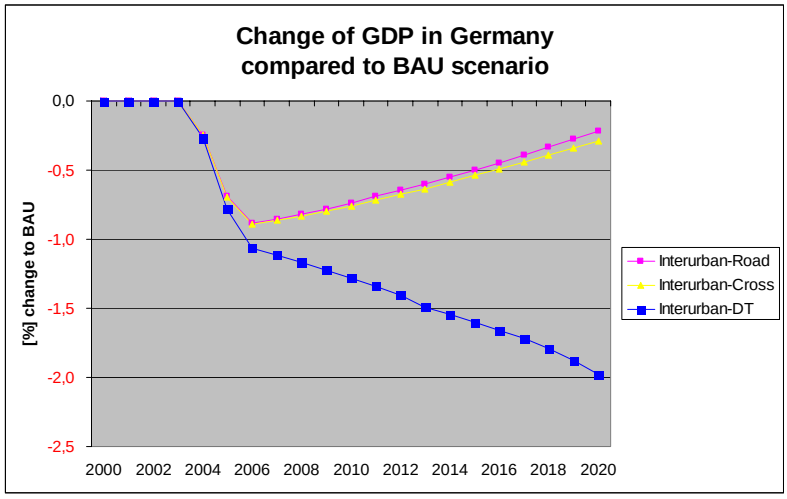
Although the level of detail of the model exceeds the capability of the MOLINO model by far, ASTRA lags of the possibility to model transport funds. Further it is not able to deliver welfare

measures in the neo-classical sense. Thus, the model was only used for a limited number of regulation schemes. Apart from the business-as-usual case, which describes the member states' transport policy according to current plans, only the pricing scenarios of charging all road vehicles on all network plans is analysed. Within this framework three alternatives of revenue spending are considered:

- Variant "Road": All revenues are earmarked to the road sector, where 50 % are spent for motorways and 50 % are spent for trunk roads. Within each road category the vast majority of revenues are spent for capacity extension measures.
- Variant "Cross": In this case an equal share of funds is allocated to road and to rail transport. Within the railways 60 % are invested into new network capacity, 20 % into facilities (e.g. inter-modal terminals) and 20 % into rolling stock.
- Variant "DT": Transfer of funds to the general budget and using them for decreasing direct taxes. In this case 100 % of revenues are transferred to the consumers. According to the results found by several model applications (CGEurope, E3ME in Schade 2004) consumer price increases induced by this measure are neglected.

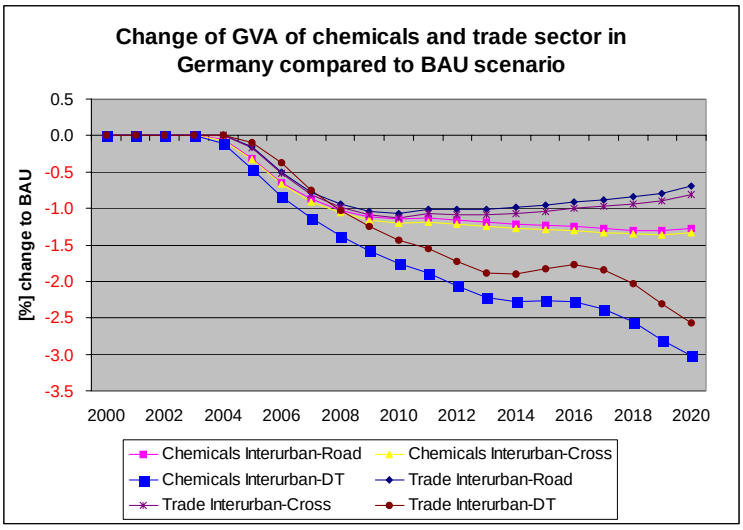
The outputs of the ASTRA model are shown at sample of illustrative examples. Figure 17 shows the slope of GDP in the tree scenarios relative to the BAU case. After an initial fall of GDP by 1 % against BAU the reinvestment-scenarios "road" and "cross" nearly recover until 2020, while the revenue use for direct tax reduction ("DT") keeps on declining down to a difference in GDP of 2 % relative to the BAU case in 2020. The slope of the two reinvestment variants (road and cross) are very similar, but investments in road transport result in slightly better values than the cross-subsidisation to rail.

Figure 4: ASTRA results: GDP relative to BAU



Due to the inter-relationship between transport and economy transport demand shows a similar picture than the development of GDP figures. The decline of transport volumes due to pricing measures, however, has a positive impact on the environment as these scenarios entail a reduced emission of pollutants and greenhouse gases. On the other hand labour markets are or course negatively impacted by this situation. A more differentiated view on selected economic sectors is given by Figure 5 for chemicals and for the trade sector. The figure demonstrates that the trade sector develops slightly better as it profits from the infrastructure improvements due to revenue re-investment programmes more quickly than industry branches.

Figure 5: ASTRA results: GVA for chemicals and trade sector relative to BAU



While the superiority of road investments is in line with the findings of the MOLINO model, this is not the case for the rather pessimistic view concerning the public use of revenues. In this point the two models totally contradict to each other.

The initial decline of the macro-economic indicators is due to the shift of transport demand to slower modes which reduces the productivity of transport-intensive market segments such as the export market.

The later positive development of the reinvestment scenarios can be explained by productivity gains of the economy and of the trade sector due to improved transport market conditions and by employment effects entailed by network, facility and rolling stock investments. In contrast, the sole stimulation of consumption by lowering direct taxes in the DT-case can not outweigh the productivity losses due to road pricing.

Similar developments can be observed for GVA, employment, disposable income, exports, transport demand and CO2-emissions. Only on the latter case the negative performance of the public sector alternative turns out positive. Concerning all other variables listed ASTRA coincides with the less enthusiastic view of the MOLINO model concerning the introduction of road pricing.

5 Conclusions

The welfare analysis performed with the MOLINO model for the German tolling study has shown that the welfare superior solution is a social marginal cost pricing scheme with revenues feeding into the general budget rather than earmarking them to the transport sector. However, this result is highly sensitive to the value chosen for the MCPF (marginal cost of public fund). The results presented in this chapter are based on calculations with a value for MCPF = 2.21 taken from Kleven and Kreiner (2003) for proportional tax reforms in Germany, a value which is rather high compared to other countries. A sensitivity analysis with a value of 1.35 (the value for Switzerland, see Doll 2005) has shown that the direction and the sign of results do not change but the preference for the general budget solution is less clearly expressed. The positive welfare effects of not earmarking revenues was also observed for model runs with an average cost pricing scheme. However, while the modeling indicate high

efficiency gains results for the no-earmarking option the acceptability survey conducted in parallel to this study has revealed that such a solution seems to be not acceptable for those affected by charging.

If (for example for political and/or acceptability reasons) it has been decided to earmark HGV revenues to the transport system, as it has been done in current practice in Germany, the model runs have shown that for most cases that it is welfare optimal to allocate revenues to the road sector and within the road network to the motorways. The reason for the welfare-inferiority of modal cross-subsidisation options studied in the model runs is that the time savings estimated for road are much higher than for rail (the speed-flow curves calibrated for the German road network have a higher slope than those for rail) . These findings which were obtained with a partial-equilibrium model (MOLINO) are reinforced by the results obtained with a system-dynamic model (ASTRA) for the medium to long run. It has been demonstrated that investments into the network generate sustainable productivity gains and employment effects. Furthermore, the modelling exercise has shown that network maintenance and renewal is to be preferred over new construction of transport infrastructure capacity although these results should be treated with some caution due to the fact that the model does not contain any sophisticated network deterioration module.

Comparing these case study findings with current practice in Germany shows that the HGV charging scheme, the institutional framework and the use of revenues follows only partly these results. The charge level is based on average costs instead of the welfare superior social marginal cost pricing principle. Revenues do not go to the general budget as recommended by the modelling results but the current scheme with an intermodal distribution of revenues follows rather political, practical and acceptability considerations. The 50 % share of revenues dedicated to motorways might be considered as a practicable compromise between the efficiency consideration, acceptability issues and practical financing needs for transport modes.

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