MACROECONOMIC ANALYSIS OF TRANSPORT PRICING REGIMES FOR THE EU

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Abstract. This paper presents a macroeconomic analysis of 10 different transport pricing policies that have been designed in EU funded projects like REVENUE or TIPMAC. The policies differ in terms of where and for which mode charges are introduced and how revenues of the charges are allocated to the economic actors. The impact analysis is performed by using the integrated economy – transport – environment assessment model ASTRA. The analysis identifies a set of transport-economic mechanisms that are relevant to consider and to design successful pricing policies for transport.

1. European transport policy setting

Transport pricing constitutes one of the basic transport policies of the European Commission emphasized first with regard to fair payment of transport infrastructure [2] and more recently adding the objective of internalization of external environmental and social cost of transport [3]. However, a large variety of options exist to introduce transport pricing and to make reasonable use of the revenues that are generated by such pricing policies. This paper analyses a set of pricing policies applied in the REVENUE[2] and TIPMAC[3] projects with respect to their transport and economic impacts.

The applied pricing policies in this analysis consist of two elements: first, a charging regime that defines on which type of infrastructure and for which mode the transport charges are introduced. Alternative charging regimes comprise congestion charges for roads in urban areas, charges on interurban roads and charges for all modes that are oriented at levels that would cover the social marginal cost of each mode. Second, a

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[2] REVENUE = Revenue Use from Transport Pricing, project funded by the European Commission 5th RTD framework

[3] TIPMAC = Transport infrastructure and policy: a macroeconomic analysis for the EU, project funded by the European Commission 5th RTD framework

revenue allocation regime that determines the usage of revenues generated by the transport charges. Alternative allocation approaches include a reduction of direct taxes, a reduction of labor costs, investment into road mode, only, and investment into road and rail mode i.e. cross subsidies from road to rail as in the respective policies only road charges are introduced. This structure of pricing policies is presented in Table 1.

CODE OF POLICY	Revenue allocation regime			
Charging regime	Refund by direct tax reduction	Refund by labour cost reduction	Reinvestment in mode of charge collection	Reinvestment by cross-subsidisation
Congestion charging in urban areas	Congestion-DT	Congestion-LC	Congestion-Road	Congestion-Cross
Interurban road user tolls	Interurban-DT	Interurban-LC	Interurban-Road	Interurban-Cross
SMCP oriented charges for all modes (TIPMAC scenarios)	SMCP-DT	SMCP-LC		

Table 1. Structure of analyzed pricing policies.

The charging level for the pricing policies are defined on the base of existing European estimates of either congestion costs or infrastructure and environmental cost. Congestion charges are implemented in ASTRA for local road transport in metropolitan and high-density areas. The charging values are taken from the UNITE[4] project [1,5]. Interurban road charges are also based on the UNITE results. They are imposed on long distance transport of trips over 50 km distance. The charge levels are presented in Table 2. The SMCP oriented charges are taken from the TIPMAC project [7]. Charges are introduced for all modes and all trip distances according to their infrastructure and environmental cost. The level of charges is differentiated for the EU15 countries since e.g. the environmental cost depend on population density in a country.[5] In all scenarios existing tolls are replaced by the new charges from the year 2004 onwards.

Euro / tkm or Euro / pkm	General cost values from UNITE				Derived cost values in scenario analysis	
	Average infrastructure	Marginal infrastructure	Congestion charges *	Accidents, environment and others	Urban congestion charge	Inter-urban road tolls
Road passenger local	0,02	0,001	1,0	0,09	0,1	
Road passenger LD	0,02	0,001	0,7	0,05		0,02
Road freight local	0,1	0,02	2,7	0,24	0,1	
Road freight LD	0,015	0,003	0,22	0,015		0,015
Rail passenger LD	0,04	0,0003	0,13	0,03		
Rail freight LD	0,01	0,0004	0,04	0,007		

*Values for vehicles under congested conditions. For total averages: Inter-urban roads: 2%, urban roads 10% congestion. Rail = 10% congestion / delay, LD = Long distance transport

Table 2: Prices proposed for defining the ASTRA-T model runs

[4] UNITE = UNIfication of accounts and marginal costs for Transport Efficiency, project funded by the European Commission 5th RTD framework

[5] The charge levels are presented in [7] and due to page limits can not be shown here.

2. Impact analysis with ASTRA model

Impact analysis of pricing policies in this paper is performed by applying the integrated economy-transport-environment model ASTRA (=Assessment of Transport Strategies) [8]. ASTRA is developed and applied in several European research projects to analyse the long-term impacts of transport and other policies for the fifteen EU member states before May 2004. ASTRA comprises eight modules: population (POP), macro-economy (MAC), regional economy (REM), foreign trade (FOT), vehicle fleet (VFT), transport (TRA), environment (ENV) and welfare measurement (WEM). Between these eight modules manifold interactions are implemented.

Most relevant for this paper is the interaction between the economic modules (MAC, FOT, REM) and the transport module. The MAC incorporates an input-output (IO) model with 25 economic sectors to reflect sectoral dependencies. Interaction between demand and supply on national level is depicted by a Keynesian final demand model where consumption and exports drive investments and a potential output model based on an extended production function approach following endogenous growth theory by using endogenised total factor productivity (TFP) on the supply side. These models are completed by an employment model fed by the IO-model and a government model distinguishing a set of categories of revenue and expenditure flows of governments. Finally, micro-macro-bridges establish linkages between the micro-level transport models and the macro-level models.

Trade is calculated on the sectoral level for each combination of country pairs. Trade flows depend on national influences like GDP growth, sectoral labour productivity and on transport influences. Transport is modelled by a classical 4-stage transport model driven by endogenous macroeconomic, trade and sectoral influences on the generation stage and by generalized cost on the distribution and modal-split stages. A rather rough assignment stage provides influences on travel times by linking transport demand to modal capacities. Outputs that feed back from transport to the economic models include (generalised) cost, average travel times, transport performance, transport expenditures and tax revenues.

ASTRA is implemented by means of system dynamics modelling, an evolutionary approach in which market equilibrium could happen by accident but not by design compared for instance with CGE models for which existence of market equilibria constitutes a prerequisite. Hence, price effects may play a role in ASTRA but dominant are behavioural and structural equations for long-term changes that are backed-up by theory and econometric techniques. The application of such an evolutionary, dynamic model reveals as results trajectories of reactions to transport policies instead of point forecast.

System Dynamics methodology used to implement ASTRA is first developed during the 1960ies [4]. Mathematically a system dynamics model consists of a system of non-linear differential equations that are computed by numerical integration since usually analytic solutions for the system of equations cannot be found [9]. Construction of System Dynamics models assumes that the behaviour of a system is primary determined by its feedback mechanisms. "*The central concept that system dynamicists use to understand system structure is the idea of two-way causation or feedback*." [6].

The integrated modular approach of ASTRA-T has the advantage that feedback loops, which commence on the micro- or meso-level in one of the modules (e.g. transport expenditures for one mode and one OD-pair in one distance band in the TRA) and then end up with an effect on the national level (e.g. changes in sectoral consumption and gross-value-added), can influence the originating module such that the feedback loop is closed e.g. in this case by the integration of the MAC module. Closing the feedback loop then implies to establish either macro-micro-bridges (e.g. from GDP and sectoral output to goods flows) or vice versa micro-macro-bridges (e.g. from transport investments into vehicle fleets to overall investments). To transfer the impacts of the transport policies from the transport system via these micro-macro bridges into the economic system and to measure the resulting economic impacts, which are frequently called the indirect effects of the transport policy, constitutes key objectives of ASTRA.

3. Economic impacts of the transport pricing scenarios

Policy analysis in ASTRA is undertaken by comparing the policy scenarios with a business-as-usual scenario (BAU). The BAU considers the economic development as developed in the TIPMAC project and the demographic development according to EUROSTAT population forecast [7]. Transport policies present in BAU include those already decided e.g. the implementation of the TEN and the EURO IV and V emission standards. The policies are tested for medium-term time horizon until 2020. This framework leads to the trend development of major variables for EU15 as shown in Figure 1. GDP increases by +54% between 2000 and 2020, which is equivalent to an annual growth rate of about 2.2%. Export remains a major driver of economic development with a growth of +111%, while employment increases only by +5.4% measured as full-time equivalents and by +16% referring to the total employment, which implies that part-time employment is growing significantly. The environmental indicators describe a diverse picture with CO_2 emissions from transport growing by +31% and NO_x emissions shrinking by -43% due to the growing share and the improvements of catalysts in the fleet.

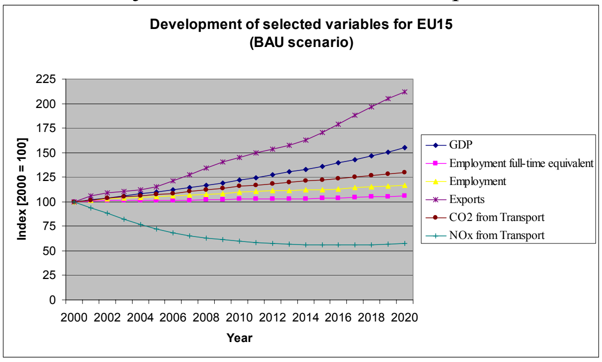

Figure 1. Trends in BAU scenario.

The main transport indicators in BAU for passenger transport reveal a growth of performance of +29%, of car-ownership of +30% and of car fleet of +34%. Expenditures for passenger transport also increase with +37% for personal trips, +44% for tourism trips and +95% for business trips. For freight transport a growth of volume in tons of +64% is forecasted, leading to an increased performance of +94%, which is due to the even stronger growing trade and the related increase in transport distances.

3.1. Basic results of policies

The first result to note is the significance of revenues that are generated by the policies. The urban congestion charge scenarios generate revenues of about 40 Bio EURO annually for the EU15. Introducing the interurban road charges leads to about 70 Bio EURO annually and the SMCP oriented charges to 330 Bio EURO annually. Looking at these large numbers it becomes obvious that the question how to allocate this money to different spending purposes is rather important.

The analysis of results of the 10 pricing and allocation policies commences with an overview on a number of key indicators presented as relative changes (in percent) to the BAU scenario in Table 3. The table shows that the assessment of the scenarios depends to some extent on the weighting of criteria e.g. the congestion charging scenarios all lead to increased GDP, a positive result, while they also increase CO_2 emissions of transport, a negative result, such that trade-offs between the different indicators exist.

A consistent result is obtained for the linkage between the selected charging regime and the impacts on exports. Congestion charging does not affect exports, while all charges that are imposed to long distance transport (interurban tolls, SMCP) cause significant negative results with reductions of exports between -1.7 and -3%. If then there is kicked-off no counterbalancing positive stimulus then GDP decreases like in interurban-DT and interurban-LC. While in the interurban-Road and interurban-Cross scenarios a positive stimulus is activated through the investment into new transport infrastructure (inv. grow by +2.34 and +2.06%) and the corresponding improvement of travel times such that the negative impact on total factor productivity (TFP) is less strong. Always corresponding with the decline of exports is a reduction of freight tons transported and the reduction is largest when also GDP is reduced. The results for employment are diverse, because they depend on the sectoral shifts that are triggered by a scenario i.e. if transport demand shifts to public transport services due to road charges employment tends to increase, but since in parallel the overall expenditures for transport increase such that private demand for goods and services of non-transport related sectors decreases leading to reduced employment in these sectors, the overall results can become negative or positive and differs for instance also between the EU countries due to their different sectoral economic structure.

Policy	GDP	Employ-ment	Consump-tion	Invest-ment	Export	TFP	tons	tkm	trips	pkm	CO_2
Congestion-DT	1.52	-0.03	2.45	7.53	0.16	0.84	0.14	16.12	-0.04	0.24	5.41
Congestion-LC	0.87	-0.12	1.05	4.30	0.11	0.58	0.05	16.10	-0.05	0.21	3.84
Congestion-Road	1.42	0.48	1.08	3.96	0.19	0.76	0.69	16.45	-0.01	0.35	5.18
Congestion-Cross	1.33	0.42	0.95	3.91	0.18	0.66	0.58	16.42	-0.02	0.37	5.08
Interurban-DT	-1.19	-0.78	-0.11	0.10	-2.17	-1.79	-2.18	-0.53	0.01	-0.49	-5.31
Interurban-LC	-1.79	-0.84	-1.59	-2.78	-2.21	-2.03	-2.18	-0.50	-0.02	-0.54	-5.27
Interurban-Road	0.35	0.47	0.61	2.34	-1.77	-0.70	-0.85	0.20	-0.04	-0.31	-4.55
Interurban-Cross	0.17	0.39	0.39	2.06	-1.81	-0.91	-0.98	0.23	-0.04	-0.31	-4.84
SMCP-DT	1.13	-0.45	2.99	7.44	-3.03	0.07	-1.91	17.28	-0.42	-2.37	-3.91
SMCP-LC	-0.62	-0.77	-1.21	-0.57	-3.04	-0.59	-2.08	17.44	-0.44	-2.50	-3.75

Table 3. Overview of results of the ASTRA model (changes against BAU in %)

Table 3 has shown the results for the final simulation year 2020. However, some of the reactions to the charging policies reveal a dynamic pattern that is changing over time. This is presented in Figure 2. The strongest short-term reaction in the policies is evoked by the allocation of revenues to reduce direct taxes. In these scenarios GDP shows a short-term peak in 2003-2004 due to the increase of private consumption. The following years two other dynamics enfold: first, exports are reduced in the scenarios that charge long distance transport such that GDP declines (2004-2007), and, second, in those scenarios that allocate revenues to investment the positive impact of these investments start to enfold after 2007 such that GDP increases again, which can be best seen with Interurban-Road and Interurban-Cross scenario that until 2007 loose about 0.7% of GDP but become positive around 2015 and finally reveal a growth of 0.2-0.4% of GDP. For employment on the right side of Figure 2 again the picture is much more diverse due to the manifold sectoral interactions.

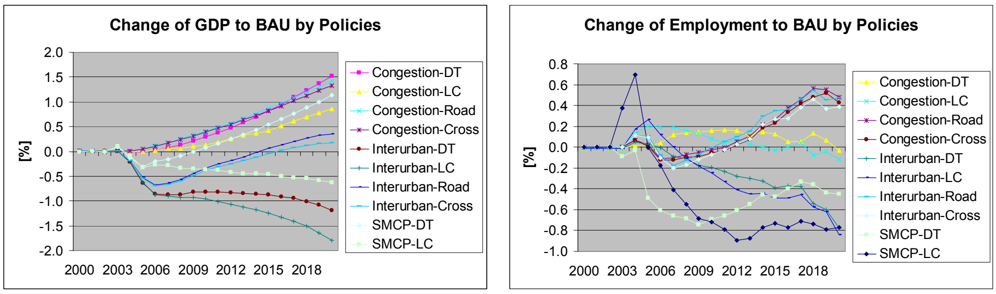

Figure 2. Dynamic development of changes to BAU over time.

3.2. Sensitivity of transport-economic linkages to policies

This section goes a bit further into the dynamics of the transport-economic interactions that shape the results for the different scenarios. The dynamics can be measured at the micro-macro bridges of ASTRA, which translate changes in micro-economic behavior into changes of macro-economic indicators. The sensitivity analysis focuses on six of these micro-macro-bridges, which have proved relevance in former analyses. For each of them a scenario run with deactivating the bridging mechanism by replacing its endogenous results with the BAU results is performed. By backward-conclusion considering the scenario results with activated mechanism the influence of transport on the economy is determined. The following micro-macro-bridges are considered:

- Transport on private **consumption** and on sectoral consumption (mineral oil products, car purchase, transport services).
- Transport on **employment**, i.e. employment in vehicle manufacturing and transport services like trains for freight forwarders.
- Transport on **exports**, i.e. impact of generalised costs on sectoral export flows.
- Transport on **intermediates** production, i.e. transport services are pre-product, of which price changes are reflected in the output or the GVA of the sectors.

- Transport on the demand for **investments** as higher demand for transport services entails investments in vehicles, tracks or terminals.
- Transport on **productivity**, i.e. freight transport as part of the production chain can influence total factor productivity (TFP) by changes in transport times.

For presentation of results the Interurban-Cross scenario with introduction of transport charges for long distance transport and allocation of revenues to investments into road and rail infrastructure is selected. Table 4 presents the results as percent changes to the results of the full Interurban-Cross scenario. A positive sign implies that the micro-macro-bridge has a negative impact on the outcome of the scenario, since excluding the mechanism leads to a more positive scenario and vice versa. The strongest positive impact on the economic development is provided by the productivity push through improved travel times, which is not only valid for this scenario, but also for most of the other scenarios. The strongest negative impact comes from the altered investment behavior in the transport sector. However, looking at the overall result of GDP change to BAU (Table 3) the final balance of all mechanisms leads to a slight growth of GDP of 0,17%.

[%] to full scenario	Impact on variable										
Link transport on:	GDP	Employ-ment	Consump-tion	Invest-ment	Export	TFP	tons	tkm	trips	pkm	CO_2
Consumption	-0.381	-0.296	-0.558	-1.106	-0.076	-0.203	-0.344	-0.211	0.057	0.015	-0.230
Employment	0.267	0.386	0.625	0.022	-0.059	0.134	0.235	0.108	0.043	0.121	0.159
Export	-0.439	-0.297	-0.576	-0.765	-1.720	-0.268	-1.035	-1.742	0.072	0.019	-0.751
Intermediates	-0.005	-0.011	0.199	0.050	-0.088	-0.113	-0.166	-0.311	0.108	0.076	-0.003
Investment	3.031	1.509	3.252	7.925	0.588	1.810	1.809	1.293	0.036	0.369	1.016
Productivity	-2.675	-0.680	-3.003	-6.081	-0.723	-2.398	-1.622	-1.287	0.091	-0.120	-0.790
Total result	0.17	0.39	0.39	2.06	-1.81	-0.91	-0.98	0.23	-0.04	-0.31	-4.84

Table 4. Sensitivity results for economic mechanisms in Interurban-Cross scenario

4. Conclusions

This paper analyses the introduction of fully-fledged transport pricing policies for the EU i.e. pricing policies that consider both the reactions within the transport system and the transfer of reactions to the economic system as well as the allocation of revenues generated. by the transport charges.

Ten policies differing in charging regime and revenue allocation method are analysed. Depending on the combination of charging regime and revenue allocation the policies can either lead to positive or negative economic results. Positive economic impacts are observed for urban congestion charges since these do not affect negatively exports while they enfold positive stimuli via the revenue allocation methods e.g. stimulating private consumption or investments. In the case of interurban tolls or SMCP oriented charges exports are always negatively affected such that a final positive economic outcome can only be achieved if further economic mechanisms are activated that counterbalance the export decrease. Most effective in this respect is the productivity growth induced by improvement of travel times e.g. by infrastructure investment and reduced congestion due to the charges. Other mechanisms that can perform this economic counterbalance are the increase of private consumption due to the tax reduction, though in some cases this remains a short-term stimulus only, or the sectoral shifts of private demand that may affect positively the employment and investment decisions e.g. if demand shifts to sectors with higher labor demand or stronger investment requirements.

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