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ROAD PRICING FOR HEAVY GOODS VEHICLES TRANSPORT: ASSESSING THE ECONOMIC IMPACT IN A DISAGGREGATED MACROECONOMETRIC MODEL

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Abstract

The paper assesses the economic impact of a toll imposed on heavy-goods vehicles proportional to distance driven. The macroeconomic impact of the toll is estimated by using the disaggregated econometric model MULTIMAC of the Austrian economy. The assumption is that all toll revenues will be invested in the network of motorways. The toll is implemented in the model by using information on transport margins from the Austrian input – output statistics. The toll is distributed among goods in different categories of use (exports, consumption, intermediate demand) and thereby increases prices of demand (but not of production). The transport input row in the input – output matrix is changed according to the price elasticities taken from the literature. The toll will raise domestic prices especially for mineral products and the oil processing industry. Due to investment of the revenues the toll will increae GDP. The number of employed will rise in line with GDP and unemployment will drop slightly. The relative price increase of domestic production and the domestic final demand increase (investment) will reduce exports and boost imports leading to a deterioration of the foreign trade balance.

JEL Codes: E17, C67, L91

Introduction

The traditional model of trade treats transport costs like the introduction of tariff and non-tariff trade barriers. Higher transport costs lead to a decline in competitive pressure and distortions in regional production patterns as well as price levels. Added to these static losses will be dynamic efficiency losses: decreasing competitive pressure lowers the incentive for enterprises to improve their effectiveness. Low transport costs and easy access to large markets facilitates the large-scale production of components and fragmentation of the value added chain, which allows even small-scale firms to obtain returns to scale. Higher transport costs hamper the construction of delivery networks for component production (for the significance of communication and transport costs s.: Harris (2001)) . The positive welfare effects of fragmentation and specialisation have been shown in the literature using the traditional Heckscher-Ohlin model (s. among others: Arndt (1998), Jones,Kierzkowski (2001)). The introduction of trade barriers like a tariff, that is redistributed in a lump sum manner has well defined negative welfare effects. These negative welfare effects can be transformed into negative income effects for income measured at world prices in a partial as well as general equilibrium setting (s.: Vousden (1990)). As the advantages of specialisation in trade are linked to the existing just-in-time deliveries based mainly on road haulage, the introduction of a toll levied on trucks may lead to macroeconomic welfare losses.

The starting point for tolls on freight transport is the account of 'public' or external costs of freight transport, which should be internalised and therefore borne by each transport system. The attempts to estimate the external costs of road freight transport in Europe (INFRAS/IWW (1995)) reveal, that not even the infrastructure costs are borne by the road transport sector via the existing taxes and tolls. For truck transport, external costs comprise the cost of road construction and maintenance, road supervision, personal injuries from accident (to the extent not covered by motor insurance), environmental damage from emissions, impaired scenery, land use change etc. In direct compensation for its external costs, the truck transport industry contributes only road taxes. A number of traffic-specific charges (mineral oil tax, vehicle tax, etc.) can be viewed as compensation for the external costs caused. Accordingly, the largest part of all the other external costs is borne by the general public. Additional taxes and tolls for road freight transport therefore can counteract existing distortions and market failures. Charging for road freight transport therefore might be seen as one measure to reduce congestion, fossil energy consumption and CO_2 emissions of the transport sector, which are expected to increase overall Europe and especially for trans-alpine flows in a 'without measures' scenario (Nijkamp, et.al. (1997)). Introducing a road freight toll for heavy goods vehicles can be seen as a domestic measure within Austria to reduce the negative external effects of road transport and therefore increase welfare. From the perspective of partial analysis the relevant issues are the expected demand reactions to the toll, that should assure the achievement of the environmental and other political targets for road transport. Price elasticities of demand as reported in Oum, et.al. (1992) play an important role in this research field.

The main arguments in the debate on road pricing therefore are the empirical estimates of external costs and its negative welfare implications on the one hand and the negative macroeconomic welfare effects of rising transport costs from the standard theoretical model on the other hand. The latter effects can even be demonstrated in the case of a lump sum redistribution of the road freight toll revenues. In empirical research we have learned from the economic evaluation of other revenue neutral economic instruments (taxes, emission permits), that their introduction has manifold impacts on the total economy, mainly depending on the form of revenue recycling.

To our awareness there exists almost no literature on the economic impact of taxing road freight and recycling the revenues. The most important and seminal study in this context is Barker, Köhler (2000). We follow their methodology as we also use a disaggregated macroeconometric model for Austria similar to their model E3ME for the European regions and carefully think about implementing all relevant changes of the road freight toll as well as of recycling the toll revenues. The analysed scenarios differ, as in our study revenue neutrality is achieved by investment in additional road infrastructure in order to decrease congestion, whereas Barker, Köhler (2000) assume revenue recycling through lowering labour taxes. Our assumption also differs from the lump sum redistribution assumption of tarrifs in the theoretical trade model (Vousden (1990)).

The paper is organized as follows. In the first section we describe the different blocks of the disaggregated macroeconometric model used for the economic evaluation comprising equations for factor demand and prices, a block describing goods demand at different stages (intermediate demand, final demand) and a block for the labour market and wage formation. In section 2 we line out, how the road freight toll is implemented in the model taking into account the different impact channels such as the price system, the demand for freight activities of other industries and the infrastructure investment out of the toll revenues. Empirical results from model simulations until 2010 are presented in section 3. The final section draws some conclusions from the analysis.

1. MULTIMAC: A Disaggregated Macroeconometric Model

MULTIMAC is an input – output based macroeconomic model at a medium aggregation level of 36 industries, that combines econometric functions for goods and factor demand, prices, wages and the labour market with the input-output accounting framework. A full description of the current version of MULTIMAC can be found in Kratena, Zakarias (2001). The model is oriented along the same lines as other large scale macroeconomic input-output based models like the INFORUM model family (Almon (1991)) and the European multiregional model E3ME (Barker, et. al. (1999)). In the model we have tried to combine the advantages of econometric techniques with consistent microeconomic functional forms and to use specifications derived from well known microeconomic concepts. Input – output analysis plays an important role at the price side as well as on the goods demand side and in both cases the phenomenon of changing input – output structures is treated with.

1.1.Factor Demand and Prices by Industry

Factor demand is explained in the framework of an extended Generalized Leontief-cost function (s.: Morrison (1989, 1990), Conrad - Seitz (1994) and Meade (1998) for the US INFORUM model). The variable factors are the inputs of intermediate demand of an industry, V, with price p_v and labour input L with wage rate w, and a deterministic trend t representing technical progress. The price p for gross output QA is determined by a constant mark up μ on variable costs as in Conrad and Seitz (1994), which corresponds to the model of monopolistic competition in the markets. Starting point is the (short term) cost function for variable costs G:

(1) $$G = QA\left[\sum_i \sum_j \alpha_{ij}\left(p_i p_j\right)^{1/2} + \sum_i \gamma_{it} p_i t^{1/2} + \sum_i \gamma_{tt} p_i t\right],$$

with p_i, p_j as the input prices of the variable factors.

Applying Shephard's Lemma to the cost function one derives factor demands in terms of optimal input coefficients :

(2) $$\frac{V}{QA} = \alpha_{VV} + \alpha_{VL}\left(\frac{w}{p_V}\right)^{1/2} + \gamma_{Vt} t^{1/2} + \gamma_{tt} t\ ,$$

(3) $$\frac{L}{QA} = \alpha_{LL} + \alpha_{VL}\left(\frac{p_V}{w}\right)^{1/2} + \gamma_{Lt} t^{1/2} + \gamma_{tt} t\ .$$

Marginal costs $\partial G/\partial X$ for our case are given as:

(4) $$\partial G/\partial QA = \alpha_{VV}p_v + \alpha_{LL}w + 2\alpha_{VL}(p_v w)^{1/2} + \gamma_{vt}p_v t^{1/2} + \gamma_{Lt}wt^{1/2} + \gamma_{tt}(p_v + w)t$$

which yields the following output price equation applying the fixed mark up μ :

(5) $$p = [1 + \mu]\ [\alpha_{VV}p_v + \alpha_{LL}w + 2\alpha_{VL}(p_v w)^{1/2} + \gamma_{vt}p_v t^{1/2} + \gamma_{Lt}wt^{1/2} + \gamma_{tt}(p_v + w)t\ ].$$

Estimation results for the system of equations – composed of (2), (3), and (5) and results for own and cross price elasticities of factor demand are documented in Kratena, Zakarias (2001). The price of intermediate demand an industry faces is determined by the output prices of the other industries in the home country and abroad as described in the traditional input – output price model. The input coefficient along the column of an industry (V_i/QA_i), is modelled with the help of the Generalized Leontief – function (equation (2)) and equals the total of the two column sums for *i* of technical coefficient matrices (derived from input – output tables) for domestic and imported goods (**A(d)** , **A(m)**). From this traditional price model we can write the intermediate input coefficient at current prices ($\mathbf{p_v V/QA}$) as a matrix multiplication of a row vector of domestic prices **p** and a row vector of import prices $\mathbf{p_m}$ with **A(d)** and **A(m)** to get the row vector $\mathbf{p_v V/QA}$:

$$(6) \qquad (\mathbf{p_v V/QA}) = (\mathbf{p_m\, A(m)} + \mathbf{p\, A(d)})$$

In analogy to that we can introduce the input – output level of disaggregation in the factor demand equations by treating the column sum **V/QA** as a bundle of n inputs. Assuming a constant structure for the n inputs within **V/QA** given by matrices **Z** with elements Vji/Vi each for domestic (d) and imported (m) inputs, $\mathbf{p_v}$ becomes:

$$(7) \qquad \mathbf{p_v} = (\mathbf{p_m\, Z(m)} + \mathbf{p\, Z(d)})$$

Equation (7) solves exactly for the input – output years, in other years the price index of National Accounts for $\mathbf{p_v}$ may deviate from the value calculated with (7) using fixed matrices of the base year for **Z(m)** and **Z(d)**. This difference is bridged by simple equations linking the two price indices.

1.2 Goods Demand

The total goods demand vector **Q** is made up of the imports vector **M** and the vector of domestic output **QA**[1]**.** The input – output definition of the commodity balance is:

(8) $\mathbf{Q} = \mathbf{QA} + \mathbf{M} = \mathbf{QH} + \mathbf{F}$

where **QH** is the intermediate demand vector and **F** is the final demand vector. The final demand vector **F** is the sum of a vector of private consumption, **C**, a vector of gross capital formation, **I**, as well as a vector of exports, **EX,** and a vector of public consumption, **G**:

(9) $\mathbf{F} = \mathbf{C} + \mathbf{I} + \mathbf{G} + \mathbf{EX}$

Exports are calibrated with an implicit price elasticity of *–1* and public consumption is exogenous, whereas private consumption, gross capital formation and imports are modelled by econometric equations.

[1] MULTIMAC IV makes no distinction between industries and commodities (although Austrian input – output statistics does), but includes a row for transfers to take into account non-characteristic production by industries.

1.2.1 Intermediate Demand

Introducing the technical coefficients matrix **A** (the sum of domestic and imported elements), and splitting all matrices and vectors into an energy (e) and a non-energy (ne) part, the commodity balance for non-energy therefore becomes:

(10) $$\mathbf{Q_{ne}} = \mathbf{A_{ne}} * \mathbf{QA} + \mathbf{F_{ne}}.$$

The technical coefficients matrix $\mathbf{A_{ne}}$ comprises the non-energy input in non-energy sectors as well as the non-energy input in energy sectors; **QA** therefore is the total output vector (energy and non-energy). The original matrix of technical coefficients in the current version stems from the 1990 input – output table of Austria and technical change in matrix **A** has to be considered. This includes at a first stage changes along the column as described above. Once the total input coefficient **V/QA** is determined, the sum of non-energy inputs (along the column) is given by:

(11) $$\sum a_{ne} = V/QA - \sum a_e ,$$

where technical change in the sum of energy inputs $\sum a_e$ is described in an energy model.

Technical change in the input – output structure ‘along the row’ is further introduced by a method based on Conway (1990) and Israilevich et.al. (1996). Given the availabilty of data for the goods structure of non-energy final demand ($\mathbf{F_{ne}}$) and non-energy imports ($\mathbf{M_{ne}}$) in the input-output classification the actual vector of intermediate demand can be calculated:

(12) $\mathbf{QH_{ne} = QA_{ne} - F_{ne} + M_{ne}}$.

On the other hand a series of 'hypothetical' intermediate demand (vector) for the non-energy sectors ($\mathbf{QH_{ne,t}^{H}}$) assuming constant coefficients in $\mathbf{A_{ne}}$ according to the 1990 input-output table can be calculated (introducing time subscripts):

(13) $\mathbf{QH_{ne,t}^{H} = A_{ne,90} * QA_{t}}$.

Note that $\mathbf{QH_{ne,t}^{H}}$ as computed by (13) will by definition be equal to $\mathbf{QH_{ne,t}}$ in the year 1990.

The adjustment process between actual and 'hypothetical' intermediate demand is described by econometric equations, that estimate a linear or log-linear relationship between $\mathbf{QH_{ne,t}}$ and $\mathbf{QH_{ne,t}^{H}}$.

1.2.2 Final Demand

Disadggregated partial models for private consumption, investment and imports complement the demand side of MULTIMAC IV.

Private Consumption

The consumption model combines single equation specifications with system estimation. The groups modelled via single equations comprise *Gross Rent and Water* (3), *Transport* (4), *Heating* (8), and *Furniture* (9).The energy categories *Transport* and *Heating* are determined in an energy model like the energy input coefficient in (11). Furniture is seen as a durable good and described by an investment function.

The remaining fraction of total expenditure (after deduction of expenditure on the first 4 groups) is distributed among the remaining categories via an Almost Ideal Demand System (AIDS, s.: Deaton and Muellbauer (1980)) with total expenditure for the AIDS (denoted as CNAIDS) as a residual:

(14) CNAIDS = CN – CN3 – CN4 – CN8 – CN9.

where CN_i is consumption at current prices. The well known budget share equations of AIDS are:

(15) $$w_i = \alpha_0 + \sum_{j=1}^{n} \gamma_{ij} \ln p_j + \beta_i \ln\left(\frac{CNAIDS}{P^S}\right)$$

where w_i denotes the budget share of good i, p_j is the price of good j and CNAIDS as above. The Stone price – index, P^S, approximates the original price index from the 'translog – function part' of AIDS by $\ln P^S = \sum_k w_k \ln p_k$. Approximated expenditure and price elasticities are derived following Green and Alston (1990) and Alston et. al. (1994). The 9 main consumption categories are linked with the 37 industry structure of private consumption using a bridge matrix. The total sum of **CR** is given by an aggregate consumption equation with disposable household income as explaining variable:

(16) $\Delta CR_t = (\Delta(YD_t/PC_t), ECM)$

where ECM denotes an error correction mechanism.

Gross Investment

The model uses capital stock data by industry i ($K_{i,t}$) given by the accumulation identity with given depreciation rates (δ) within industries and gross investment $J_{i,t}$ as:

$$(17) \quad K_{i,t} - K_{i,t-1} = J_{i,t} - \delta K_{i,t-1}.$$

Capital accumulation is described by *stock adjustment* – models, where the actual capital stock adjusts to some 'desired' or 'optimal' capital stock (s.: Egebo, et.al. (1990)). The general *stock adjustment* – model in log-linear form can be written as:

$$(18) \quad \log(K_{i,t}) - \log(K_{i,t-1}) = \tau_1 [\log K^*_{i,t} - \log K_{i,t-1}] + \tau_2 [\log K_{i,t-1} - \log K_{i,t-2}].$$

with the necessary condition $\tau_1 > 0$. The desired capital stock could result from including a fixed factor capital in the Generalized Leontief - functions described in section 2.1 above, whenever *user costs* of capital are given.. In the current version of MULTIMAC IV K* depends on the current level of output only: $\log(K^*_{i,t}) = F[\log QA_{i,t}]$. Inserting K* into (18) above yields the stock adjustment equation:

$$(19) \quad \log(K_{i,t}) - \log(K_{i,t-1}) = \alpha_K + \gamma_K \log(QA_{i,t}) - \tau_1 \log(K_{i,t-1}) + \tau_2 (\log(K_{i,t-1}) - \log(K_{i,t-2}))$$

Investment by industry is as in the case of consumption categories transformed into investment by investment goods at the level of 36 industries by a bridge matrix.

Imports

Total demand for the goods of an industry *i* is split up into a domestic and an imported component by an AIDS import demand system as described in Anderton, Pesaran and Wren-Lewis (1992). The shares are given as:

(20) $$\frac{MN_i}{QN_i} = \alpha_m + \gamma_{md} \log p_i + \gamma_{mm} \log p_{m,i} + \beta_m \log\left(\frac{QN_i}{PQ_i}\right) + \mu x$$

(21) $$\frac{QAN_i}{QN_i} = \alpha_d + \gamma_{dm} \log p_i + \gamma_{dd} \log p_{d,i} + \beta_d \log\left(\frac{QN_i}{PQ_i}\right) + \mu x \,.$$

The fraction of imports of good *i* in total demand of that good is explained by both the domestic (p_i) and imported price ($p_{m,i}$), the proportion of total demand of *i* (QA_i) and an composite price index PQ_i, as well as a variable x which shall capture the gap between the individual level of the demand function (on which the cost and utility functions of the AIDS are based) and the actual empirical level of market demand functions, which are observed by the data (see Cooper and McLaren (1992) and Kratena and Wüger (1999)). Here, we chose a measure of the openness of the economy as a proxy for a larger variety of goods from different sources that are available all over the world. This ‘openness variable’ is approximated by the share of total exports in total output (x).

1.3 Labour Market and Wages

The seminal work for disaggregated labour markets is Layard, Nickell, Jackman (1991). The model outlined here differs from the Layard, Nickell, Jackman model (1991) by explicitly defining sectoral labour demand for each sectoral output level given by functions for final demand, intermediate demand and imports. Concerning labour mobility between the sectors the Layard, Nickell, Jackman (1991) study introduces costly movement between the labour market segments in a Harris, Todaro model of migration between the sectors. More recent studies on migration reject the Harris, Todaro assumption of equilibrium zero net migration and assume an equilibrium *stock* of migrants (Hatton (1995), Boeri and Brücker (2000)). For each expected income differential a certain percentage of the total labour force is willing to migrate. The labour force in each segment can then be seen as comprising one constant part given by pure labour supply effects and one part of migrant stock from other labour market segments, which reacts to expected income differentials. The distribution of the total labour force among segments is therefore composed by a constant, an elasticity of sectoral labour forces to total labour force and the wage differential elasticity:

(22) $LF_i/LF = a_1 + a_2 \log(LF) + a_2 \log(w_i/w)$

where w is the total wage rate. The labour market segments are derived by aggregating the 36 industries of MULTIMAC into 3 industries with different average skill levels (high skilled, medium skilled, low skilled). The data base for this aggregation procedure is the industries * occupations employment matrix for the year 2000 using the correspondence of highly aggregated ISCO occupation groups with skill levels. The treatment of labour force by industry allows us to work with unemployment rates by industries, ur_i, : $ur_i = (LF_i - L_i) / LF_i$. Total participation of the labour force in total population in working age is a function of total economic activity as measured by total output and/or employment and the overall real wage rate (as in E3ME (Barker, et. al. (1999))). As in E3ME male and female labour force participation are treated separately.

Union wage bargaining equations complement the model, which are again specified similar to E3ME (Barker, et.al. (1999)). Wage formation in the labour market segments depends on consumer price changes, ΔPC, on productivity changes, $\Delta(QA_i/L_i)$, and on the level as well as on changes in the sectoral unemployment rate. The latter variables measure the influence of labour market performance in the target function of unions. The wage rates for the 36 industries are further explained in terms of the wage rate of the skill category industry to which they belong.

(23) $\Delta\log(wr_i) = a_1 + a_2\,\Delta\log(PC) + a_3\,\Delta\log(QA_i/L_i) + a_4\,\Delta\log(ur_i) + a_5\,\log(ur_i)$

(24) $\Delta\log(wr_j) = a_1 + a_2\,\Delta\log(wr_i) + a_3\,\Delta\log(QA_j/L_j)$

with *j* as 36 industries and *i* as the 3 skill category industries.

2. Model Implementation of Road Pricing

Road pricing represents an increase in transport costs in all demand categories. Starting point for its implementation are therefore the statistics on freight transport and transport margins data, which have been collected by Statistics Austria to construct the Austrian input – output table 1995.[2] Transport margins are levied on producer prices (together with trade margins) in order to arrive at consumers prices. The demand components we distinguish for transport margins by each commodity are: (i)intermediates (aggregate to all other industries), (ii)exports and (iii)other final demand (aggegate of private consumption, gross investment and public consumption). Accounting for the difference between producer and consumer prices we can rewrite the commodity balance of equation (8) for a good *i* by:

$$(25) \quad p_i\, QA_i + p_{M,\,i}\, M_i + T_i + H_i = p_{X,\,i}\, X_i + p_{QH,\,i}\, QH_i + p_{F,\,i}\, F_i\ ,$$

where *T* are transport margins and *H* are trade margins and all *p* are prices. Final demand is split now into exports and other final demand, represented by *F*. The prices are consumer prices on the right hand side of (25) and producer prices on the left hand side. Actually the model does not deal with margins in the detailed method laid down in equation (25). For the components of final demand (consumption, investment, exports) margins are introduced, when converting variables from national account categories to input – output industries and for intermediate demand all margins on the different goods are simply aggregated into the corresponding transport activities. The costs of transport for the different industries are integrated into the rows of transport activities of the input – output matrix. The implementation of the first round price effects of road pricing must therefore be carried out by changing exogenously the constants of price equations or directly prices.

The data set of transport margins from the input-output-statistics of 1995 not only comprised total transport margins (T_i), but allowed to differentiate between intermediates, exports and other final demand for each commodity *i* :

(26) $T_i = T_{X,\,i} + T_{QH,\,i} + T_{F,\,i}$.

These margins can now be directly added to the respective demand components thereby showing the bridge between producer and consumer prices. Introducing a toll on heavy goods vehicles transport is implemented as a change in these margins applying an extra ‚toll margin'. The differentiation of transport margins by demand components *for each good i* allows to take into account different ‚toll margins' for the same good depending on the demand component it is delivered to (for example steel products delivered to domestic investment incur a different price effect by road pricing than steel products exported). The impact of the toll on transport costs is by this procedure translated into an increase in consumer prices $p_{X,\,i}$, $p_{QH,\,i}$ and $p_{F,\,i}$ in equation (25). The impact on final demand prices ($p_{X,\,i}$, $p_{F,\,i}$) is directly implemented, the impact on intermediates by good *i* ($p_{QH,\,i}$) has to be converted to an increase in the intermediates prices by user industry . [3] This is done using equation (7) for given domestic and import intermediate price effects. The resulting change in the total intermediate price of an industry ($\Delta p_{v,i}$) induces substitution between intermediates and labour according to the factor demand parameters. Transport costs therefore have a direct impact on the organisation of the value added chain in the model.

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[2] We are heavily indebted to Erwin Kolleritsch from statistics Austria for supplying us with an excellent data set of transport margins.

Additionally we have to take into account the impact of road pricing on transport demand of firms. Partly road transport will be substituted by rail transport, partly it will be reduced in absolute terms. Transport demand is not explicitly modelled in MULTIMAC, but we apply the method lined out in Barker,Köhler (2000), where transport demand effects of road freight are implemented by changing the ‚transport row' of the input – output matrix. That applies to the matrix of technical coefficients as well as to the transport components of exports and other final demand. As Barker,Köhler (2000) we rely on Oum,Waters,Yong (1992) for price elasticities of transport demand. The reported elasticities for road transport range from *–0.52* to *–1.55* for different goods, the aggregate elasticity (for all goods) is *–0.69*. For our study we can assume considerable substitution effects between road and rail transport. On the other hand due to data availability in NACE classification road and rail transport are aggregated in our model within one land transport sector. Therefore we assume elasticities for the total transport sector to lie at the lower bound of the range: for intermediates: *-0.3,* for other final demand *–0.5* and for exports *–0.2* .

The revenues from heavy goods vehicles pricing (at constant prices) are introdouced as a new endogenous variable in the model, directly linked to the transport activities induced by the different demand categories. We assume that the sum of these (endogenous) revenues are invested in road infrastructure, thereby increasing the respective part of the final demand vector (road investment). This procedure guarantees 'ex post' revenue neutrality of road pricing.

[3] Note that applying one unique price impact for intermediates ‚along the input-output row' implicitly assumes that the impact is invariant from the industry that buys the respective good.

3. Results

A toll levied on trucks will increase the cost of road transport. At a rate of 25 cents per vehicle kilometre of a 4-axle truck, the cost of transports on motorways would go up by some 35 percent. Altogether, transport costs make up some 2 percent of the overall costs of goods. The economic impact of road pricing will thus be quite minor, but some sectors of the economy will show a considerable impact.

Tolls levied on internal and import transports (hauling industry and own transports) will as described in the last section be felt by the intermediate inputs and final domestic demand. The total toll margin from road pricing on these two demand categories will make up € 300.5 million, or about 29 percent of the value of services rendered by the hauling industry (truck transport margin) for these two demand categories. With regard to exports, the toll margin accounts for € 37.6 million, which makes up a smaller part of the value of services rendered by the hauling industry for goods exports. The toll margin by goods categories is calculated using data on road haulage by goods categories (NSTR categories) and transport purposes as well as transport margins data from the 1995 input-output table. In this calculations we take into consideration, that tolls will be levied only on priority roads. The toll margin makes up € 193.5 million for intermediate demand inputs, € 107.0 million for final demand, and € 37.6 million for exports.

Table 1: Total toll margins,1995

Of the total toll margin of € 338.1 million, about 21 percent apply to 'Non-metallic Mineral Products', 12 percent to 'Food and Tobacco', almost 10 percent to 'Manufacturing of Refined Petroleum Products' and 9 percent to the 'Ferrous&Non-Ferrous Metals' sector (Table 1).

The first direct impact of road pricing for heavy goods vehicles is an increase of domestic prices, partly directly via transport costs of final demand components (consumption, exports), partly indirectly via transport costs for intermediate inputs of industries. Consumer prices increase by 0.2 percent, the deflator of total exports also slightly increases (Table 2, all impacts are described as changes from a baseline without road pricing). These price changes in consumption and exports exert further influence on real disposable income of households as well as competitiveness and substitution effects between single goods within the demand categories due to changes in relative prices.

Table 2: Impact of road pricing on goods prices

The largest price increases of domestic prices as a consequence of road pricing exhibit the industries 'Non-metallic Mineral Products' , 'Manufacturing of Refined Petroleum Products' and 'Timber&Wood'. The smallest price increases are found in the industries 'Office Machines', 'Electrical Goods' and the industry 'Other Manufactures' (comprising furniture and mechanical and optical instruments).

Firms face an increase in the price index of all intermediate inputs, which has a twofold impact on performance in different industries. On the one hand the cost push cannot be passed on fully to output prices in a competitive international environment and on the other hand intermediate inputs (both domestic and imported) are partly substituted by value added (labour) in an industry leading to a slowdown of fragmentation of production processes. This impact can be seen as the distortion of higher transport costs compared to the 'free trade' case according to the theoretical model of trade. Actually this only holds for the imported part of intermediate inputs. We do not differentiate between imported and domestic intermediate inputs at the level of factor demand, so that the slowdown of fragmentation of production processes only partly has implications for external trade.

As laid down above, we assume that revenues from road pricing are fully reinvested in road infrastructure (revenue neutrality) thereby boosting domestic investment. This is a clear difference to the lump sum redistribution assumption of the theoretical model, but also to the assumption of revenue recycling via lower labour costs as in Barker, Köhler (2000). The decrease of transport activities and the output of the domestic transport sector also has multiplier effects on other industries given the input – output structures.

Table 3: Macroeconomic impact of road pricing

The macroeconomic effects can be mainly described as a demand shift between final demand categories, where a slight decrease of exports is accompanied by a small increase in private consumption and a much larger increase of gross capital formation (Table 2). The slightly positive net impact on consumption reveals, that positive multiplier effects of road infrastructure investment outweigh the negative effects of higher consumer prices on real disposable incomes. These multiplier effects in the spirit of the 'Haavelmo' theorem are based on the shifting of resources from disposable household income (affected by price effects) to investment, where part of the lost household income would have been saved. Besides this macroeconomic mechanism the 'Haavelmo' effect of our scenario is based on the different factor intensities of the industries affected by the resource shifting. Imports are increased due to the demand effects and by the worsening of competitivenes of domestic goods compared to imports.[4] The decrease in exports compared with an increase in imports leads to a worsening of the external trade balance. In general the impact on output by industries mirrors the demand shift between the different final demand categories (private consumption, exports, gross capital formation) as well as the demand reactions in intermediate inputs. GDP slightly increases due to the positive impact of road infrastructure investment, the construction sector

[4] Import prices are assumed to remain constant, as they only increase in the (negligible) proportion of the Austrian highway transport cost component in the total price of the imported product. Domestic firms face an increase in their transport costs levied on the production of all their goods.

output increases considerably. Demand as well as domestic output decrease in the following industries: 'Chemicals', 'Textiles,Clothing&Footwear', 'Rubber&Plastic Products', 'Ferrous&Non-Ferrous Metals', 'Non-metallic Mineral Products' as well as in the Transport sectors (Table 3).

Table 4: Impact of road pricing on output by industries

The impact on employment by industry slightly differs from the output effects regarding the sectoral structure. The main influence on employment besides the output change stems from changes in the gross wage rate. Introducing road pricing increases consumer prices and the road infrastructure investment also increases the price level, both exerting upward pressure on the wage rate. Another influence on the wage rate comes from the labour market, where a decrease in sectoral unemployment rates has a positive impact on wages in the underlying bargaining model. In some industries therefore positive changes in output are accompanied by negative changes in employment due to substitution effects induced by the wage rate increaes. This effect counteracts the substitution towards labour induced by an increase in the price of intermediates.

Table 5: Impact of road pricing on employment by industries

The impact on the labour market is characterised by a decrease in unemployment smaller than the employment effect due to labour force reactions. These labour force reactions gain importance during the simulation period (up to 2010). The employment as well as labour force effects differ between the labour market segments. The long term total decrease in the unemployment rate is 0.2 percent, for low skill labour the unemployment rate drops by 1.2 percent.

Table 6: Impact of road pricing on the labour market

Conclusions

The impact of road pricing has been analysed using an input – output based macroeconomic model at a medium aggregation level of 36 industries (MULTIMAC). The model incorporates important features of CGE models using consistent microeconomic functional forms, but is based on econometric estimation and solved without 'equilibrium constraints'. Concerning the production patterns along the value added chain the model treats intermediate demand and labour as substitutes, so that outsourcing is driven by the relative price of intermediates (compared to labour).

The introduction of a toll on truck transport increases transport costs leading to price effects according to the distribution of these additional transport costs among demand categories and goods. The main impacts are a decrease in demand, especially of transport services and a substitution between intermediate inputs and labour. As far as imported intermediates are concerned domestic value added increases at the expense of imports. In general the impact of the toll represents the picture of the textbook model: welfare losses through price increases associated with a shift to more expensive and less productive resources. The textbook model would predict this outcome even in the case of a lump sum redistribution of the toll, although the redistribution would counteract the negative impact. In our case (which is relevant for Austria) the toll revenues are redistributed via investment in road infrastructure. For this case we find a net positive impact on GDP and the labour market, as the multiplier effects outweigh the negative effects of higher transport costs ('Haavelmo' effect). The decrease in road transport services leads to a decrease in external costs (not quantified in this study), which should have a positive impact on welfare.

Table 1: Toll margins, 1995

	Tollmargin	
	Million €	Percentage shares
Agriculture, Forestry and Fishing	22.5	6.6
Mining of Coal and Lignite	2.8	0.8
Manufacture of Refined Petroleum Products	32.8	9.7
Ferrous and Non Ferrous Metals	31.4	9.3
Non-metallic Mineral Products	69.5	20.6
Chemicals	22.5	6.7
Metal Products	10.2	3.0
Agricultural and Industrial Machines	20.7	6.1
Office Machines	1.2	0.3
Electrical Goods	8.0	2.4
Transport Equipment	15.6	4.6
Food and Tobacco	41.5	12.3
Textiles, Clothing and Footwear	13.9	4.1
Timber and Wood	13.4	4.0
Paper, Pulp	11.3	3.4
Printing Products	2.6	0.8
Rubber and Plastic Products	11.0	3.3
Recycling	0.8	0.2
Other Manufactures	6.5	1.9
Total	338.1	100.0

Source: WIFO calculations.

Table 2: Impact of road pricing on goods prices

	Difference from "baseline" in percent	
	2004	2010
Agriculture, Forestry and Fishing	+0.24	+1.39
Manufacture of Refined Petroleum Products	+0.63	+0.63
Ferrous and Non Ferrous Metals	+0.23	+0.22
Non-metallic Mineral Products	+0.77	+0.88
Chemicals	+0.36	+0.44
Metal Products	+0.23	+0.31
Agricultural and Industrial Machines	+0.27	+0.45
Office Machines	+0.10	+0.30
Electrical Goods	+0.16	+0.29
Transport Equipment	+0.22	+0.32
Food and Tobacco	+0.28	+0.70
Textiles, Clothing and Footwear	+0.23	+0.49
Timber and Wood	+0.37	+0.53
Paper, Pulp	+0.34	+0.39
Printing Products	+0.22	+0.33
Rubber and Plastic Products	+0.25	+0.35
Other Manufactures	+0.09	+0.23
Total consumer prices	+0.20	+0.74

Source: WIFO calculations.

Table 3: Macroeconomic impact of road pricing

	Difference from baseline in percent	
	2004	2010
Private consumption	+ 0.15	+ 0.51
Gross investment	+ 0.65	+ 0.75
Export	– 0.07	– 0.07
Final demand	+ 0.17	+ 0.34
Import	+ 0.17	+ 0.38
GDP, constant prices 1995	+ 0.15	+ 0.30

Source: WIFO calculations.

Table 4: Impact of road pricing on output by industries

	Difference from baseline in percent	
	2004	2010
Agriculture, Forestry and Fishing	+ 0.04	+ 0.22
Mining of Coal and Lignite	± 0.00	± 0.00
Extraction of Crude Petroleum and Natural Gas	± 0.00	± 0.00
Manufacture of Refined Petroleum Products	± 0.00	± 0.00
Electricity, Steam and Hot Water Supply	± 0.00	± 0.00
Collection, Purification and Distribution of Water	+ 0.08	+ 0.36
Ferrous and Non Ferrous Metals	– 0.21	– 0.19
Non-metallic Mineral Products	– 0.09	– 0.03
Chemicals	– 0.45	– 1.05
Metal Products	+ 0.04	+ 0.08
Agricultural and Industrial Machines	± 0.00	+ 0.18
Office Machines	+ 0.16	+ 0.41
Electrical Goods	– 0.03	+ 0.01
Transport Equipment	– 0.04	+ 0.07
Food and Tobacco	± 0.00	+ 0.04
Textiles, Clothing and Footwear	– 0.29	– 0.68
Timber and Wood	+ 0.03	+ 0.12
Paper, Pulp	– 0.17	+ 0.03
Printing Products	+ 0.18	+ 0.71
Rubber and Plastic Products	– 0.23	– 0.49
Recycling	± 0.00	+ 0.00
Other Manufactures	+ 0.02	+ 0.12
Construction	+ 0.90	+ 1.06
Distribution	+ 0.17	+ 0.53
Hotels and Restaurants	+ 0.36	+ 1.31
Inland Transport	– 0.22	– 0.22
Water and Air Transport	– 0.05	± 0.00
Supporting and Auxiliary Transport	– 0.13	– 0.22
Communications	+ 0.36	+ 1.30
Bank, Finance and Insurance	+ 0.15	+ 0.61
Real Estate	+ 0.07	+ 0.26
Software and Data Processing	+ 0.08	+ 0.40
R&D, Business Services	+ 0.27	+ 0.58
Other Market Services	+ 0.19	+ 0.73
Non-market Services	+ 0.07	+ 0.26
Total	+ 0.13	+ 0.35

Source: WIFO calculations.

Table 5: Impact of road pricing on employment by industries

	Difference from baseline in percent	
	2004	2010
Agriculture, Forestry and Fishing	– 0.03	– 0.12
Mining of Coal and Lignite	– 0.44	–
Extraction of Crude Petroleum and Natural Gas	± 0.00	± 0.00
Manufacture of Refined Petroleum Products	± 0.00	± 0.00
Electricity, Steam and Hot Water Supply	– 0.01	– 0.10
Collection, Purification and Distribution of Water	+ 0.07	+ 0.32
Ferrous and Non Ferrous Metals	+ 0.12	+ 0.12
Non-metallic Mineral Products	– 0.04	– 0.14
Chemicals	– 0.42	– 1.09
Metal Products	+ 0.14	+ 0.02
Agricultural and Industrial Machines	+ 0.04	– 0.23
Office Machines	– 0.44	–30.76
Electrical Goods	– 0.02	– 0.56
Transport Equipment	– 0.03	– 0.82
Food and Tobacco	– 0.03	– 0.09
Textiles, Clothing and Footwear	– 0.36	– 2.15
Timber and Wood	+ 0.04	± 0.00
Paper, Pulp	– 0.16	– 0.23
Printing Products	+ 0.05	– 0.03
Rubber and Plastic Products	– 0.23	– 0.49
Recycling	– 0.04	– 0.09
Other Manufactures	+ 0.05	– 0.24
Construction	+ 0.94	+ 0.88
Distribution	+ 0.14	+ 0.18
Hotels and Restaurants	+ 0.34	+ 1.25
Inland Transport	– 0.21	– 0.23
Water and Air Transport	– 0.06	– 0.11
Supporting and Auxiliary Transport	– 0.20	– 0.62
Communications	+ 0.02	+ 0.09
Bank, Finance and Insurance	+ 0.13	+ 0.34
Real Estate	+ 0.02	+ 0.07
Software and Data Processing	+ 0.04	– 0.13
R&D, Business Services	+ 0.29	+ 0.61
Other Market Services	+ 0.38	+ 0.73
Non-market Services	+ 0.07	+ 0.24
Total	+ 0.17	+ 0.28

Source: WIFO calculations.

Table 6: Impact of road pricing on the labour market

	Difference from baseline in percentage points	
	2004	2010
Unemployment rate, total	– 0.16	– 0.20
High skill	– 0.12	– 0.03
Medium skill	– 0.23	– 0.05
Low skill	– 0.01	– 1.21
	Difference from baseline in thousand	
Labour force	+ 0.3	+ 3.0
Unemployment	– 5.4	– 7.1
Employment	+ 5.7	+ 10.1

Source: WIFO calculations.

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