ECONOMIC IMPACTS OF THE INTRODUCTION OF THE GERMAN HGV TOLL SYSTEM – AN APPLICATION OF THE INPUT-OUTPUT TECHNIQUE

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Abstract

When the German Parliament decided in September 2000 to introduce a heavy goods vehicle (HGV) toll system for the German motorways, the decision process has been accompanied by vivid discussions about the economic effects of this toll. Though the toll of 0.15 €/km is raised for trucks only, the discussion has been stamped by the fear of an additional burden for the already poor performing German economy.

The paper at hand is subdivided into two main parts. The first section discusses the German HGV toll in further detail with a focus on the calculation of the charges. It is followed by an analysis of the macroeconomic impacts induced by the toll. Based on a 69 sector input-output model for the German economy, particularly potential undesirable price increases are calculated. However, if the revenues, which result from the toll, re-enter the economic circle higher demand may cause positive macroeconomic effects. While the price effects are calculated with the help of a supply-driven input-output model, employment effects result from the application of the classical input-output model.

Keywords: German HGV toll system; Macroeconomic impacts; Input-output
Topic area: B7 Input-Output System and Transportation

1. The German HGV toll system

1.1. Background

Until 1995 any type of vehicle could have used German motorways free of charge. Then, in 1995, Germany joined the Eurovignette-System, which collects fees for the usage of motorways in a couple of EU Member States via time-variant vignettes for HGV over 12t gross vehicle weight (GVW). In its final amendment of June 1999 the fees were set variable with the number of axles and the emission standard of the vehicles. Table 1 shows the maximum charges and the price structure of an annual vignette as contained in annex II of the directive.

Table 1: Maximum annual charges in Euro of the Eurovignette according to EC (1999)

Vehicle configuration	Exhaust Emission Standard		
	Non-EURO	EURO-I	EURO-II and cleaner
Up to 3 axles	960	850	750
4 and more axles	1550	1400	1250

Besides these time-related fees, Directive 1999/625/EC promotes the introduction of distance-based tolls for heavy goods vehicles. Based on this regulation and driven by the scarcity of public funds, the German government has set in a governmental commission for the financing of transport infrastructure in 2000. The commission's final report of September 2000 (Paellmann 2000) has recommended to replace the tax-financing of the federal road system by a user charge system. It was recommended to raise charges in a first step only for HGVs over 12t GVW on motorways and to extend the charging system to light vehicles in the future. Based on the calculations of transport infrastructure costs by the German Institute for Economic Research (DIW) and on reports of the Federal Ministry for Transport, Building and Housing concerning financing gaps in road maintenance, the commission has estimated a charge level of roughly 15 Euro-Cent per km for HGVs. Thereof 2.5 Euro-Cent/km are assumed to be already paid via the mineral oil tax. Thus, the effective price increase of road haulage was recommended to be 12.5 Euro-Cent/km for HGVs on motorways.

The federal government was ready to follow the main recommendations of the Paellmann-Commission and decided in August 2001 to introduce an electronic fee collection system on German motorways. The start of the system was scheduled for August 2003. However, due to massive technical and organizational difficulties the definite starting date is still not clear yet. The problem for the German government is not only the missing income from the toll system, but also the non-availability of the revenues from the Eurovignette-system, since the participation has been cancelled out from September 2003 on.

The tariffs for the planned HGV charge have been calculated by the Prognos AG (Basle) in collaboration with the University of Karlsruhe (Prognos/IWW 2002). Details of the calculation model and its results are presented in the following sub-section.

1.2. Calculation of the charge level

The predominant objective of the road infrastructure cost allocation study developed by Prognos and IWW is to derive fair and efficient user charges for the different vehicle categories using the federal roads. In this sense it is oriented to decision-making and to future application, from which is followed that it can not be based on a purely historical cost accounting exercise. The charges, which are derived from infrastructure costing, should provide sufficient income that would make an independent federal road company (or agency) financially sustainable in the long run. This implies that all costs, including capital costs, are recovered, taking into account that future reinvestment cycles, new investment and current expenditures, which are necessary to keep the network in good quality conditions and capable to take up the forecasted demand, are taken into account.

Against the background of the recommendations of the Paellmann-Commision (Paellmann 2000), which are strongly in favor of establishing an independent federal road infrastructure company (or agency), Prognos/IWW have started from the assumption that a public enterprise will be responsible for building, operating, maintaining, managing and financing the federal road infrastructure. Such an enterprise would form a self-financing unit, i.e. it would try to recover all future costs of the infrastructure through an appropriate charging system. Contrasting a private enterprise it is not aiming to make profits, it would preserve the public conditions on the capital market (lower interest rates) and would not have to take into account force majeure risk, which still will be taken by the state.

With assuming the public enterprise as the regime of decision-making, the basic structure of the accounting approach is defined. Obviously a future oriented full cost account has to be provided, marginal costing or expenditure calculations are not enough. The issues of the accounting procedure are similar to those in regulated markets for telecommunication, air traffic control or electricity interconnections in the case of essential network facilities. Also in these markets fair solutions for cost allocations have to be found, which are free of discrimination on one hand and leave enough incentives to the providers to develop the capacity and the quality of the infrastructure supply on the other hand.

The methodological framework for accounting and distributing the full costs of the German transport infrastructure has been defined in 1969 by a Working Group of the MOT. The German Institute of Economic Research in Berlin (DIW), has elaborated infrastructure cost accounts periodically (roughly every three years) until the beginning of the nineties. The accounting structure is subdivided by

- Capital costs (depreciation and interest on capital), and
- Running costs.

Capital costs represent the largest cost block while their evaluation provides most of the problems associated with the accounting and allocation procedure. The single evaluation steps will be commented in turn. Capital cost accounting starts with the estimation of the *gross asset value* of the federal roads. This value is differentiated into road links and construction elements, which presupposes the use of a data bank, which is available from the MOT. The monetary evaluation is based on current market prices. The *net asset value* for the federal road network is calculated by correcting the gross value by the deteriorated capital parts. Contrasting other accounting methods this is not done on the base of planned (normalized) depreciation calculus. Instead a detailed analysis and evaluation of the road quality has been performed for the federal primaries in 1997/98 and for the motorways in 1998/99.

As a consequence of the flexible method of valuation of assets, the calculation of depreciation values can be based on the generated information on quality indicators, age and expected traffic load as well. The annual depreciation values are derived from the principle of economic depreciation established by Hotelling (1938) and revived by Knieps, Küpper and Langen (Knieps et al. 2000). The yearly amount of depreciation is then defined as the difference between the market value of the used asset (selling value) between the beginning and the end of the year.

It follows from the choice of depreciation method that the calculation of interest on capital has to be done with a nominal rate of discount, because the asset values have been calculated on a nominal base. In Germany, a real discount rate of 3% is used for cost-benefit analysis of transport investments. Presently the inflation rate for construction works is very low, below 1% per year, and might be increasing in the medium term to an inflation rate of about 2%. This justifies to set the nominal rate of discount for 2003 at 4%, increasing to a magnitude of 5% in the year 2010. For comparison: In the Swiss road cost allocation study a discount rate of 5,3% is used.

The *running costs* correspond to expenditures, which can be taken from fiscal budgets:

- Expenditures for current maintenance, repair and equipment
- Expenditures for administration,
- Expenditures for traffic police,
- Expenditures for traffic control (including: Federal Agency for Road Freight Transport) and
- Yearly costs of the payment system for the user (according to information of the MOT).

Unfortunately it is not possible to derive all expenditures from the budget figures. This results from the fact that budgets of different public bodies are affected (Federal and State's budget) and budget categories do not correspond with expenditure categories. Therefore different sources were used to fill the white spots in the data bank (DIW (2000), Paellmann (2000), documents from selected federal states).

The principles of *allocating the total costs to the vehicle categories* have been redefined compared with the methodology of 1969 and the procedures of the DIW. Basic principles are causality, specificity and fairness. This leads to a staged process of cost allocation with 21 cost categories and 5 allocation steps, i.e. altogether 105 mapping rules. The five allocation steps are:

- Proportionally distributed costs (proportional with respect to vehicle km of the single vehicle categories = "1:1 costs")
- System specific cost for cars (and other vehicles with gross weight below 12 tons)
- System specific cost for heavy goods vehicles (12 ton gross weight or more)
- Capacity dependent cost and
- Weight dependent cost.

Only for weight dependent cost an allocation according to causality is possible. This is performed using the updated results of the AASHO road test in the US (third and fourth power of the axle loads). In order to apply the specificity principle, the requirements of vehicle categories for specific design parameters, leading to specific construction elements, have to be analyzed. This analysis starts with a stand-alone test, i.e. it is assumed that the federal roads are designed according to the specific requirements of one vehicle category only (only for cars, only for light trucks, only for heavy goods vehicles).

In the following step the capacity dependent costs, associated with space requirement, have been analyzed. Vehicle flow analysis has yielded particular equivalence factors for road space requirement. An articulated truck for instance is allocated an equivalence factor of 4.5 (=4.5 passenger car units).

1.3. Main results

On the average the share of total motorway costs which is allocated to HGV is 45%. Without considering the costs of the payment system it would drop to about 40%. This is substantially lower compared to the traditional costing method of 1969 which would result in a share (without costs of a payment system) of about 50%.

The charges are differentiated according to weight and environmental categories. For the latter purpose the EURO standards from 0 to 5 were used, supplemented by the EEV category (Enhanced Environmentally Friendly Vehicle). It has to be considered that the structure of the vehicle fleet is changing within the period from 2003 to 2010. This aspect has been treated by a cohort simulation, using the IWW ASTRA system dynamics model (IWW et al. 2001). The weight categories from 12 to 40 tons are transformed into number of axles, because the payment system identifies axles instead of payloads. This leads to the overall differentiation of user charges shown in table 2.

Table 2: User Charges Differentiated by Axles and Environmental Categories

		Emission standards 2003 - 2005 1)		
Year	**No. of axles**	**EURO-4, -5 and EEV***	**EURO-2, -3**	**Pre-EURO and EURO-1**
2003	up to 3	10	13	15
	4 and more	12	15	17
2005	up to 3	11	14	16
	4 and more	12	16	18
2010	up to 3	10	12	15
	4 and more	12	15	18

* EEV = **E**nhanced **E**nvironmentally Friendly **V**ehicle - 1) Categories will be re-defined after 2005 according to the actual fleet structure

The relationship between figures of the same axle category show that the maximum range of the European Directive 1999/62/EC for differentiating charges according to environmental aspects has been exhausted (50%).

2. Average costs, tariffs and price changes

In its final report, the Paellmann-Commission has investigated the question, which part of the taxes and charges currently paid by the hauliers can be seen as earmarked to the transport sector. This share of taxes then has to be reduced, either by lowering current taxes and charges or by considering it within the toll tariffs as already internalized. In general, taxes are non-earmarked contributions to the overall budget. They are not linked to the subject of their levy, and consequently one could argue, that motor vehicle or fuel tax do not internalize the costs of road infrastructure. However, until 1976, a particular share of fuel tax has been earmarked for road construction purposes. This fact has been used by the authors of the Paellmann-Report (Paellmann 2000) to estimate, that roughly 7.5 Euro-Cent per liter Diesel, which corresponds to roughly 2.5 Euro-Cent per km driven,can be considered as the vehicle operators' contribution to the internalization of uncovered road infrastructure costs. This argument was also acknowledged by the German government and the tariffs for the planned motorway toll system were lowered from 15 Euro-Cent to 12.7 Euro-Cent (referring to the conclusions of the Paellmann-Commision, in this paper we assume a tariff reduction by 2.5 Euro-Cent).

In advance of the detailed motorway toll implementation plans, the German Federal Environmental Agency (UBA) has launched a study of its potential transport-sector specific and environmental impacts (IWW 2001). The study was followed by the research project DESIRE on design, implementation paths and consequences of EU-wide interurban road pricing schemes for HGVs (IWW/TRT 2003, Rothengatter / Doll 2003). Both studies have estimated the cost effects for hauliers and for the forwarding industries driven by:

- the price level of the toll and the transport segments affected by it and by
- the reactions of the hauliers and forwarders, trying to avoid or compensate cost increases.

The toll system in its current specification is applied to vehicles over 12t GVW driving on motorways. Further, prices vary with the number of axles and the environmental standard of the vehicles. Thus, the reaction of the hauliers will be to avoid motorways where ever economically sensible, in the medium term, to re-structure the vehicle fleet in order to make more use of environmentally friendly and light vehicles. However, the cost saving potential of these measures is limited. It is estimated that in average 3% to 4% of traffic will shift off the motorways, but as this implies an increase of the HGV load of other roads (mainly federal primaries), increased congestion and thus longer travel times are entailed.

In addition more modern vehicles with high environmental standards are expensive and the market segments, in which big HGVs can be replaced by light lorries is limited. Finally the structure and the prices of the toll system will adopt to the changing vehicle fleet in such a way, that overall revenues remain unchanged.

The only way for the haulage industry to compensate for parts of the cost increase is to make better use of the available vehicle stock by increasing load factors and by avoiding empty hauls. This can either be done by improved tour planning or by co-operations or fusions of small and medium-sized companies. As could be observed in Switzerland after the introduction of the mileage-dependent HGV fee, small haulage companies will have difficulties to survive under these harder market conditions. In other words, parts of the cost savings will be achieved by the loss of working places. However, this might affect foreign hauliers more than national ones as foreigners do have longer costly access routes to the origin and / or from the final destination of their hauls.

Taking into account all these aspects, as well as the compensation of 2.5 Euro-Cent / km paid by the government, IWW (2001) estimates that transportation costs passed on from the hauliers to the forwarders, i.e. the freight tariffs, will increase by 4.2% across all market segments. To derive this result, IWW (2001) has segmented the transport market into two commodity types (unitized goods and bulk goods) and into three distance types (regional transport up to 150 km, other domestic transport and international haulage). The bulk goods market is characterized by higher loading factors and less use of motorways, a higher share of heavy vehicles and a lower lime preference compared to the market of unitized goods. Due to the latter two items, the cost increases entailed by the motorway toll are more expressed in the "cheaper" bulk market. The distance bands are characterized in a way that regional shipments do make comparably little use of motorways compared to long distance hauls. Furthermore a high share of the vehicle fleet used in this segment is below 12t GVW and thus the vast majority of hauls are anyway not subject to the motorway toll.

Table 3 depicts the resulting cost increases found by IWW (2001) by the stage of cost reduction and by the hauliers.

Table 3: Cost development on road haulage by transport sector

Distance category	Regional Transport		Domestic haulage		International haulage	
Goods type	Unitized	Bulk	Unitized	Bulk	Unitized	Bulk
Before compensation	1.2%	1.9%	7.7%	7.8%	8.9%	8.9%
Total increase before compensation	5.6%					
After compensation	1.0%	1.6%	6.4%	6.5%	7.4%	7.4%
Total increase after compensation	4.7%					
After route shift	0.9%	1.4%	6.1%	6.2%	7.1%	7.1%
After operational adaptation	0.9%	1.4%	5.8%	5.9%	6.8%	6.8%
Total increase after operational adaptation	4.2%					
Market share	14.3%	26.1%	20.2%	12.7%	24.3%	2.4%

Source: IWW (2001)

The figures reveal that the compensation paid by the state to the hauliers (2,5 Euro-Cent) constitutes the highest item for cost reduction. Measures internal to the haulage sector, in contrast, compensate only for 0.6% of the price increase between 7.7 percent and 8.9 percent in long-distance transport. These reduction measures correspond to an effective toll level of 11.3 Euro-Cent / km. The average cost increase before compensation equals 5.6 percent. After compensation, transport undertakings face increases of 4.7 percent. Assuming route shifts and operational adaptation average increases might drop to 4.2 percent.

3. Supply driven price effects caused by the HGV toll system

In recent years the German rate of inflation ranged between 0.5 and 2.5%. While according to official statistics, the Euro could not be identified as booster of prices, the majority of the German population believed, particularly in the first two Euro-years, in a different story. Even after the discussion about German deflation trends in summer 2003, the population still reacts in a rather sensitive way if prices are concerned. Within the transport field this is true for increasing fuel prices but does also hold for the introduction of the HGV toll. On the one hand the high density of HGV on, and the poor condition of, German motorways leads to a relative high acceptance of the HGV toll by private users. On the other hand private consumers fear negative impacts on the overall price level.

With regard to the general relevance of transport services, the HGV toll indeed increases production cost for various sectors and may subsequently affect consumer prices. Thus the magnitude of the sectoral price effects should be scrutinized more closely. The paper at hand identifies these price effects, with the help of an input-output price model. The model is based on a German 70 sector input-output table for 1998, which has recently been published by the German office of statistics.

Price effects can be subdivided into direct and indirect effects. According to table 4 total costs of road transport undertakings increase by 4.7% after compensation and 4.2% after additional route shifts and other operational adaptation.

However, indirect price effects for sector ‘Road transport’ and the rest of the economy have not been considered yet. Services provided by sector ‘Road transport’ have a strong intermediate character, which in turn causes indirect price effects for all sectors. Assuming sector ‘Road transport’ fully passes the price effects on to the remaining sectors, the first round sectoral cost increases mainly depend on the output coefficients of road transport and the importance of transport services for the respective sector.

The output-coefficients represents the output shares delivered to each sector. Sector ‘Road Transport’ delivers for example 3 percent of its total output to sector ‘Food and animal feed’, 2.6 percent to ‘Construction’, 2.1 percent to ‘Road vehicle production’ and so on. In total 37 percent of road transport services are provided for industrial production (including services) and 63 percent for categories of the final demand, particular private consumption and exports.

In order to estimate price effects for the sectors, which absorb transport services, the relative importance of transport services as an input must be considered in a second step.

E.g. for the food and animal feed production the consumed transport services equal 1401Mill. Euro, which accounts for the above mentioned 3 percent of total transport outputs, but only for 1.4 percent of total inputs needed for the food production.

Out of 70 considered sectors only three industries show input-shares of road transport services above two percent, namely ‘Wood and wood products’ (2.8 percent), ‘Ceramic, minerals, building materials’ (2.7 percent) and ‘Chemical pulp, paper’ (2.5 percent). For another twelve sectors, shares range between one and two percent. Clearly the modest input shares indicate marginal rather than significant indirect price effects.

Sector ‘Road transport’ does not only deliver its services to other sectors, but consumes transport services itself. Since total outputs match total inputs the input- and output-shares of transport services delivered from and to sector ‘Road transport’ equal 3.2 percent, which is the highest value for both categories.

In addition to these so-called first round indirect effects, which depend on the relevant direct transport-shares, subsequent indirect effects will occur. Wood production for example is affected in a relatively strong manner by increasing transport prices. In subsequent rounds sectors, which consume wood products in a significant way, will be influenced, via the more expansive wood inputs, as well.

With respect to the detailed consideration of intermediate flows, the input-output analysis offers an appropriate instrument to calculate entirely direct and indirect price effects. However, since the classical input-output model is mostly be applied in order to derive demand driven backward linkages, the analysis of the supply driven price effects requires the compilation of forward multipliers. While backward linkages show a sector's relationship to its production inputs, forward linkages measure the dependence upon other sectors as buyers of its output. In early studies the row sum of the Leontief inverse matrix was used as forward multiplier. However, JONES (1976) found that instead of the input coefficients, the output coefficients, identified by the Ghosh matrix, would better match the purpose of measuring forward multipliers. Hence nowadays the Ghosh inverse matrix, which is derived below, replaces the Leontief inverse matrix in case of identifying forward linkages. Though the Ghosh model is often used for analyzing the supply-side effect on sectoral outputs, OOSTERHAVEN (1989) doubted convincingly its plausibility for this purpose. DIETZENBACHER (1997), however, interprets the Ghosh model as price model and finally argues: "The model gives the new (or additional) output values corresponding to new (or additional) primary costs under the assumption of fixed quantities" (DIETZENBACHER, 1998, p. 10). Oriented on DIETZENBACHER's interpretation the study at hand calculates price effects with the help of the Ghosh inverse matrix $(I-A')^{-1}$ and finally sets up the model according to formula (1).

(1) $x=(I-A')^{-1} z$

The Ghosh inverse takes the unity matrix I and the output-coefficient matrix A' into account. Vector z shows the primary inputs, including the original tax load. As a result the output vector x can be calculated. In a second step the development of the tax load is considered for each sector. In line with the assumption that only the HGV toll shall affect prices, elements of z* remain unchanged for all sectors but for 'Road transport', where the additional toll is added. The application of formula (2) yields a new equilibrium with constant (since static) inverse and a new output vector x*.

(2) $x^*=(I-A')^{-1} z^*$

In contrast to vector z*, where only one element differs from vector z, the integration of direct and indirect effects via the Ghosh inverse matrix yields new output levels for almost all sectors (x*). Since the physical production remains unchanged, output increases must result from the HGV toll, paid on top of the taxes by sector 'Road transport'. Consequently the changes of sectoral output levels point to the sectoral price effects induced solely by the HGV toll.

The following calculations take the cost increases given by table 4 into account. Price effects have been calculated for the maximum cost increases of 5..6 percent (if transport undertakings are not compensated) and the minimum rise of cost (4.2 percent). Thus a corridor of possible price effects can be stretched. Since, at least in the short run, the medium direct cost increases of 4.7 percent (after compensation but before other route shift and other adaptations) can be expected, price effects may settle in the middle of the given corridors.

Assuming the maximum cost increases, 60 out of 69 branches show total price increases below 0.1 percent. Another 8 sectors find themselves within the range between 0.1 and 0.2 percent. Only 'Road transport' itself shows a total effect of 5.77 percent. Since the assumed maximum direct price effect was set to 5.6 percent indirect price effects of 0.17 percent occur for this sector.

Table 4 gives, in order of price increases, an overview of the ten sectors (i=1...10) affected most significantly by the HGV toll. In addition the last raw shows the accumulated changes of the whole economy and the average price effects. A complete list of price effects for all sectors is given in the annex. The columns show old (xi) and new output level (x*i) in Mill. EURO as well as rising prices of the respective sectors in percent.

Due to the direct effect of the HGV toll, price increases affect sector 'Road transport' in the most significant way. The above-mentioned sectors, with over average shares of transport services follow next. In absolute terms, sector 'Tobacco' and 'Forestry' are of minor importance. However, particularly food production and construction services show significant absolute increases and form the base for an average price increase of the whole economy of 0.11% for the maximum alternative.

Table 4: Output level and price increases of selected sectors

Sector	**Old output (xi) (Mill. EURO)**	**New output (x*i) (Mill. EURO)**		**Price increases**	
		Min	**Max**	**Min**	**Max**
Road Transport	46285	48288	48956	4.33%	5.77%
Wood and wood products	27028	27065	27077	0.14%	0.18%
Ceramics, building materials	34597	34638	34651	0.12%	0.16%
Tobacco	4749	4754	4755	0.09%	0.12%
Paper and paper products	14613	14625	14629	0.08%	0.11%
Pulp (chemical)	20788	20805	20811	0.08%	0.11%
Forestry	2596	2598	2599	0.08%	0.10%
Beverage	21870	21887	21892	0.07%	0.10%
Food and animal feed	125219	125312	125342	0.07%	0.10%
Construction	121304	121391	121419	0.07%	0.09%
Whole economy	3846247	3849378	3850421	0.08%	0.11%

The results show that the introduction of the HGV toll would lead to price increases for almost all industries. However, effects would be marginal for all sectors but 'Road transport'. Clearly the results must be interpreted carefully, since the input-output table of 1998 (which is at this aggregation level the newest table available) and the rates calculated for 2003. Structural changes and varying transport volume may strengthen the effects. In fact the trend of increasing (road) transport volume (in terms of ton kilometers and average distance) still continues in Germany and would lead to higher absolute cost increases for the Road transport sector. Contrary industrial and private consumer could react to rising prices and may substitute transport-intensive by other goods, which in turn could finally slow down the tendency of constantly increasing transport volumes.

4. Demand driven employment effects caused by the HGV toll system

It has already been pointed to the fact that the HGV toll is a charge rather than a tax. Since the sector 'Road transport' has to pay the same amount either way, the difference does not matter, if the supply driven model is applied. In contrast the differentiation clearly affects the demand side. While a tax is collected by the ministry of finance and could in theory be spent for any purpose, charges are earmarked. In case of the HGV toll, the revenues have to be used for the maintenance of existing and the build up of new infrastructure. Thus the beneficiary can be identified in more simple way. The original intention of the Paellmann-Commission has been to keep the total level of infrastructure investment constant and to use the free resources for other purposes. However, the revenues of the HGV toll will most likely add to the momentary expenses in the transport field, which in turn may help to realize new projects. Therefore infrastructure projects will absorb roundabout 83% of the revenues and will consequently increase demand of construction services. The remaining 17% will be used for the development and the operation of the system, which in turn stimulates sectors 'Electronics' and 'Complementary transport services'. For the study at hand both sectors shall benefit equally.

In order to identify the supply driven price effects, produced quantities were assumed to remain unchanged. Contrary demand driven effects will by definition affect the physical outputs as well. These impacts can be derived by the application of the classical static input-output model, which allows the calculation of backward multipliers. The backward linkages provide information about the potential stimulus to any sector, if the final demand of sector j is increased by one unit. This effect is subdivided into a direct and an indirect part. The input coefficient matrix A shows the direct effects. Since an additional output of sector j will not only influence the direct inputs, but will also lead to increasing inputs of the direct inputs, the initial or first-round effect is followed by a second-, third- till nth-round effect. Finally the Leontief inverse matrix $(I-A)^{-1}$ generates the total effects of the additional final demand. Formula (3) shows the basic equation of the model:

(3) $x=(I-A)^{-1}\ y$

The Leontief inverse is based on the unity matrix I and the input coefficient matrix A. y represents the final demand of the sectors. The multiplication with the Leontief inverse results in vector x, which shows the sectors' production values. If the revenues of the HGV toll flow back into the economic system as assumed above, the additional final demand of three sectors, given by y^{+}, leads to increasing outputs x^{+} for almost all sectors.

(4) $x^{+}=(I-A)^{-1}\ y^{+}$

Though increasing production values may indicate economic growth, high output levels per se, potentially accompanied by extended material throughput and increasing emissions, hardly serve as an appropriate indicator of higher welfare. Thus the positive side effects caused by higher outputs, particularly increasing household income and additional employment, should be stressed in a more prominent way. Consequently the study at hand will focus on the employment impacts. These arise from the sectors' productivity, derived from the input-output table, and the modified outputs, given by vector x^{+}. The general idea is to divide the additional output x_i^{+} by productivity p_i for any sector i and thus to derive the additional employment.

However, the results will probably overestimate the impacts in practice for two reasons:

First, the companies will only create additional jobs, if the plants' current labor utilization is close to maximum. Otherwise already employed workers will extend their working hours first, which may result in higher household income and additional working hours but not in additional jobs. The same holds if the companies are close to maximum utilization but do not trust in sustainable growth. Again employees would work overtime and get a time-compensation in weak periods. This is particularly true for the construction sector, which is affected significantly in this case.

Second, the capital utilization is not close to the maximum or firms introduce new technologies. In both cases capital productivity would increase and would consequently reduce the pressure to employ new workers.

Being aware of this problem, two alternative calculations with the following assumptions have been performed: no productivity increases and high productivity increases with a growth rate of 8 percent. Table 5 shows the potential job generation, according to the two assumptions. For the sake of clearness the table is limited to the 10 sectors with the highest impacts. The last raw shows the effect for the whole economy.

Due to the assumption that almost 90 percent of the revenues, resulting from the HGV toll, are invested into new transport infrastructure, sector ‘Construction’ obviously benefits most. Almost 30 thousand new jobs could be created, if no productivity increases are expected. Even with the assumption of rising productivity by 8 percent significant employment effects can be expected.

Some sectors, which already occurred, when price effects were discussed, show up again. This is true for ‘Ceramics, building materials’, ‘Wood and wood products’ and ‘Road transport’. But while these sectors played an important role within the supply-driven analysis because of their strong linkage to transport services, the demand-driven effects result from the close relationship to construction activities.

Contrary to the supply-driven approach, the top ten group includes some typical service sectors, namely ‘Business related services’, ‘Financing’ and ‘Wholesale’. Clearly these sectors show close linkages with construction activities, however another reason for their strong employment effects can be explained by a relatively low labor productivity compared to manufacturing industries.

Table 5: Generation of new jobs, induced by re-investment of HGV toll

Sector	**New jobs with no productivity increases (in 1000)**	**New jobs with productivity growth of 8% (in 1000)**
Construction	29.9	27.7
Business related services	3.0	2.8
Ceramics, building materials	2.7	2.5
Complementary transport services	1.4	1.3
Wholesale	1.2	1.1
Financing	0.9	0.8
Wood and wood products	0.6	0.6
Ferrous metals	0.5	0.5
Supporting construction services	0.5	0.5
Road transport	0.5	0.5
Whole economy	46.7	43.2

Due to the relative importance of transport services for the construction activities, the sector 'Road transport' would benefit from an increasing demand of construction services as well. However, the demand-driven results are based on the backflow of the revenues and do not include potential negative employment impacts, which may result from the operational adaptation within the transport undertakings. Though it has been argued above that foreign operators might be affected in a more significant way, some small domestic undertakings (including related jobs) may vanish as well. Consequently the described positive employment effects, resulting from higher demand, should not be considered as net effects, but may help to soften the negative effects, which may accompany operational adaptations.

In total the re-entry of the revenues into the economic circle entails roundabout 45 thousand new jobs, which accounts for roundabout 0.1 percent of the total number of employees in 1998 and 1 percent of the (registered) unemployed persons.

The calculated backward effects depend on the assumption that the toll-revenues will be spent on top of the current infrastructure expenditures. If the revenues will just replace other expenditures, obviously employment effects would differ significantly. Whether the effects would be lower or would outperform the calculated implications, mainly depends on the alternative field of investment.

5. Critique and conclusions

The application of the input-output model allows a detailed analysis of sectoral price, output and finally employment effects initiated by the introduction of a German HGV toll. However, though the approach enables the user to identify direct and indirect effects, which derive from road pricing or the higher demand of construction services, the static character of the input-output analysis does not offer the integration of feedback loops outside the intermediate sphere. Changes of private and public households' consumption patterns as well as adaptations of interest rates and investments remain unconsidered. In addition the consequences of time gaps between charging and re-entry of the revenues could have been included into a dynamic model in a better way. Being aware of this problematic, the authors have chosen the static input-output approach anyway for two reasons:

First, the findings are very close to the results of a dynamic approach performed within the DESIRE project. Doll et al. (2003) identified rather marginal effects for the overall economic performance initiated by comparable road pricing schemes. In fact the model, which includes a 25 sector input-output module, suggests changes of the overall GDP growth, induced by road pricing, between –0.08 and 0.04 percent within Europe.

Secondly, dynamic modelling considers, per definition, the interaction of various simultaneous impulses. HGV toll, eco-tax and a strong (or a weak) US-Dollar would cause certain cumulative effects, which hardly can be isolated. However, the main aim of this study has been to identify the effects driven by the HGV toll only.

According to this aim, it can be concluded that neither undesirable price effects nor positive employment effects play a significant role for the overall economic performance. Besides the transport branch itself, no other sector shows price increases over 0.2 percent. The majority even shows price effects less than 0.1 percent. For the whole economy prices are assumed to rise by 0.11 percent.

Once the revenues re-enter the economic circle, specifically construction services are expected to increase output and thus employment. Furthermore services related to construction activities, namely business related services and financing benefit over-average. If the revenues are re-invested into additional infrastructure projects, in total roundabout 45 thousand new jobs could be created. This equals no more than 0.1 percent of total employees, but also 1 percent of registered unemployed persons.

In the end little stronger positive effects may balance negative impacts, which occur at further stage. However, though transport undertakings will be forced to improve their logistics and thus increase competitiveness, particularly small transport undertakings will face serious difficulties and may to a certain degree even vanish from the market.

If in addition the currently unsatisfactory condition of German motorways will improve, the overall impacts of the HGV toll could be seen as a step into the right direction. However, it should be discussed whether external effects should be included in a next step.

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Annex

Table A1: Price increases in percent induced by HGV toll and new jobs if revenues are re-invested into infrastructure (sector 1-39)

	Price increases (in %)		New jobs (in 1000)	
	Min	Max	No productivity growth	Productivity increases by 8%
1 Agriculture	0,04	0,06	0,0	0,0
2 Forestry	0,08	0,10	0,1	0,1
3 Fishery	0,01	0,01	0,0	0,0
4 Coal mining	0,05	0,06	0,1	0,1
5 Crude petroleum, natural gas	0,00	0,00	0,0	0,0
6 Other mining products	0,02	0,03	0,3	0,3
7 Food and animal feed	0,07	0,10	0,0	0,0
8 Beverages	0,07	0,10	0,0	0,0
9 Tabacco	0,09	0,12	0,0	0,0
10 Textiles	0,04	0,06	0,0	0,0
11 Clothing	0,02	0,03	0,0	0,0
12 Leather	0,03	0,03	0,0	0,0
13 Wood and wood products	0,14	0,18	0,6	0,6
14 Pulp (chemical)	0,08	0,11	0,0	0,0
15 Paper and paper products	0,08	0,11	0,0	0,0
16 Publishing industry	0,02	0,03	0,0	0,0
17 Printing industry	0,06	0,08	0,1	0,1
18 Products of coal, petroleum	0,03	0,04	0,0	0,0
19 Pharmaceutical products	0,03	0,04	0,0	0,0
20 Chemistry	0,04	0,05	0,1	0,1
21 Rubber products	0,04	0,05	0,0	0,0
22 Plastic products	0,05	0,06	0,4	0,4
23 Glas, glas products	0,05	0,06	0,0	0,0
24 Fine ceramics, building materials	0,12	0,16	2,7	2,5
25 Ferrous metals	0,07	0,09	0,1	0,1
26 Non-ferrous metals	0,03	0,04	0,0	0,0
27 Moulding products	0,05	0,07	0,0	0,0
28 Finished metal goods, steelproducts	0,05	0,06	0,5	0,5
29 Mechanical engineering	0,03	0,04	0,1	0,1
30 Automatic data processing product	0,01	0,01	0,0	0,0
31 Products used by energy supply	0,02	0,03	0,1	0,1
32 Electronics	0,02	0,02	0,5	0,5
33 Instrumental engineering	0,02	0,03	0,0	0,0
34 Road vehicles	0,04	0,05	0,0	0,0
35 Other vehicles	0,02	0,02	0,0	0,0
36 Furniture, sport equip., jewelry	0,06	0,07	0,0	0,0
37 Secondary raw material	0,03	0,03	0,0	0,0
38 Energy supply, (without gas)	0,03	0,04	0,1	0,1
39 Gas supply	0,01	0,01	0,0	0,0

Table A1: Price increases in percent induced by HGV toll and new jobs if revenues are re-invested into infrastructure (sector 40-69)

	Price increases (in %)		New jobs (in 1000)	
	Min	Max	No productivity growth	Productivity increases by 8%
40 Water supply	0,01	0,01	0,0	0,0
41 Construction	0,07	0,09	29,9	27,7
42 Supporting construction services	0,04	0,06	0,5	0,5
43 Vehicle repair, gas station	0,02	0,03	0,3	0,3
44 Wholesale	0,01	0,01	1,2	1,1
45 Retail trade	0,01	0,02	0,4	0,3
46 Restaurants, hotels	0,06	0,08	0,3	0,2
47 Railway, road transport	0,01	0,02	0,1	0,1
48 Road transport	4,33	5,77	0,5	0,5
49 Inland waterway, short sea shipping	0,02	0,02	0,0	0,0
50 Air transport	0,02	0,03	0,0	0,0
51 Complementary transport services	0,02	0,03	1,4	1,3
52 Telecommunication	0,01	0,01	0,2	0,2
53 Financing	0,02	0,02	0,9	0,8
54 Insurance	0,01	0,01	0,1	0,1
55 Complementary financing services	0,00	0,00	0,1	0,1
56 Renting (housing)	0,01	0,01	0,5	0,5
57 Renting of other products (e.g. cars)	0,00	0,00	0,1	0,1
58 Services of data processing	0,00	0,00	0,1	0,1
59 Science, R&D	0,01	0,02	0,0	0,0
60 Business related services	0,01	0,01	3,0	2,8
61 Public organisations, defence	0,02	0,02	0,3	0,3
62 Social insurances	0,02	0,02	0,0	0,0
63 Educational services	0,06	0,08	0,0	0,0
64 Public health and veterinary	0,01	0,02	0,0	0,0
65 Sewage treatment and waste disposal	0,02	0,03	0,1	0,1
66 Non-market private organisations	0,02	0,03	0,2	0,2
67 Services for sports and culture	0,01	0,02	0,1	0,1
68 Other market services	0,01	0,01	0,2	0,2
69 Services of private households	0,00	0,00	0,0	0,0
70 Whole economy	0,08	0,11	46,7	43,2