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Andreas Knorr/André Heinemann/Alexander Eisenkopf

Germany's Autobahn Toll for Heavy Goods Vehicles after four Years: Experiences and Perspectives

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Abstract

On January 1st, 2005, Germany introduced a road charging system for all heavy goods vehicles (HGV) using the country's *Autobahn* network (i.e. the country's main interstate highways). The introduction of this so-called *Lkw-Maut* (HGV toll) marked a watershed event in the history of Germany's transport policy as it represented the first ever deviation from the traditional approach of financing road infrastructures out of the general budget. In our paper we will first provide an overview of the current legal and institutional framework of the German *Lkw-Maut* regime. Then we will analyse its performance and shortcomings since its implementation in 2005, using a model which enhances the traditional theory of club goods by incorporating the relevance of the degree of rivalry for the efficient provision of road infrastructures.

Key words: Electronic road pricing, congestion charging, infrastructure planning

JEL codes: G 28, L91, L98

Contents

I. Introduction

On January 1st, 2005, delayed by 3 years due to unexpected technical glitches (and trailing pioneer Singapore by 3 decades), Germany finally introduced a road charging system for all heavy goods vehicles (HGV) using the country's *Autobahn* network (i.e. the country's main interstate highways). This so-called *Lkw-Maut* (HGV toll) is based on the distance driven, the number of axles and the emission category of the vehicle; however, no congestion component exists. A watershed event in the history of Germany's transport policy, the introduction of the toll nevertheless represented the first ever deviation from the traditional approach of financing road infrastructures out of the general budget. Massive lobbying by the road haulers' trade associations and the lobbies of all transport-intensive manufacturing industries, which cited concerns over the future competitiveness of the German trucking industry, as well as manufacturing, failed to stop the toll. In this paper we will first provide an overview of the current legal and institutional framework of the German *Lkw-Maut* regime. Then we will perform an in-depth analysis of its performance and shortcomings since its implementation in 2005 using a model which enhances the traditional theory of club goods by incorporating the relevance of the degree of rivalry for the efficient provision of road infrastructure.

II. Road infrastructure planning and financing in Germany

a. The existing road network

After Russia, Germany is Europe's most populous state with a current population of 82.2m. At a surface area of 357,114 sq.km, this translates into an average population density of 229.9 inhabitants/sq.km. However, in contrast to most other developed countries the population is very evenly distributed across the territory as a result of Germany's polycentric economic and political structure. Last not least, due to Germany's geographic location in the very heart of the European Un-

ion – it borders on nine countries[1] – almost all of Europe's most important East-West and many key North-South transit routes run across the country. Especially after the European Union's Eastern enlargement on May 1st, 2004, these vital transport arteries have seen a dramatic rise in the number of users.

Currently, Germany's non-local road network has a total length of 231,359 kilometers. The *Autobahn* network – which handles about one third of all traffic – comprises 12,531 kilometers, with six or more lanes available on around 3,000 kilometers. In addition, 40,711 kilometers of *Bundesstrassen* (Federal trunk roads) link all major and most minor municipalities of the country. The remainder are state roads (86,597 kilometers) and county roads (91,520 kilometers) (Statistisches Bundesamt (2008, 427). However, the quality of the road infrastructure has sharply deteriorated over the past three decades, especially in former West Germany, due to the lack of sufficient public funding after reunification (a substantial amount of the budget was redeployed to and invested in former East Germany). The most visible indicator for this negative trend is the sizeable decline of the modernity level of roads and bridges from 85 per cent in 1970 to a mere 67 per cent in 2004 (Friedrich Ebert-Stiftung – Managerkreis 2006, 2; Wirtschaftsrat 2000).

b. Road infrastructure planning and financing in Germany

Regarding its political and administrative system, Germany is not a unitary state but a highly decentralized political entity. In short, the country is organized into three layers of government: the Federal level, the 16 *Länder* (states) and the 12,263 local municipalities, only 2,074 of which are cities (Statistisches Bundesamt 2008, 427). Only in a few fields have policy competences been exclusively assigned to a specific level of government. By contrast, it is estimated that around 70 per cent of all legislation must be jointly passed by the *Bundestag* – the German parliament (roughly equivalent to the *U.S. House of Representatives*) – and the *Bundesrat* (Federal Council, roughly equivalent to the *U.S. Senate*).

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1 Denmark, the Netherlands, Belgium, Luxemburg, France, Switzerland, Austria, the Czech Republic and Poland.

Transport infrastructure policy is a case in point (Institut für Mobilitätsforschung 2007, 84ff.). According to article 90 (1) of the German Constitution, the Federal government is the legal owner of all Federal (trunk) roads, i.e. of *Autobahnen* and *Bundesstrassen*. However, their administration – including the competence for planning and completion –, rests with the respective state governments by proxy. Moreover, the *Länder* exert substantial influence throughout the entire the planning process concerning Federal road projects (and all other Federal transport infrastructures as well). Formally, the responsibility for transport infrastructure planning at the Federal level resides with the *Bundesministerium für Verkehr, Bau und Stadtentwicklung* (*BMVBS*; Federal Ministry of Transport, Building and Urban Affairs). Since the 1970ies, the *Bundesverkehrswegeplan* (Federal Transport Infrastructure Plan) has provided a ranking of all Federal transport infrastructure projects, based on a thorough cost-benefit analysis (complemented by an environmental impact assessment and an assessment of potential regional development effects); it has been updated at irregular intervals and on average less than once in a decade. As a rule of thumb only projects with an expected benefit-cost ration >3.0 will be realized. More often than not, however, it is the state governments which propose specific infrastructure projects for evaluation and inclusion in the *Bundesverkehrswegeplan*. Their motivation is not exclusively the desire to eliminate existing regional infrastructure bottlenecks. Rather, the successful lobbying for the inclusion of a proposed road project into the *Bundesverkehrswegeplan* does also shift the financing burden from the Länder budget to the Federal government, allowing the *Länder* effectively to ride free on the Federal budget.

Before the introduction of the *Lkw-Maut* for the *Autobahn* network in 2005, all road infrastructure projects in Germany were financed through a mix of general and, though to a much lesser degree, road transport-specific tax revenues, in particular the vehicle tax[2] and the gasoline tax[3]. Inevitably, this arrangement produced a major inefficiency: All traffic by foreign-registered vehicles – as for trucks, this means a 34.6 per cent share in terms of all mileage (Bundesamt für den Güterverkehr 2009a) – which did not refuel in Germany effectively was not subject to any form of road user charge and effectively

2 Which is based on a vehicle's motor size – measured by the cubic capacity – and emission class.

3 Which amounts to roughly 75 per cent of the per liter gasoline price.

enjoyed a “free ride”. Protests from Germany’s road haulage firms prompted the government to seek a remedy at the EU level in order to create a more level playing field. The result was the first ever HGV toll system in Germany: a simple time-based levy designated as the so-called *Eurovignette* – a simple decal to be stuck to the inside of a truck’s windscreen – which was jointly introduced by Germany, Belgium, the Netherlands, Luxemburg, Denmark and Sweden in 1995.

Finally, on January 1st, 2005, a selective electronic HGV toll system, the *Lkw-Maut*, was introduced. It subjects all heavy trucks with a gross vehicle weight in excess of 12 tons which travel on any *Autobahn* or one of three highly congested, parallel running *Bundesstrassen* to a road user charge.

III. The *Lkw-Maut*: an overview

a. Legal basis

The first legal attempt to introduce a user charge for trucks was made in 1990 by German government. However, the charge had to be abolished only a few weeks later as it was not compatible with EC laws. In 1994, The German government passed the *Fernstraßenbauprivatfinanzierungsgesetz* (*FStrPrivFinG*) – the Private Financing of Highway Construction Act – of 1994 which legalized road infrastructure PPPs in Germany for the first time ever (Beckers 2005). On October 25th, 1993, the European Community passed Council Directive 1993/89/EC, the so-called *Eurovignette* directive which created the legal framework for HGV tolls in the Community by specifying the conditions for the levying of tolls for road usage. It was later replaced by EC Directive 1999/62/EG. In particular, the directive stipulated that only HGV in excess of 12 tons could be subject to road user fees. Moreoever, it permitted member states to differentiate road user charges based on objective environmental criteria (Seidel/Schlag/ Wieland/ Schade/ Matthes 2004, 2). The directive was transformed into German law with the *Autobahnmautgesetz* (Motorway Toll Act) of 2002. Not only does this law specify which vehicle classes and roads are subject to the toll. It also authorizes the Federal government to pass specific regulations to implement the toll. These pieces of secondary law include

- *Verordnung zur Erhebung, zum Nachweis der ordnungsgemäßen Entrichtung und zur Erstattung der Maut* (HGV Toll Regulation) which specifies some technicalities regarding the levying of the toll;
- the *Mauthöheverordnung* (Toll Level Regulation) which regulates the amount of the toll; and the
- *Verordnung zur Ausdehnung der Mautpflicht auf bestimmte Abschnitte von Bundesstraßen* (Tolling Extension Regulation) which extended the toll to some heavily travelled Bundesstrassen which were used by truckers to bypass the toll.

The 2006 revision of Directive 1999/62/EG will substantially increase the scope of HGV toll systems in the European Union from 2010, by extending their coverage twofold. First, all trucks with a gross vehicles weight greater than 3.5 tons will be included. Second, a toll may be levied on all trunk and all parallel roads afterwards. Moreover, the revised directive requires the interoperability of all electronic toll systems in the EU.

b. Technology

Several alternative tolling systems are in use worldwide (Broaddus/ Gertz 2008):

- *Vignettes*, i.e. a time-based toll system which allows unlimited raod use for a certain period of time (usually 1 day, 1 month or 1 year). As proof of payment, usually a decal must be attached to the inside of the windshield.
- *Toll plazas* are used to levy a toll for the use of certain road segments. Some are based on simple manual payment through counters while more advanced systems make use of electronic tags and beacons to automatically bill registered users. In the latter case, cars need to be equipped with a electronic chipcards which communicate with *Dedicated Short Range Communications* (*DSRC*) technology embedded in gantries.
- *GPS, i.e. satellite-based technology* permits to toll road users by the kilometer without impeding the free flow of cars. For the system to work all cars must be equipped with an on-board unit

(*OBU*) which ensures automatic log-on and communicates the itinerary and the due toll to the tolling agency for billing purposes.

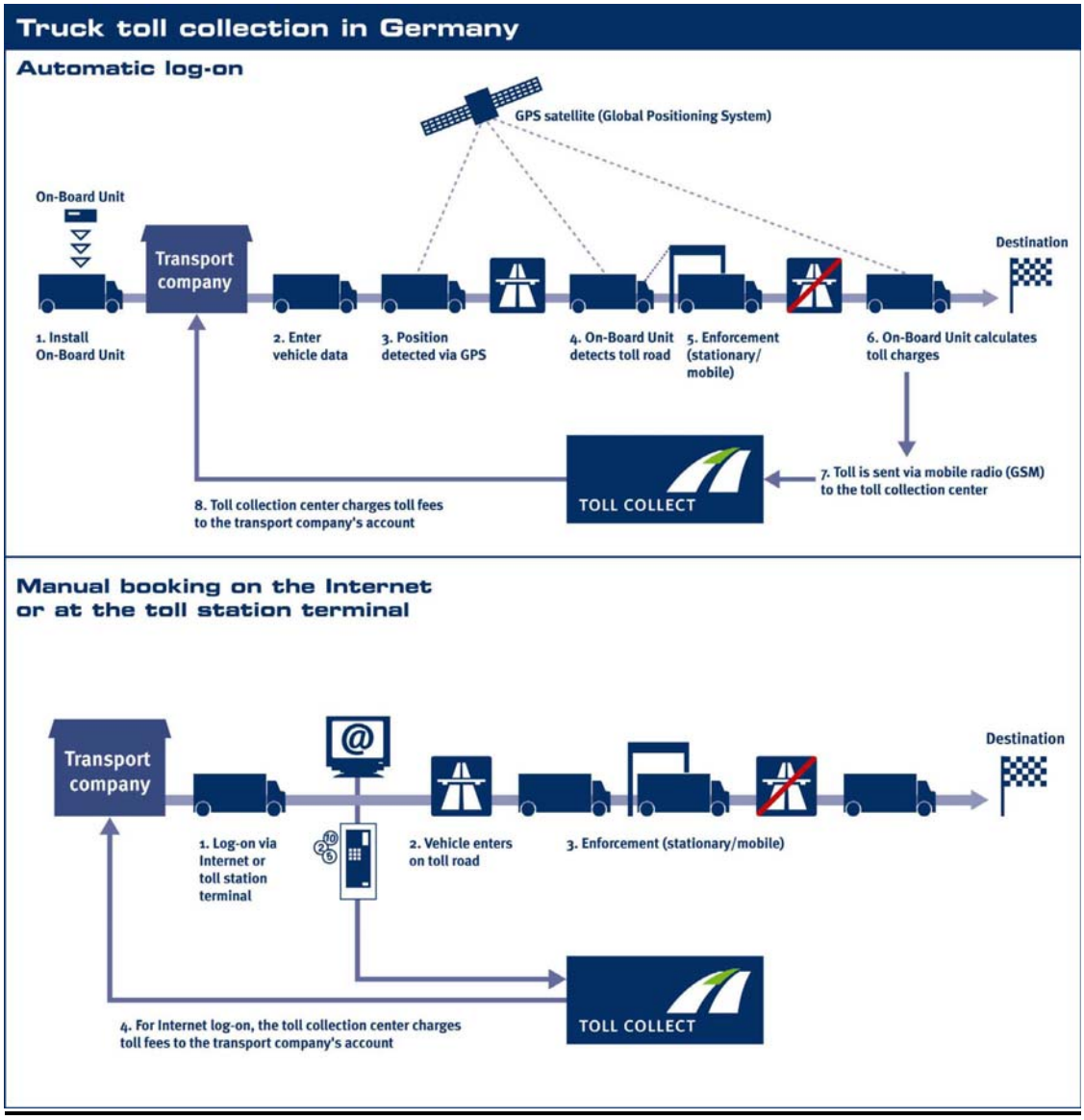
Technologically, the German *Lkw-Maut* is the world's only *GPS*-based system so far. It works as follows (Toll Collect 2009): For automatic log-on and billing, an *OBU* must be installed on the truck (while the *OBU* is provided free of charge from the toll operating company, it must be installed at the trucking companies' expense). This, in turn, is only possible after the haulage company has registered itself plus all its trucks with *Toll Collect*, the private-sector company which was selected in a complicated and legally controversial public tender to operate the *Lkw-Maut* on behalf of the German government. Currently, a total of 938,000 vehicles, operated by 122,000 firms, are registered with *Toll Collect* (Toll Collect 2008). The installation of the *OBU*s may only be performed by specialist firms – located both in Germany and some neighbouring countries – which have obtained *Toll Collect*'s authorization to do so. The *OBU*s use *GPS* technology to track the trucks' movements on the toll roads. As a back-up solution for the unlikely event of a complete shutdown of the US-operated *GPS* system, they are also connected to the on-board odometer and tachograph. Finally, a wireless *GSM* link from the *OBU* – which automatically calculated the toll due – to Toll Collect is used to authorize payment. By September 2008, 640,414 *OBU*s had been installed, 59 per of which in Germany-registered trucks. (Springer 2008). Currently, around 90 per cent of the toll revenue is generated from *OBU*-equipped trucks (Toll Collect 2008).

Alternatively, manual log-on options exist for vehicles without *OBU*. First, 3,500 terminals are available at petrol stations and rest areas all over Germany, most of which were set up close to border crossings. Moreover, prepayment via the internet is also offered. In both cases, the driver needs to enter vehicle, departure time, origin and destination information into the system which will then calculate the due toll based on the shortest possible route within the toll network. Table 1 below provides a graphic overview of the toll collection process.

Finally, enforcement is secured through 300 toll checker gantries – which are equipped with infrared detection devices as well as high-resultion cameras to film the trucks' licence plates – plus 300 mobile patrol vehicles. The latter are manned with 540 staff from the *Bundesamt für Güterverkehr* (Federal Office of Freight) which have

police powers and perform on the spot checks on toll roads to verify if payment has been made and/or an *OBU* has been installed. The patrol vehicles are equipped with infrared short range *DSRC* devices which can be used for the monitoring of trucks in motion.

Table 1: Toll collection



Source: Toll Collect (2009).

c. Implementation (problems)

The development of the *Lkw-Maut* began in 2002 with the objective getting the system in working order by August 31st, 2003. However, the enourmous challenges of launching such a complex new technology, including the complicated selection process for the toll operating company, were greatly underrated by all parties involved in this largest of all public private partnerships in Germany's history (Fleischer/ Halbritter 2004): the German government and the winning bidders, a consortium of *Daimler AG*, *Deutsche Telekom* and *Cofiroute S.A.* (the leading French motorway operator). The toll system was installed and is run by *Toll Collect Ltd*., in which *Daimler Financial Services AG* and *Deutsche Telekom AG* each hold a 45 per cent share, while *Cofiroute S.A.* controls the remaining 10 per cent. The role of the public partner, the *Bundesministerium für Verkehr, Bau und Stadtentwicklung* is to administer the contract (which consists of 17,000 pages) between the government and *Toll Collect* and to regulate the toll system, in particular the amount of the toll.

After several postponements, the *Lkw-Maut* went online on January 1st, 2005; however it was not until January 1st, 2006, that the system become fully operational. Ever since it has operated very smoothly – at a 99.75 per cent reliability rate compared to the 99 per cent fixed as a requirement in the contract – without any major techical glitches or service disruptions. However, as the German government had abolished the *Eurovignette* as of August 31st, 2003, at least €3bn were lost in uncollected tolls as a result of the repeated delays, effectively giving trucking companies two years of free *Autobahn* use (abstracting, of course, from the vehicle tax and the gasoline tax). In autumn 2004, the Federal government sued the consortium for €3.5bn in punitive damages. A final court decision is not expected until 2010, while the legal fees for the government alone have so far reached €54m (Financial Times Deutschland 2009).

d. Objectives

With the introduction of the toll, the German government tried to achieve the following objectives (Bundesministerium für Verkehr, Bau und Stadtentwicklung 2009):

- To switch from a tax-based system of road infrastructure financing to a fee-based user pays system; in particular to charge the operators of HGVs a much higher portion of the far above average maintenance and operation costs caused by these vehicles compared to regular passenger cars;
- to secure funding for investment (maintenance and upgrading) of transport infrastructures – including but not limited to road infrastructure;
- to create a fiscal incentive to use HGVs more efficiently (.i.e. to reduce the number of empty runs) and to switch freight to more environmentally friendly modes of transport such as the railroad and inland waterways as well; and
- to promote innovative technologies, i.e. to establish the *Toll Collect* consortium as a world market leader in electronic road pricing systems.

e. The toll – coverage and amount

Article 1 of the *Autobahnmautgesetz* regulated that all freight carrying vehicles with a gross vehicle weight greater than 12 tons which use any segment of German *Autobahn* network[4] as well as three parallel running *Bundesstrassen* are subject to the *Lkw-Maut*. However, a number of vehicle classes are fully exempt:

- Buses and coaches;
- government vehicles;
- military and police vehicles;
- fire service vehicles;
- civil defence and emergency vehicles;
- vehicles used by charitable organisation in disaster relief missions;
- vehicles used for road maintenance, sweeping and winter services; and
- "vehicles used exclusively for purposes of the showman's and circus industry".

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4 The act excluded two small *Autobahn* portions near border crossings from the toll.

The toll is distance-based, weight-based (using the number of axles as a proxy) and emission-based but lacks a congestion-related component. Following the introduction of the new toll structure on January 1st, 2009, substantial rebates are now available for low-emission vehicles. Thus, while the difference between the lowest and highest toll categories was previously set at around 50 percent, it is now close to 100 percent. As a result, the range of tolls has widened, and the system has become more differentiated overall.

To be more precise, the toll system now also takes into account whether a vehicle has been retrofitted with particulate abatement equipment to reduce emissions. Therefore, two new particulate abatement categories (*PAC*s) have been integrated in the charging structure. *PAC*s are standards for the retrofitting of equipment to reduce emissions of particulate matter. In short, *PAC I* meets the particulate matter emissions level of stipulated by the *Euro-II-Standard* and *PAC II* meets the *Euro-III-Standard*. So *PAC I* and *PAC II* are, respectively, equivalent to *Euro-I-Standard* and *Euro-II-Standard* in the tolling charge structure. Table 2 below provides the full price list valid as of January 1st, 2009. It also includes the toll amounts due after the next increase in January 1st, 2011.

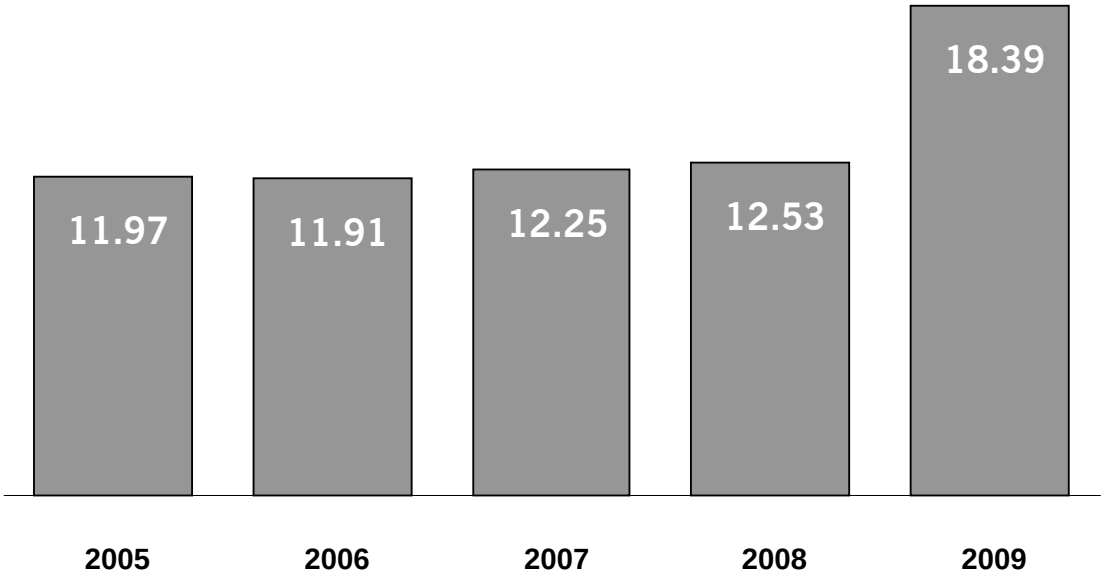
Table 2: Charging structure of the LKW-Maut (as of January 1st, 2009)

Emission category	Toll category	Toll per driven kilometre	
		From 1 January 2009	From 1 January 2011
EEV	**Category A**	Up to 3 axles: 14.1 cents	Up to 3 axles: 14.0 cents
		4 axles or more: 15.5 cents	4 axles or more: 15.4 cents
Euro V	**Category A**	Up to 3 axles: 14.1 cents	Up to 3 axles: 14.0 cents
		4 axles or more: 15.5 cents	4 axles or more: 15.4 cents
Euro IV or Euro III with PAC 2, 3 or 4	**Category B**	Up to 3 axles: 16.9 cents	Up to 3 axles: 16.8 cents
		4 axles or more: 18.3 cents	4 axles or more: 18.2 cents
Euro III or Euro II with PAC 1, 2, 3 or 4	**Category C**	Up to 3 axles: 19.0 cents	Up to 3 axles: 21.0 cents
		4 axles or more: 20.4 cents	4 axles or more: 22.4 cents
Euro II	**Category D**	Up to 3 axles: 27.4 cents	Up to 3 axles: 27.3 cents
		4 axles or more: 28.8 cents	4 axles or more: 28.7 cents
Euro I /Euro 0	**Category D**	Up to 3 axles: 27.4 cents	Up to 3 axles: 27.3 cents
		4 axles or more: 28.8 cents	4 axles or more: 28.7 cents

Source: § 1 of the Regulation Amending Motorway Toll Legislation and the Vehicle Licensing Regulation of 20 November 2008, Federal Law Gazette I, p. 2226.

As shown in table 3 below, the average toll per kilometer has remained quite stable in the frist three years of the *Lkw-Maut*. The 2009 fee adjustment, however, has made the average toll rise by 46 per cent.

Table 3: Average toll per kilometer (in € cents)



Source: Bundesverband Güterkraftverkehr Logistik und Entsorgung (BGL) 2009.

However, it is noteworthy in this context that the vehicle tax – which does not accrue to the Federal government but to the state in which the vehicle is registered – was lowered to the minimum amount required under European Union law to (partly) compensate German road haulage companies for the additional costs imposed on them due to toll.

f. Traffic, financial and environmental results to date

In 2008, a record of 27.6m kilometers were travelled on the German toll roads, 9.6m of which by foreign-registered trucks (Bundesamt für Güterverkehr 2009b, 17). What is more, new registrations of trucks with a gross vehicle weight between 10 and 12 tons increased substantially in the first years after the introduction of the toll, presumably to legally avoid the toll. In 2003, only 4.946 new units had been registered this category. This number increased to 5.665 units in 2004, 7.228 units in 2005, 7.286 units in 2006, 8.101 units in 2007 only to decline to 7.381 units in 2008. However, new registrations in this category currently amount to a mere 3 per cent of

all new truck registrations in Germany, while lorries with a gross vehicle weight over 12 tons command a 10 per cent market share, compared to 87 per cent for small trucks below 8 tons (Bundesamt für Güterverkehr 2009b, 17).

On the revenue side, the *Lkw-Maut* has by and large exceeded the expected (and predicted) results; in 2005, €2.87bn were raised, a figure that increased to €3.08bn in 2006, to €3.36bn in 2007 and to €3.46 bn in 2008 – although the 4th quarter saw an 8.7 per cent decline compared to one year ago due to the economic crisis (Bundesamt für Güterverkehr 2007, 12, and 2009b, 16f.). However, the system is rather costly to run, with the PPP agreement guaranteeing the *Toll Collect* consortium a 20 per cent share of the revenues, i.e. around €600m per year.

The share of more environmentally friendly trucks has increased substantially over time. In 2008, the share of trucks in the *Euro 5* category reached 32.7 per cent, compared to 5.7 per cent in 2006 and 17.6 per cent in 2007. Regarding the *Euro 4* and *Euro 3* categories, the respective figures were 7.8 per cent (2006: 2.8 per cent) and 49.1 (down from 68.0 per cent in 2006). However, given the fact that from October 2006 new *Euro 3* category vehicles could not be registered in Germany anymore, this improved environmental performance clearly is not primarily the result of the *Lkw-Maut*. Last not least, no discernible modal split change to the benefit of the railroads and inland waterways has taken place.

g. Utilization of the toll revenues

As stipulated in article 11 of the *Autobahmautgesetz*, the fee revenues generated through the *Lkw-Maut* must be earmarked for transportation infrastructure investments. According to an internal decision made by the *Bundesministerium für Verkehr, Bau und Stadtentwicklung*, the following allocation formula has been applied since 2009:

- Road infrastructures: 58 per cent (50 per cent until 2008);
- Rail infrastructures: 30 per cent (38 per cent until 2008);
- Inland waterways: 12 per cent (12 per cent until 2008).

As mentioned above, 20 per cent of the revenues accrue to *Toll Collect*. Finally, €150m per year are earmarked to compensate the states for revenue losses as a result of the reduction of the vehicle tax for trucks, while €100m are being made available to road haulage companies which replace older HGVs with more modern low-emission trucks (Böger/Zumpe 2008).

IV. Analysis: how to increase the efficiency of the *Lkw-Maut*?

a. Public goods, private goods, and mixed goods

The different economic characteristics of goods (textbook style) are shown in table 4 below.

Table 4: Economic characteristics of goods

		Exclusion	
		possible	**impossible**
Rivalry in consumption	**yes**	Pure private goods	Common-pool goods
	no	Club goods/ Toll goods	Pure public goods

Source: Illustration by authors.

E.g., a pure public good exhibits both non-rivalness in consumption and non-excludability of free-riders (Musgrave/ Musgrave/Kullmer, 1994, 67 ff). Simply put, the consumption of a public good by one individual does not reduce the availability of the good for consumption for any other individual. In other words, any number of individuals can consume the same good simultaneously at no additional costs of provision. Moreover, additional demand will not deteriorate the quality of the good. However, it is impossible to exclude those individuals from the consumption of the good who are unwilling to pay for its

provision (Laux-Meiselbach, 1988, 128). As a result, a market-based ("voluntary") supply of public goods will not work in principle.

On the other hand pure private goods are characterized by full rivalness and full excludability; a bap which has been consumed by an individual cannot be consumed by another.

However, Buchanan (1965) pointed that the simplistic dualism between pure public goods and pure private goods is unrealistic. In a real world setting most goods are mixed goods and take the form of club goods (or toll goods). This means that the utility derived from the consumption of these goods is a function of the number of consumers who use the good at the same time because of the limited capacity or supply available for consumption. In this situation, any additional consumer will reduce the utility accruing to the "old" consumers. On the other hand, however, every new consumer will also reduce the individual financing burden which must be borne by every single user (Erlei/Leschke/Sauerland, 2007, 345).

The production costs of these two alternatives (pure public goods versus pure private goods) can written as (Grossekettler, 1985, 214):

1) $$C = C(q) = C(xn^{\gamma})$$

where C denotes the costs, x is one unit of a pure public or pure private good, n is a term for the number of individuals who consume the good and γ is a congestion parameter, defined as:

2) $$\varepsilon_{q,n} = \frac{\frac{\partial q}{q}}{\frac{\partial n}{n}} = \frac{\partial q}{\partial n} * \frac{n}{q} = \gamma$$

This elasticity $\varepsilon_{q,n}$ measures the relative variation of the supply quantity (q) depending on a variation of the number of consumers of the good (n) at the same time. For $\varepsilon_{q,n} < 1$ the additionally provided supply quantity (∂q) increases by a disproportionately small extent as a result of an increase in the number of consumers (∂n). This proves that group advantages related to the group size of consumer exist (Erlei/Leschke/Sauerland, 2007, 346). Specially $\bar{\gamma} = 1 - \gamma$ can be a measure für group advantages in consumption (Grossekettler, 1985, 217).

Thus, n can be defined as the number of persons who participate as "members" in the sharing of the good (Buchannan, 1965, 3). In other words, n is a set of potential consumers and $\gamma = 0$ and $\gamma = 1$ represent the two special cases of pure public goods and pure private goods. Accordingly, the special cost function for pure public goods and pure private goods can be derived (Grossekettler, 1985, 214) as:

$C = C(q) = C(x)$ for pure public goods, and

$C = C(q) = C(xn)$ for pure private goods

Club goods (also known as collective goods or toll goods) can be classified as a subtype of a public good, for which there is non-rivalness in consumption but full excludability. However, an exclusion in the absence of congestion is useless because under these circumstances – i.e. during off-peak hours – also a lack of rivalry in consumption exists.

In this case, the elasticity of the provision costs (in relation to output changes) can be written as:

$$(3) \qquad \varepsilon_{PC,Q} = \frac{\frac{\partial PC}{PC}}{\frac{\partial q}{q}} = \frac{\partial PC}{\partial q} * \frac{q}{PC} = \delta$$

where PC are the provision costs. For $\varepsilon_{PC,q} < 1$ therefore economies of scale exist. The multiplication of $\varepsilon_{q,n}$ and $\varepsilon_{PC,q}$, γ and δ respectively, results in:

$$(4) \qquad \varepsilon_{q,n} \cdot \varepsilon_{PC,q} = \frac{\frac{\partial q}{q}}{\frac{\partial n}{n}} \cdot \frac{\frac{\partial PC}{PC}}{\frac{\partial q}{q}} = \frac{\frac{\partial PC}{PC}}{\frac{\partial n}{n}}$$

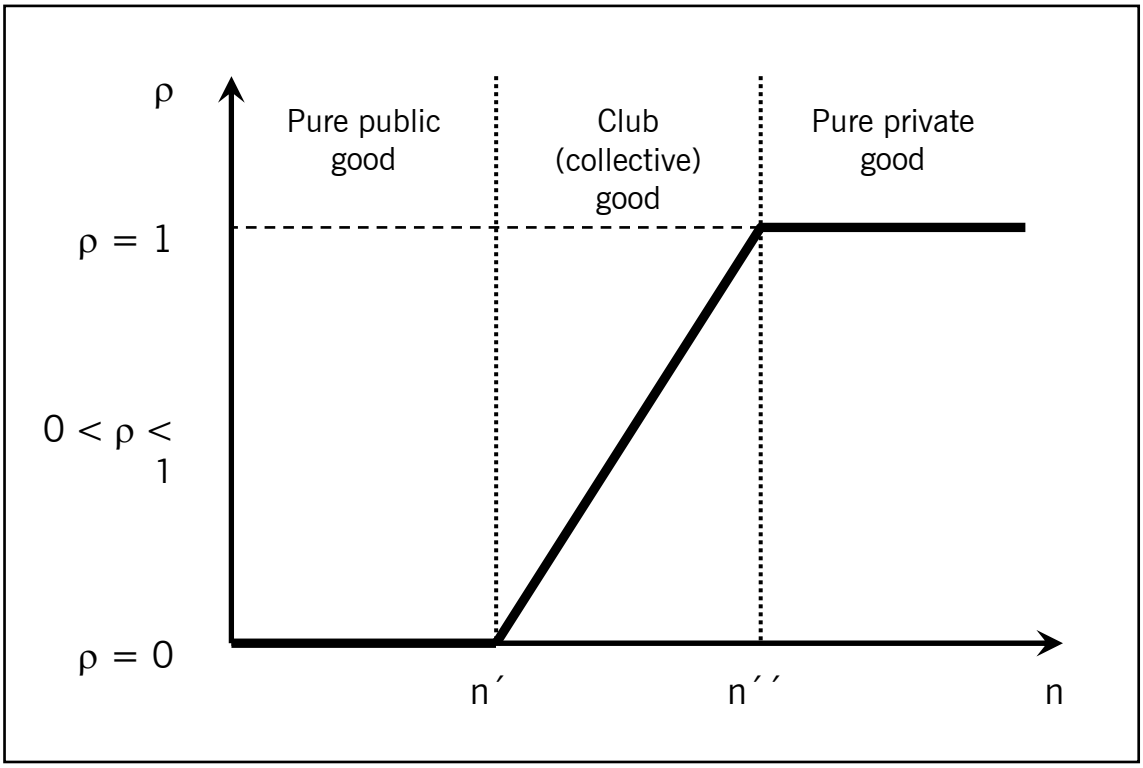
$$(4a) \qquad \varepsilon_{PC,n} = \frac{\frac{\partial PC}{PC}}{\frac{\partial n}{n}} = \frac{\partial PC}{\partial n} \cdot \frac{n}{PC} = \rho$$

This result proves that the degree of rivalry ρ can be defined as a relative variation of the provision costs (PC) as a result of the relative variation of the number of persons who are jointly consuming the good (n).Thus, the provision costs are defined as factory costs and production costs respectively, and in the case of external procurement the procurement costs also including all transaction costs. So it can be

shown that the degree of rivalry ρ can also be derived by consideration of different supply quantities (q) with two sub elasticity (Sauerland, 1997, 47; Erlei/Leschke/Sauerland, 2007, 345f.) and we can formulate the degree of rivalry as:

(5) $\gamma \cdot \delta = \rho$

Figure 1: Goods and their respective degree of rivalry



Source: Illustration by authors.

The graph clearly shows that as long as public goods are not congested (and also not-exludable) the degree of rivalry is zero (Oates, 1988, 85) and the marginal costs of provision to accommodate an additional consumer are zero as well. That is why, in this context, we speak of public goods and/or non-congested club goods (Erlei/Leschke/ Sauerland, 2007, 347). Pecorino (2009) also distinguishes between pure public goods and pure private goods according to their respective degrees of rivalry (Pecorino, 2009, 162f.). In this situation no rivalry between "new" consumers "old" consumers exists, and additional capacity of the good need not be provided.

However, once a critical number of users has been attracted (n') (figure 1), the degree of rivalry will be increase. If the capacity of a public good cannot be extended accordingly, this additional demand will also change the economic characteristics of the good. In particular, with the rising number of consumers the quality of the public good will deteriorate due to increasing congestion; positive congestion costs are the unavoidable result, and the degree of rivalry will also go up. To give a real world example, in this scenario an existing motorway would have to extended by adding at least one additional lane to accommodate the higher number of motorists. In other words, in the extreme case of a full-blown traffic jam, a new user is only able to enter the motorway if another driver has exited it before. Now, beyond n'' (figure 1) the degree of rivalry increases to $\rho = 1$.

b. Implications: the case for a fourth toll dimension

Let us now apply these results to road user charges in general and the German *Lkw-Maut* in particular. Any road network is characterized by fixed capacity for the time being, i.e. extending the network to accommodate additional users often is a very time-consuming process. First of all, there a some goods which are non-rivalrous in production and in consumption, e.g TV programmes. A tv programm cannot only be consumed by many consumers without increasing the provision costs; moreover, one consumer's usage does not impede upon the usage of others, meaning that congestion cannot occur at all in this case. By contrast, reading a book and driving a car cannot be performed at the same time, so there is a rivalry in consumption. In other words, for all practical purposes books and cars can be classified as collective goods based on the concept of economic rivalry (Schröder, 2006, 226).

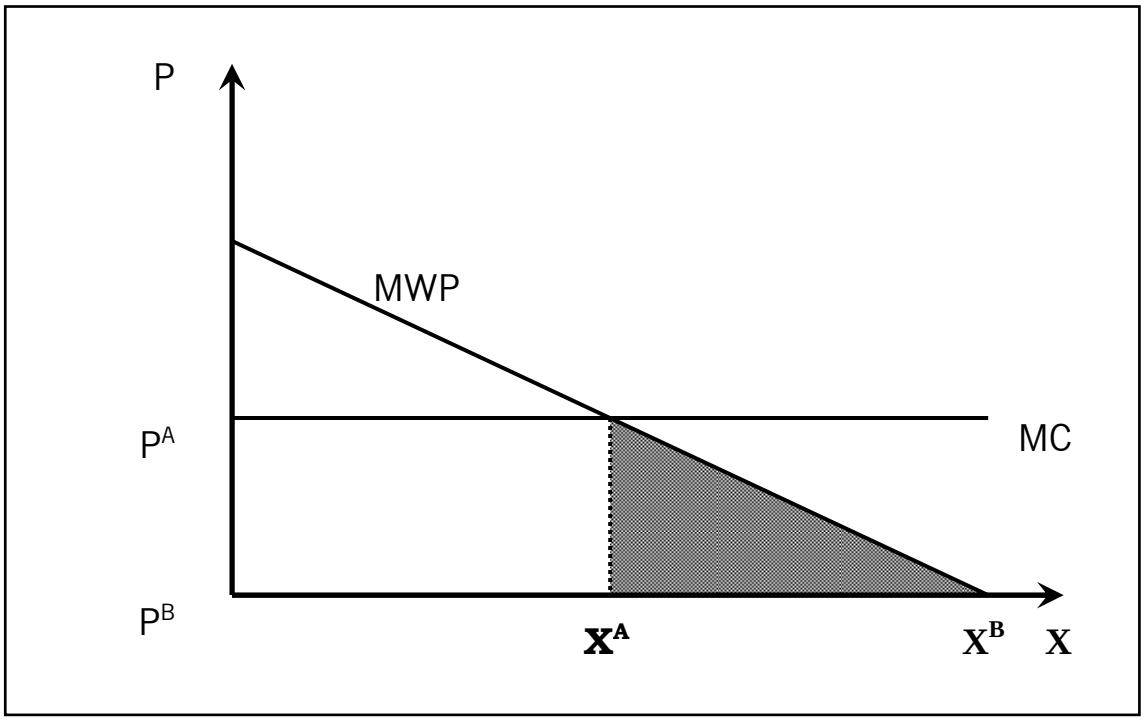
Formally, this can be stated as follows. From $\rho = 0$ follows $p = 0$ (Grossekettler, 1991, 75), if the equilibrium condition $P = MC$ is considered.

This has important implications for the financing of those infrastructure goods, for which, like roads, typically $\rho = 0$. In this case, all (potential) users should contribute to the set-up costs through a usage-independent (basic fee). Currently, the German vehicle tax can be interpreted as a basic fee in this sense. However, all foreign

registered vehicles – trucks and passenger cars alike – are legally exempt from this charge.

Regarding the efficient allocation of the marginal costs of road infrastructure use to individual users, it should not be overlooked that usage patterns differ substantially between peak and off-peak hours. To be more precise, motorways do exhibit the economic characteristics of pure public goods at night and during off-peak hours when no congestion or traffic jams exist. As a result, charging users the same amount during these periods as during the peak hours is inefficient as HGVs may typically use the motorway network without creating any congestion-related quality loss for other motorists. This welfare loss is equivalent to the shaded area in figure 2 below and proof that, on efficiency grounds, every toll levied for the usage of road characterized by variable demand should include a (variable) congestion-related component. Our findings are consistent with Birulin's (2006, 291) who demonstrated that excludable, congested goods with fixed capacity "can be produced in a first-best mechanism".

Figure 2: Marginal costs and welfare loss of tolling in "jam-free" (off-peak) periods



Source: Jakubowski/Lorenz (2008, 528).

MC: Marginal costs of provision
MWP: Marginal willingness to pay

V. Should the *Lkw-Maut* be extended to passenger vehicles?

While trucks expose road infrastructures to substantially more strain than passenger cars due to their much higher load per axle, the is no convincing economic case for exempting passenger vehicles from the toll (Hartwig/Marner 2005). Generally speaking, the economic advantages of a universal toll system have been amply demonstrated by the many urban road pricing schemes in operation worldwide, such as in Singapore (since 1975), London (since February 2003) and Stockholm (since 2007) as well as by the universal motorway tolls levied in France, Italy, Japan and the US turnpikes, to name just a few examples. In the case of Germany, the inefficiencies of the tax-financed status quo are widely felt in this area, too:

- a substantial free rider problem with respect to the large number of foreign-registered passenger vehicles which use German roads for transit purposes at no charge (if refuelling is unneccessary);
- increasing congestion even outside the large agglomerations;
- insufficient public funding for raod infrastructure maintenance and, where required, extension.

Politically, however, epxtending the scope of the toll to include passenger vehicle remains a very distant prospect, last not least because it is fiercely opposed by the *ADAC* (German Automobile Association), Germany's largest and one of the most influential special interests groups, which represents around 14m motorists. In a nutshell, most voters (and motorists) fear that a new road user charge would be levied on top of the existing vehicle and gasoline taxes, thus substantially increasing the price of individual mobility. A credible commitment by the main political parties to reduce these specific taxes in return is nowhere on the horizon, especially in these times of exploding government debt.

VI. Conclusions

After four years the German *Lkw-Maut* may overall be considered a success. Not only were all political objectives achieved – except for the intended modal split shift towards more environmentally friendly modes of transport. Moreover, the toll (combined with the specific

compensatory measures taken by the government) has become widely accepted among road haulage companies as a meaningful attempt to create a more level playing field between German an foreign-based trucking companies. However, two shortcomings remain: First, the lack of a congestion-related component in the toll for which a convincing economic case can be made. Second, the political failure to extend the scope of the toll to include passenger vehicles as well, whioch would have created the world's most comprehensive, universal and technologically advanced electronic road pricing system worldwide.

References

Beckers, Thorsten (2005), *Die Realisierung von Projekten nach dem PPP-Ansatz bei Bundesfernstraßen. Ökonomische Grundlagen und eine Analyse des F-Modells, des A-Modells sowie des Funktionsbauvertrags*, Ph.D. thesis, Technische Universität Berlin. (http://opus.kobv.de/tuberlin/volltexte/2005/1170/pdf/beckers_thorsten.pdf).

Birulin, Oleksii (2006), "Public goods with congestion", *Journal of Economic Theory* 129, pp. 289-299.

Böger, Torsten/Michael Zumpe (2008), "LKW-Maut. Was mit den Einnahmen passiert", IHK Magdeburg. (http://www.magdeburg.ihk24.de/servicemarken/presse/IHK_Jahresthema_2009/LKW_Maut_Einnahmen.jsp)

Broaddus, Andrea/Carsten Gertz (2008), "Tolling Heavy Goods Vehicles: Overview of European Practice and Lessons from German Experience", *Transportation Research Record: Journal of the Transportation Research Board*, vol. 2066/2008, pp. 106-113.

Buchanan, James (1965), "An Economic Theory of Clubs", *Economica* 32, pp. 1-14.

Bundesamt für Güterverkehr (2007), *Marktbeobachtung Güterverkehr. Jahresbericht 2006*, Bergisch Gladbach. (http://www.bag.bund.de/cln_010/nn_46266/SharedDocs/Publikationen/DE/Marktbeobachtung/Marktb__2006-Jahresber,templateId=raw,property=publicationFile.pdf/Marktb_2006-Jahresber.pdf)

Bundesamt für Güterverkehr (2009a), *Mautstatistik. Jahrestabellen 2008*, Bergisch Gladbach. (http://www.bag.bund.de/cln_010/nn_46210/SharedDocs/Publikationen/DE/Statistik/Lkw-Maut/Jahrestab__07__08.html).

Bundesamt für Güterverkehr (2009), *Marktbeobachtung Güterverkehr. Jahresbericht 2008*, Bergisch Gladbach. (http://www.bag.bund.de/cln_010/nn_46266/SharedDocs/Publikationen/DE/Marktbeobachtung/Marktb__2008-Jahresber,templateId=raw,property=publicationFile.pdf/Marktb_2008-Jahresber.pdf)

Bundesministerium für Verkehr, Bau und Stadtentwicklung (2009a), *HGV (Heavy Goods Vehicle) toll: Innovative, ecological and fair*, Berlin. (http://www.bmvbs.de/en/Transport/Roads-,2955/Innovative_-ecological-and-fai.htm)

Bundesministerium für Verkehr, Bau und Stadtentwicklung (2009b), *Lkw-Mautänderungen zum 1. Januar 2009*, Berlin. http://www.bmvbs.de/Verkehr/Gueterverkehr-Logistik/Lkw-Maut-,1436. 1046816/Lkw-Maut-Aenderungen-zum-1.-Ja.htm

Financial Times Deutschland (2009), "Toll-Collect-Streit kostet Bund Millionen", July 1th, 2009. (http://www.ftd.de/politik/deutschland/:Lkw-Maut-Toll-Collect-Streit-kostet-Bund-Millionen/538361.html)

Fleischer, Torsten/Günter Halbritter (2004), "Toll Collect: Panne von Industrie und Politik", Internationales Verkehrswesen 56, pp. 363-366.

Friedrich Ebert-Stiftung – Mangerkreis (2006), *Podiumsdiskussion zur Präsentation des Thesenpapiers Zukunft des Verkehrs – Finanzierung und Mobilität*, Berlin (http://library.fes.de/pdf-files/stabsabteilung/04152.pdf).

Grosekettler, Heinz (1991), "Die Versorgung mit Kollektivgütern als ordnungspolitisches Problem, *Ordo – Jahrbuch für die Ordnung von Wirtschaft und Gesellschaft* 42, pp. 69-89.

Grossekettler, Heinz (1985), "Options- und Grenzkostenpreise für Kollektivgüter unterschiedlicher Art und Ordnung", *Finanzarchiv, N.F.* 43, Issue 2, pp. 211-252.

Hartwig, Karl-Hans/TorstenMarner (2005), "Maut für alle? – Straßenbenutzungsgebühren auch für Pkw", Wirtschaftsdienst 85, pp. 102-108.

Institut für Mobilitätsforschung (2007), *Verkehrsinfrastruktur-Benchmarking Europa. Verkehrsinfrastrukturausstattung und verkehrspolitische Rahmenbedingungen in ausgewählten europäischen Staaten*, Berlin. (http://www.ifmo.de/basif/pdf/publikationen/2007/Verkehrsinfrastruktur_Benchmarking_Europa.pdf).

Jakubowski, Adam/Lorenz, Christian (2008), "PKW-Maut: Für eine verbrauchs-, entfernungs- und zeitabhängige Gebühr", *Wirtschaftsdienst* 88, pp. 526-529.

Laux-Meiselbach, Wolfgang (1988), "Impossibility of Exclusion and Characteristics of Public Goods", *Journal of Public Economics* 36, pp. 127-137.

Musgrave, Richard A./Peggy B. Musgrave/Lore Kullmer (1994), *Die öffentlichen Finanzen in Theorie und Praxis 1*, 6th ed., Tübingen: Mohr.

Ng, Yew-Kwang (1973), "The Economic Theory of Clubs: Pareto Optimality Conditions", *Economica* 40, pp. 291-298.

Oates, Wallace E. (1988), "On the Measurement of Congestion in the Provision of Local Public Goods", Journal of Urban Economics 24, pp. 85-94.

Pecorino, Paul (2009), "Public goods, group size, and the degree of rivalry", *Public Choice* 138, pp. 161-169.

Sauerland, Dirk (1997), *Föderalismus zwischen Freiheit und Effizienz*, Berlin: Duncker & Humblot.

Schröder, Guido (2006), "Preise auf Grenzkostenniveau – optimal aber unmöglich?", *Ordo – Jahrbuch für die Ordnung von Wirtschaft und Gesellschaft* 57, pp. 209-240.

Seidel, Tina/Bernhard Schlag/Bernhard Wieland/Jens Schade/ Andreas Matthes (2004), "Political acceptability of transport policies in Germany – the HGV toll", TIPP Task Report 4.2.1. Case study. EU-Project funded by the European Commission, Dresden.

Springer, Johannes (2008), *GNSS based tolling. A plattform for value-added services*, Presentation given at the European Navigation Event Conference, Eindhoven, October 8th, 2008 (http://www.navigationevent.com/pdf/ene2008/Springer_Toll%20Collect_08.10._Eindhoven.pdf):

Statistisches Bundesamt (2007), *Statistisches Jahrbuch für die Bundesrepublik Deutschland 2007*, Wiesbaden.

Toll collect (2008), "Four years: Truck toll in Germany", Press release, Berlin, December 19th, 2008. (http://www.toll-collect.de/frontend/press/PressEntryVP.do;jsessionid=A165C70D6695B1D458C4103732815E53?pressId=601)

Toll Collect (2009), "Truck Toll System", Berlin. (http://www.toll-collect.de/mautsystem/tcrdifr002_mautsystem.jsp;jsessionid=18B5500990EF4C302C9EEEDB742E3602)

Wirtschaftsrat (2000), "Position Verkehrspolitik. Investitionen in die Verkehrsinfrastruktur für den Wirtschaftsstandort Bundesrepublik", *trend – Zeitschrift für Soziale Marktwirtschaft (online edition)*, no. 82. (http://www.trend-zeitschrift.de/archiv/archiv82.html)

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